July/August 2018

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ISSN 0192-303X

***InTech* is published bimonthly by the International Society of Automation (ISA).**
Vol. 65, Issue 4.

Editorial and advertising offices are at 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709; phone 919-549-8411; fax 919-549-8288; email info@isa.org. *InTech* and the ISA logo are registered trademarks of ISA. *InTech* is indexed in Engineering Index Service and Applied Science & Technology Index and is microfilmed by NA Publishing, Inc., 4750 Venture Drive, Suite 400, P.O. Box 998, Ann Arbor, MI 48106.

Subscriptions: For members in the U.S., $10.38 annually is the nondeductible portion from dues. Other subscribers: $175 in North America; $235 outside North America. Multi-year rates available on request. Single copy and back issues: $20 + shipping.

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Postmaster: Send Form 3579 to *InTech*, 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709. Periodicals postage paid at Durham and at additional mailing office.

Printed in the U.S.A.

Publications mail agreement: No. 40012611. Return undeliverable Canadian addresses to P.O. Box 503, RPO West Beaver Creek, Richmond Hill, Ontario, L48 4RG

To order REPRINTS from *InTech*, contact Jill Kaletha at 219-878-6068 or jillk@fosterprinting.com.

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InTech magazine incorporates *Industrial Computing®* magazine.

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InTech provides the most thought-provoking and authoritative coverage of automation technologies, applications, and strategies to enhance automation professionals' on-the-job success. Published by the industry's leading organization, ISA, *InTech* addresses the most critical issues facing the rapidly changing automation industry.

Digitalization – What is an automation professional's role?

By Bill Lydon, *InTech*, Chief Editor

Digitalization is creating tightly synchronized, real-time integration of business systems and manufacturing automation and is the next big step to increase productivity. Automation professionals who embrace this vision advance their careers with important roles in digitalization, participating in design, application engineering, and implementation.

The vision is to achieve manufacturing systems synchronized and optimized as part of the entire digital ecosystem encompassing customers, supply chain, production, logistics, and product life cycle. This level of integration requires greater automation, control, monitoring, and integration with other business systems.

Rethinking manufacturing systems to become part of a broader synchronized business ecosystem requires the automation professional's participation with multiple groups in companies that enable people in traditional organizational silos to collaborate.

Greater automation to accomplish these functions also addresses the shrinking labor pool and aging workforce by automating manual tasks. An important part of this process is capturing and automating the knowledge and know-how of existing personnel who are part of the aging workforce.

Rethinking manufacturing systems to become part of a broader synchronized business ecosystem requires the automation professional's participation with multiple groups in companies that enable people in traditional organizational silos to collaborate. Automation professionals already have the systems knowledge that can be applied in collaboration with other groups to achieve greater levels of manufacturing performance. Collaborative design, with multiple groups applying their respective subject-matter expertise, can create superior results.

Automation professionals have a responsibility to learn about and apply the new tools available to improve production and manufacturing:

- new sensors, such as the application of new MEMS- (micro-electro-mechanical systems) based sensors
- machine learning, analytics, and rules-based software tools
- cloud services and capabilities
- learning about applying standardized interfaces to efficiently communicate throughout the entire manufacturing business ecosystem

An important task is educating your company management that digitalization is important to remaining a viable competitive business and that automation professionals are a valuable resource. This is important work to ensure companies will be competitive on the world stage. Manufacturers throughout the world are applying automation technology to be more competitive, recognizing that low labor cost is no longer a winning strategy. The challenge is providing management with concise, meaningful information to help them learn. This should be one of the items on your task list. Some of the ways to educate management is giving them copies or links to meaningful articles along with your concise well-thought-out ideas for the digitalization of your company's manufacturing. Collaborating with information technology and manufacturing to develop white papers about the best ways to transition existing operations to digital manufacturing is a way to achieve cooperative creativity and valuable insights for management.

There are exciting opportunities for automation professionals who embrace the change. ■

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Claroty and Siemens partner on cybersecurity

Siemens, a global company for electrification, automation, and digitalization, will use industrial cybersecurity company Claroty's behavioral analysis technology in its industrial anomaly detection system. Siemens, through its global venture firm Next47, also invested in Claroty, joining a global syndicate of industrial organizations that invested $60 million in the company's Series B round, bringing the company's total investment to $93 million.

Industrial anomaly detection helps both operations and cybersecurity teams. Operations teams receive a detailed inventory of industrial assets and changes to the network. Cybersecurity teams can continuously monitor these critical networks for vulnerabilities, malicious activity, and high-risk changes across distributed industrial sites.

Siemens uses Claroty in a prepackaged offering, so customers can deploy anomaly detection in their operations. The company brings the offering to the market based on preinstalled packages on Siemens IPC. In the future, it plans to also offer it based on Siemens switches with an application processing engine provided by the Ruggedcom RX1500 series.

Siemens owns and operates nearly 300 factories, and it uses digitalizing for efficiency gains. Responsible digitalization must go hand in hand with cybersecurity. Therefore, the company is implementing a defense-in-depth security concept in its factories. Industrial anomaly detection is an important element of this concept.

The platform is comprised of multiple integrated products, built on CoreX technology. The products have a full range of cybersecurity protection, control, detection, and response. ■

PTC and Rockwell Automation strategic partnership

PTC and Rockwell Automation have entered into a definitive agreement for a strategic partnership that is intended to accelerate growth for both companies. They will be able to partner with customers around the world who want to transform their physical operations with digital technology. As part of the partnership, Rockwell Automation will make a $1 billion equity investment in PTC, and Rockwell Automation's chairman and CEO, Blake Moret, will join PTC's board of directors effective with the closing of the equity transaction.

The partnership involves both companies' resources, technologies, industry expertise, and market presence, and will include technical collaboration across the organizations as well as joint global go-to-market initiatives. In particular, PTC and Rockwell Automation have agreed to align their respective smart factory technologies and combine PTC's ThingWorx IoT, Kepware industrial connectivity, and Vuforia augmented reality platforms with Rockwell Automation's FactoryTalk MES, FactoryTalk Analytics, and industrial automation platforms.

Rockwell Automation's solutions business will be a delivery and implementation provider, supported by an ecosystem of partners that both companies have established.

Under the terms of the agreement relating to the equity investment, Rockwell Automation will make a $1 billion equity investment in PTC by acquiring 10,582,010 newly issued shares at a price of $94.50, representing an approximate 8.4 percent ownership interest in PTC based on PTC's current outstanding shares pro forma for the share issuance to Rockwell Automation.

The price per share represents an 8.6 percent premium to PTC's closing stock price on 8 June 2018, the last trading day before the announcement. Rockwell Automation intends to fund the investment through a combination of cash on hand and commercial paper borrowings. Rockwell Automation will account for its ownership interest in PTC as an available-for-sale security, reported at fair value. ■

IIoT applications for the process industry

SAP and Endress+Hauser will intensify their cooperation in the development of Industrial Internet of Things (IIoT) applications for the process industry. In the future, both companies intend to work closer together in the development of joint solutions, sales, and customer implementations.

The goal is to fully integrate the Endress+Hauser field instruments as digital twins into the SAP cloud platform. The companies want to take advantage of the services and smart apps from SAP's Leonardo system and Endress+Hauser's IIoT offering. The idea is to integrate master and sensor data, as well as measurement values, into customer business, logistics, and production processes and to develop digital services focused on predictive maintenance and predictive quality. An open platform concept is the basis for this approach.

Endress+Hauser's role in the partnership involves delivering field instrumentation knowledge in the form of digital services, which will be implemented by integrating the existing Endress+Hauser IIoT services and the SAP platform using a standardized approach.

In the SAP asset intelligence network, field instruments are represented as digital twins, which are a basis for integration into the customer's business processes. Using SAP Leonardo technologies, like machine learning, analytics, and blockchain, intelligent services can be enabled for the production environment. ■

Automation by the Numbers

18.5 GW

Multinational energy company Enel chose AVEVA's predictive asset analytics software to remotely monitor 21 thermal generation plants across Europe and South America, which have a total capacity of **18.5 GW**. The software will provide early warning notification of potential equipment issues. AVEVA is a specialist in engineering, industrial, and infrastructure software.

As urbanization increases—an additional 2.5 billion people will live in urban areas by 2050—cities and suburbs must undergo a significant transformation to create sustainable living conditions for their residents. Energy is a key pillar of this transformation, as energy companies seek to meet demographic and economic growth expectations in an environmentally friendly way. Electricity and gas companies can enhance efficiency and performance from existing capital investments by improving asset performance, made possible in part by the Industrial Internet of Things. ■

$709 million

North American sales of machine vision components and systems increased 19 percent year over year to **$709 million** in the first quarter of 2018, setting an all-time record for quarterly sales, according to new statistics issued by AIA, the industry's trade group. Total machine vision sales include sales of components and systems. The machine vision components category grew 28 percent to a new record high of $107 million during the first quarter. The growth in components was primarily driven by camera sales, which increased 44 percent to $65 million. Optics (16 percent to $12 million) and software (nine percent to $5 million) markets also experienced growth in the first quarter.

The machine vision systems category increased 17 percent to $597 million in the first quarter of 2018. Within the systems category, sales of smart cameras climbed 26 percent to $109 million, while application-specific machine vision systems grew 16 percent to $488 million. ■

Source: Fingrid

400 kilovolts

ABB will upgrade one of Helsinki's substations with its ABB Ability technology to help meet increased demand for power, improve power reliability, and assist transmission system operator, Fingrid, with its plan to digitalize its assets.

Housed in a glass-clad building, the **400-kilovolt** Länsisalmi substation is an important part of Finland's transmission grid. As part of the project, ABB replaced an outdoor air-insulated switchgear (AIS) installation with gas-insulated switchgear (GIS) technology, freeing up 70 percent of the space occupied by the old facility.

In addition to the supply, the company will install modular switchgear monitoring devices onto the GIS to enable online condition monitoring of the circuit breakers. To reduce additional cabling, signals will be locally collected via WLAN using the IEC 61850 protocol and then uploaded to the ABB Ability Ellipse asset performance management (APM) system. Sensor technology will help Fingrid digitize its assets and make Länsisalmi a modern GIS substation.

Fingrid will also pilot the use of the Ability Ellipse APM to perform predictive analytics to help prevent critical failures in the transmission asset fleet, including transformers, circuit breakers, and transmission network equipment. ■

4.5 million

Bucharest-based OMV Petrom S.A. will use Honeywell Connected Plant for prescriptive monitoring of its CCR platforming unit at its Petrobrazi refinery in Ploiesti, Romania. The CCR platforming process upgrades low-value naphtha into high-octane gasoline and aromatics. OMV Petrom is an integrated oil and gas company and the largest producer of crude oil in Romania. It provides nearly half of Romania's domestic natural gas. The company's Petrobrazi refinery near Ploiesti has a refining capacity of **4.5 million** tons per year.

OMV will use the Connected Plant's process insight reliability advisor to continuously feed plant data through Honeywell UOP process and fault models. It will also provide performance information and process recommendations. Honeywell's Reliability Advisor will help the plant mitigate issues that affect production and plant profitability by detecting and analyzing problems before they occur. It gives refineries, petrochemical, and gas processing plants greater visibility into their operations, helping identify and resolve difficult-to-detect problems that hamper production. ■

Integrated manufacturing and production

New information technology and operational technology models

By Bill Lydon

The relationship between information technology (IT) and operational technology (OT) is a topic of formal and informal discussions at industry forums, user groups, events, and tradeshows with many thoughts and opinions. There are clearly changes going on in organizations with different business models and new technology, concepts, and challenges that are driving these discussions, pilot projects, and system changes. There are some strong views about the IT and OT relationship, including:

- cooperative separation
- cooperative integration
- IT managing OT except for real-time machine and process controls
- new hybrid groups

Based on discussions with many users, the relationship between IT and OT in organizations seems to be at different stages. However, the trend does appear to be the functional integration of IT and OT, regardless of the organizational structure, to achieve improved manufacturing and production.

What is OT?

Operational technology is typically defined as the hardware and software dedicated to detecting or causing changes in physical processes through direct monitoring or control of physical devices, including machines, robots, production lines, valves, pumps, and other elements of production. The actual control is responding to production with real-time controllers, such as programmable logic controllers (PLCs), distributed control systems (DCSs), machine controllers, robots, process controllers, and other devices that monitor and control physical production. OT in many organizations also encompasses supervisory control and data acquisition systems, human-machine interface displays, historians, and remote terminal units. These systems typically communicate using industrial control networks, such as Modbus, EtherNET/IP, Profinet, and EtherCAT. More recently wireless sensors communicate using ISA100, WirelessHART, or proprietary methods.

FAST FORWARD

- The integration of IT and OT is a significant change.
- Changes are challenging and empowering automation professionals to deliver more value.
- Worldwide competition, coupled with pervasive new technologies, is driving change.

What is IT?

An early definition of information technology appeared in the November 1958 *Harvard Business Review* article, "Management in the 1980s" by Harold J. Leavitt and Thomas L. Whisler:

"The new technology does not yet have a single established name. We shall call it information technology. It is composed of several related parts. One includes techniques for processing large amounts of information rapidly, and it is epitomized by the high-speed computer. A second part centers around the application of statistical and mathematical methods to decision-making problems; it is represented by techniques like mathematical programing, and by methodologies like operations research. A third part is in the offing, though its applications have not yet emerged very clearly; it consists of the simulation of higher-order thinking through computer programs."

This is still a pretty good fundamental definition. It includes the term *operations research*. A broad definition of operations research is determining the maximum profit, performance, yield or minimum loss, risk, or cost of some real-world objective. Industrial engineering and operations research applied to industrial and process manufacturing combine two disciplines focused on the operation of complex systems to develop better systems and operational procedures. Today's new technologies are enabling achievement of these goals.

Integrated manufacturing

Manufacturing and process industries have been pursuing the concept of integrating the entire business, including product design, procurement, supply chain management, production, maintenance, and outbound logistics, for a long time. The idea of computer integrated manufacturing has been a vision since the 1970s. It is defined as the integration of the total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies to improve organizational and personnel efficiency. In the 1970s and 1980s, some large automotive and aerospace manufacturers implemented a small number of projects, but the systems and technology at that time were cumbersome, expensive, and unreliable. Another major challenge was the integration of components from different suppliers, including PLCs, DCSs, CNC machine tools, conveyors, and robots using different communications protocols. There were also competing data interchange and protocol standards between the U.S. and Europe, which was counterproductive.

Industry 4.0, smart manufacturing, et al.

More recently, a progressive line of thinking has developed in applying technology to improve manufacturing with the integration of all aspects of production and commerce across company boundaries for greater efficiency. It is exemplified by Industry 4.0, smart manufacturing, Industrial Internet of Things, and other initiatives pursuing a holistic automation, business information, and manufacturing execution architecture. The goals are significantly higher productivity, efficiency, and self-managing production processes where people, machines, equipment, logistics systems, and work in process communicate and cooperate with each other directly. This vision includes new technologies and architectures to achieve low-cost mass production efficiencies for make-to-order manufacturing of quantity one.

Single view

IT/OT convergence promotes a single view of an enterprise's information and gives every person, machine, sensor, PLC, process controller, actuator, motor control center, and other device accurate data and information in an actionable context at the right time to improve operational efficiencies and lower production costs.

Decision in real time

Decisions will be made in real time with higher levels of confidence, because more information will be available regarding the event or condition. Management of an event in an IT/OT converged architecture will execute as a closed-loop process, optimizing the factors of production. This includes customer order flow and mix, supply chain, manufacturing, production processes, outbound logistics, and customer service.

Lean manufacturing ecosystem

Going beyond a single manufacturing company, production and logistics processes are integrated intelligently across company boundaries, creating a real-time lean manufacturing ecosystem that is more efficient and flexible. This facilitates smart value-creation chains that include all of the life-cycle phases of the product from the initial product idea, development, production, use, and maintenance to recycling. In this way, the ecosystem can satisfy customer wishes for everything from product idea to recycling to be responsive and continually make improvements.

Common platforms

IT and OT groups traditionally developed in two separate communities where almost all of the communication, hardware, and software were specific to that community, resulting in complex IT and OT systems integration. The new architecture, enabled by the proliferation of communication standards, powerful processors, web services, and open source software, provides a common environment for IT and OT collaboration and integration. IT and OT groups now share fundamentals in communications and network architecture, which simplifies the transport of data across systems, thus the technology divide between IT and OT is closing.

Converging IT and OT to create more effective operations is being discussed by many users, and some are making changes to be more efficient manufacturers.

Organizational and system evolution

Applying new technologies to achieve more efficient industrial and process manufacturing companies leads to functional changes. The new integrated manufacturing and enterprise architectures led by real-time enterprise resource planning systems integrate plant floor middleware software functions into edge devices, enterprise, and cloud computing. A more traditional way to express this is OT is being integrated into IT. But this does not describe all the new possibilities of integrated systems and new computing in edge devices. Progressive companies are exploring the new functionality with organizational changes and new systems by implementing pilot projects. The integration of IT and OT brings the ability to actively monitor the field performance of complex machines and their subcomponents to better understand manufacturing and process operation, contributing to more effective continuous improvement programs. In addition there will be greater confidence in production outcomes that will improve forecasts.

Industry discussion

Converging IT and OT to create more effective operations is being discussed by many users, and some are making changes to be more efficient manufacturers. These are some thoughts from manufacturing companies.

An example of an organizational change was presented at the 2017 Ignition Community Conference by Sugar Creek Packing Co., a diversified and flexible food manufacturer. A company representative discussed how its organization has one person responsible for OT and one for IT, with both reporting to the chief information officer. He described how this improved organizational cooperation and operations over six manufacturing sites with more than 100 PLC and controller devices and more than 15,000 tags.

These thoughts from a Rockwell Automation Perspectives event panel and user presentations illustrate there are varying views about IT/OT. Managers, industry experts, and six users discussed and shared insights about their unique journeys toward creating a connected enterprise. Key comments from the panel discussion included these observations:

- IT should take the lead to move data securely, delivering it when needed.
- The challenge is having OT people familiar with the process while understanding business processes.
- Common data models are required for efficient interchange of data between IT and OT.

- The key to success is connecting the data through the entire architecture using nonproprietary, open IT standards.
- One company used to hire control engineers, designers, and mechanical engineers to design motor gearboxes and drive chains. Over the years, it found that hiring model does not work anymore. The control and mechanical design became intertwined, so it shifted to mechatronics engineers who deal in both worlds. That shift is continuing now with the addition of people who understand the physics, analytics, and IT technology.
- IT provides and manages Ethernet connections to controllers, including configuration control. Automation engineers should not be burdened with networks but focused on improving controls and optimizing automation.

The various views expressed suggest organizations have differing thoughts on organizational and technological approaches.

Goals

Leadership manufacturing companies are starting to compete worldwide and use pervasive new technologies. Whatever form the implementation of systems, architectures, and organizational structures, there are commonly expressed goals to improve manufacturing, including competitiveness, productivity, quality, and customer satisfaction. Converged information is being used to optimize fixed and variable assets. Improved operations using real-time data, coupled with analytics, brings many benefits, including lower downtime, reduced energy consumption, and higher overall equipment effectiveness.

As organizations work to benefit from the convergence of IT/OT functions, stakeholders, product owners, and organizational managers must continue to understand new integrated system models and learn from industries that are integrating systems successfully, such as the computer, Internet, and cellphone industries.

On the whole, these new technologies are challenging and empowering control and automation professionals to deliver more value as systems and manufacturing-process subject-matter experts to achieve corporate goals. ■

ABOUT THE AUTHOR

Bill Lydon (blydon@isa.org) is chief editor of *InTech*. Lydon has been active in manufacturing automation for more than 35 years. He started his career as a designer of computer-based machine tool controls; in other positions, he applied programmable logic controllers and process control technology. In addition to experience at various large companies, he cofounded and was president of a venture-capital-funded industrial automation software company.

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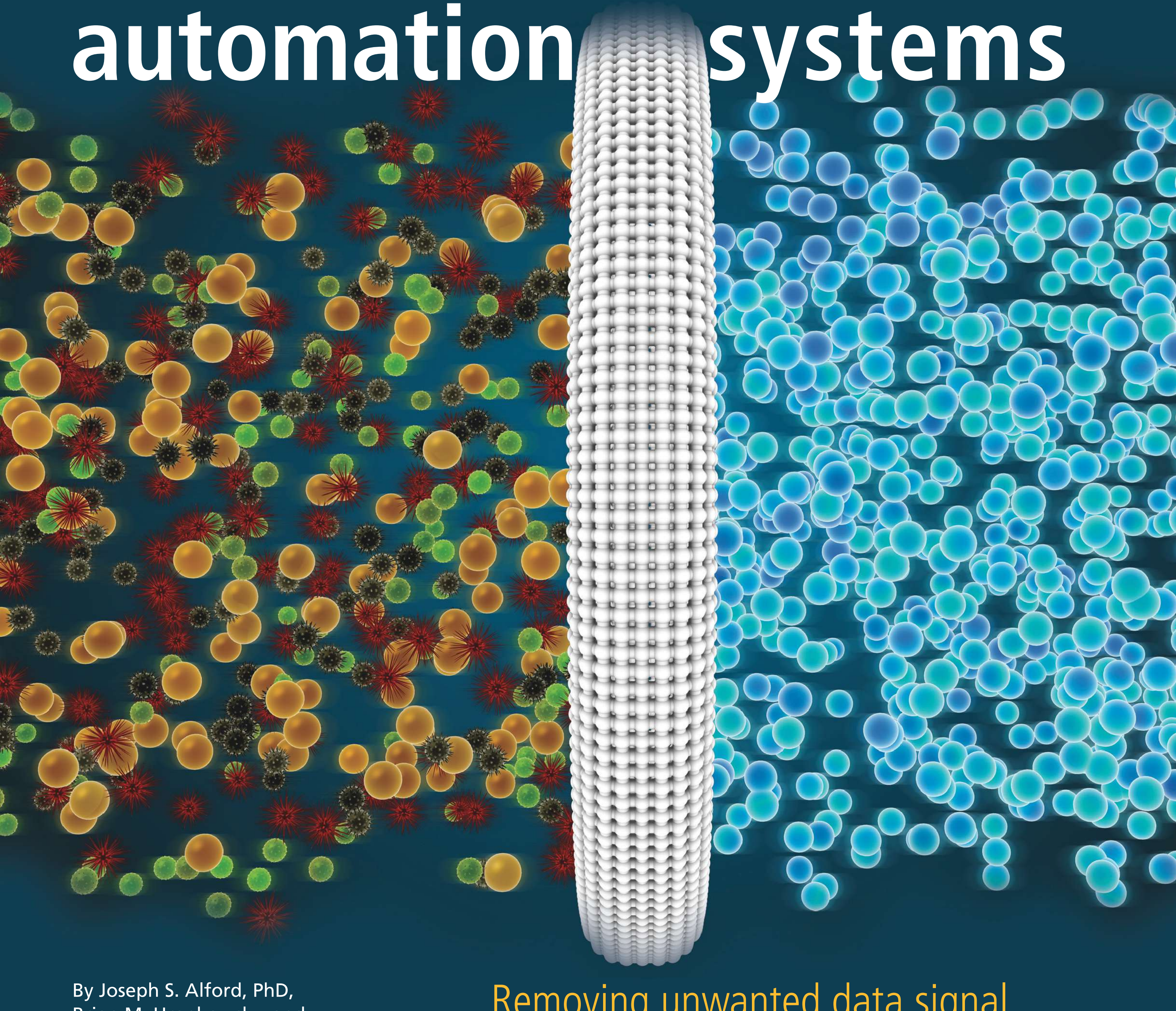
RESOURCES

"Management in the 1980s"
https://hbr.org/1958/11/management-in-the-1980s

Data filtering in process automation systems



By Joseph S. Alford, PhD,
Brian M. Hrankowsky, and
R. Russell Rhinehart

Removing unwanted data signal components or features

A data filter is a device, algorithm, or process that removes some unwanted components or features from a data signal. The unwanted component may be random noise (perhaps from mixing turbulence or mechanical vibrations), spurious outlier events (such as missed data packets or isolated spikes), or a periodic confusion (for instance from power or rotational harmonics).

FAST FORWARD

- Filtering is valuable to remove unwanted components or features from a data signal before the input is used in a process automation application.
- Data filtering must be used properly, or it can have negative consequences, including hiding real problems.
- This article discusses typical data filtering technologies used in industrial automation systems, exploring pros and cons and categories of noise removal, outlier removal, and stray signal removal.

The data signal may be a direct measurement or a virtual estimate of either a measurement or a key performance metric, which are inputs to process automation (control, historian) or enterprise management systems. In many cases, some preprocessing (data filtering) is desired before the input is presented to a controller or used in a trend plot for process representation.

Smoothing data and eliminating outliers have several advantages. For example, reducing noise in the derivative portion of a controller could lead to greater use of the derivative term in proportional, integral, derivative (PID) control (and, therefore, improved control). Data filtering also reduces distracting features in trend plots. And, less noise in a control loop's controlled variable can contribute to reduced variation in the controller output. However, data filtering can also have negative consequences, such as hiding real problems occurring or developing in a process or its equipment. It can also present a skewed (i.e., invalid) view of the magnitude and duration of real spikes occurring in the process. And, in general, data filtering causes a delay or a lag that can interfere with control. The engineer must understand that the real process value and the measured or displayed value are not the same thing.

In some applications, little or no data filtering is recommended. This is often the case with signals sent to alarm algorithms or to data collection systems, and those presented on a human-machine interface for critical process parameters (i.e., those impacting product quality) in "current Good Manufacturing Practice" (cGMP) regulated processes. In such applications, it is important to monitor and record true details of process excursions, not to reduce the perceived magnitude or extend the perceived duration of process spikes through filtering.

In some cases, there may be value in using and recording two forms of a process variable, one being the raw data from an instrument (useful in analyzing the details of a process or system excursion) and the second a filtered version useful for PID control or trend plots for presentation and publication.

Several different data filtering technologies are utilized in industrial automation systems. This article discusses some of them, including comments on pros and cons, and organizes them in categories of noise removal, outlier removal, and stray signal removal.

Most control systems (distributed control systems, programmable logic controllers, or PCs) do not have a broad menu of data filtering options to choose from; some have only one or two that are commonly applied in the process industry. However, most systems have some form of calculation blocks available for users to program or configure as part of application software, so users can implement whatever data filtering algorithm is deemed appropriate.

Noise removal methods

The concept is that the process is holding a steady value in time and that the signal is corrupted by random fluctuations. The objective of the filter is to reveal the underlying value.

Moving average filter (MA): A moving average filter reports the conventional average of data in a window:

$$\bar{X} = \frac{1}{N}\sum_{i=1}^{N} X_i,$$

in which $i = 1$ indicates the most recent data, and the average is over the past N data values.

This is termed a window of the data. At each sampling, the window moves, the newest data enters, and the oldest leaves. The user needs to specify the window length either as a time duration or as the number of the data in the window. The more data, the lower the variability is on average. At a steady condition (the nominal value is not changing, but the measurements fluctuate randomly due to noise effects), the variability of the average is related to the variability of the individual data:

$$\sigma_{\bar{X}} = \sigma_{X_i}/\sqrt{N}.$$

The $\sqrt{N}$ impact is true for any measure of variability, such as range. Note: Variation cannot be eliminated by averaging, just attenuated. The user needs to choose the value of N. A larger N means less variation, but it also means that it will take longer for the average to move to the proximity of the new value when the data value changes.

Figure 1 reveals a process (data are the markers) that is initially at a noisy steady state at a nominal value of 2, then makes a step change to a new value of 5 at the 30th sampling. The data value is on the vertical axis, and the sample number is on the horizontal axis. A data spike, a spurious signal with a value of zero, occurs at sampling 120. The thin dashed line connects the data dots to help reveal the trend. Subsequent

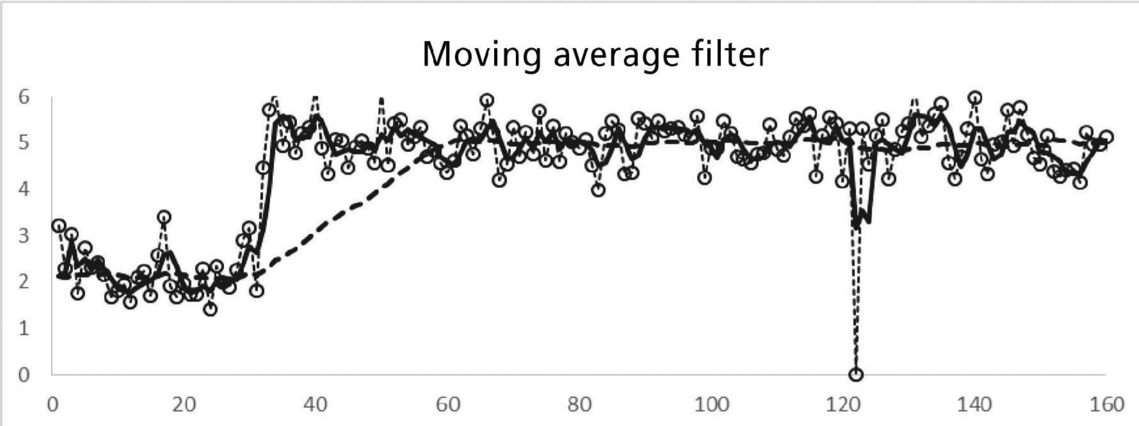


Figure 1. Characteristic performance of a moving average filter to a process step change and spike

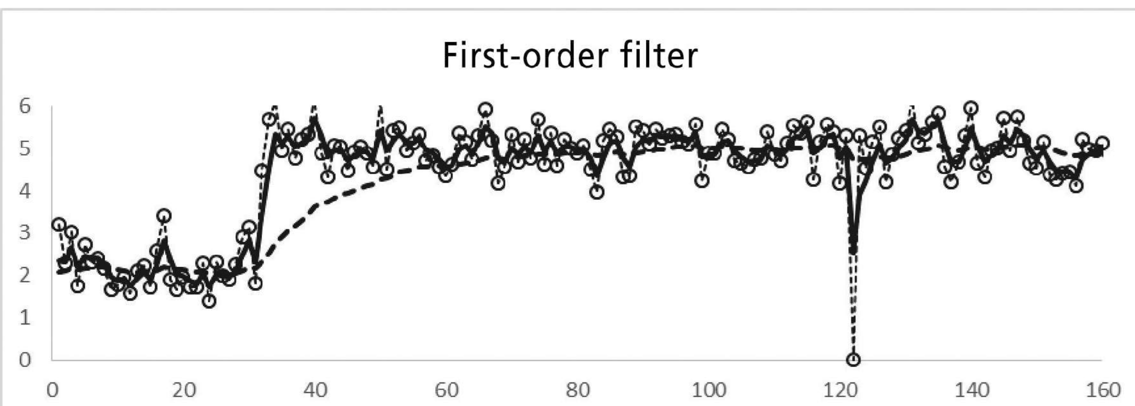


Figure 2. Characteristic performance of a first-order filter to a process step change and spike

figures will show results of diverse filtering methods on the same data.

In figure 1, the solid line represents the moving average filter with N=3 and the dashed line with N=30. Note several features:

- The MA with N=3 makes a more rapid rise to the new data value, but its variation is larger than the MA with N=30.
- The character of an MA filter response to a step change in the signal is a linear ramp toward the new value, which lasts N samples.
- The response to the one-time outlier is a pulse that has a duration of N samples and a magnitude of $1/N^{th}$ of the outlier deviation.

An advantage of the MA filter is that the concept of averaging is commonly understood, and the tuning choice of window length N is easily related. For example, moving averages are common in reporting the performance of a company stock. When periodic disturbances are present, a window length chosen to match the period will result in a signal that moves to the new average in one period. However, the algorithm causes some delay in process alarms and process control applications realizing and responding to a sudden process change. The algorithm does not reject data outliers.

First-order filter (FoF): A first-order filter has several alternate names, including exponentially weighted moving average (EWMA) and autoregressive moving average (ARMA). The FoF represents the analog device methods for filtering an electronic resistor-capacitor or pneumatic restriction and bellows, but it can be digitally performed. The advantage is that it is computationally simpler than an MA filter, which must store and process all of the data in the window. The FoF equation is:

$$X_{f,i} = \lambda X_i + (1 - \lambda) X_{f,i-1}.$$

Here lambda, λ, is the filter factor (it is not related to lambda tuning). It ranges between 0 and 1,

$0 < \lambda < 1.$

X_i is the most recent data measurement; $X_{f,i-1}$ is the prior filtered value; and $X_{f,i}$ is the new filtered value. If one derives the equation as an approximation to the moving average method, essentially:

$$\lambda = \frac{1}{N}.$$

Some vendors use the symbol f for the filter factor, and some switch the λ and $(1-\lambda)$ weighting. If one derives the FoF from the differential equation representing a first-order RC circuit, then:

$$\lambda = 1 - e^{-\Delta t/\tau},$$

where Δt is the sampling interval, and τ is the time constant. With substantial filtering, the time constant is approximately related to the number of data, $\tau \cong \Delta t N$. The user needs to be aware of the manner in which the vendor presents the filter.

The FoF also tempers, but does not

remove, noise. Here, if the process is steady, with random fluctuations, the relation for variability attenuation is:

$$\sigma_{X_f}=\sigma_{X_i}\sqrt{\frac{\lambda}{2-\lambda}}\ .$$

The user chooses the value of λ (or alternately *f* or τ) to temper the noise. Although the benefit of the FoF over the MA filter is computational simplicity, the negative is the persisting influence of long past data. In the MA, once a data value is out of the window, it no longer influences the average. However, in the FoF the past values are exponentially weighted, fading in time, but never totally leaving.

Figure 2 illustrates the performance of a FoF. The filtered value makes a first-order response to a change in the process. The lambda values of 0.500 (solid line) and 0.0645 (dashed line) are chosen to represent the same noise reduction obtained with the N=3 and N=30 values of the MA filter, $\lambda = 2/(N+1)$. Note:

- Both filtered values show an exponential rise to the new value, requiring three-to-four time constants, a period of $N \cong 3.5/\lambda$, to make about 97 percent of the change to reach the proximity of the new value.
- After the spike at sample 120, there is a progressive relaxation back to the filtered value.

The key advantage of the FoF over the MA filter is that the algorithm is computationally simple. However, the interpretation of the filter factor or time constant is less intuitive than choosing *N* in a moving average. And, the FoF does not reject outliers.

In either the MA or FoF the user must choose the filter coefficient value to best balance the lag or ramp period and to desirably temper the variation. In either case, the user needs to realize that the lag can be detrimental to control if it is similar in magnitude to the primary time constant or dead time of the process. The filter time constant should not be selected to be any greater than 1/5 the primary time constant. Filtering might be in any number of places (e.g., on the instrument or sensor, in the data acquisition transmittal system, on the I/O cards, in the control device, or as an option in the control algorithm). With a correctly implemented controller utilizing derivative, mode, filtering of the CV may not be necessary at all. Both algorithms hide the true magnitude and duration of process spikes.

Butterworth filter: Butterworth filters are a family of filters for addressing low, high, or band-limited frequency noise. The first-order low-pass Butterworth filter is the same as the FoF. As the order of the filter increases, the sharper the magnitude response is at the cutoff frequency, but more lag is introduced into the system. The FoF removes high-frequency noise (data-to-data variation) but tracks the average. However, in some frequency-based electronic applications, the user desires to have both a low-pass and high-pass filter. Although popular in electronic applications, it is rarely relevant in process monitoring or control. Some control systems use a second-order low-pass Butterworth filter due to its truer response to process changes (i.e., a lower cutoff frequency can be used to get the same desired attenuation).

Statistical filter: One of several approaches is based on a Six Sigma (statistical process control) desire to prevent tampering. In the filters discussed, even at steady conditions, the filter will continually report small deviations, and if used in automatic control, the controller will seek to correct this residual noise. The prevent-tampering concept is to hold a single filtered value until there is statistically confident evidence that the process value has changed, then change the filtered value. In one technique, a cumulative sum (CUSUM) of deviations of measurement from the filtered value is the observed metric. If the CUSUM becomes statistically significant (perhaps at the three-sigma level), then there is adequate justification to change the filtered value.

$$IF\ \left(\frac{CUSUM}{\sigma\sqrt{N}} > 3\right)\ THEN\ (X_{SPC} = X_{SPC} + CUSUM/N).$$

Figure 3 illustrates the CUSUM filter on the same data. Note that the filtered signal does not change during the initial steady state period and quickly jumps when there is a real change. It took about five samples to be statistically confident in the change from 2 to 5. In this set of data, the filter did not jump quite far enough, but made a correction after samples in the 40 to 60 period provided adequate confidence. Also note that the outlier at sample 120 was rejected.

The statistically based filters are scale independent; they adapt to the noise amplitude. One author often applies the CUSUM filter to the output of a controller to temper control action, rather than to mask the input CV activ-

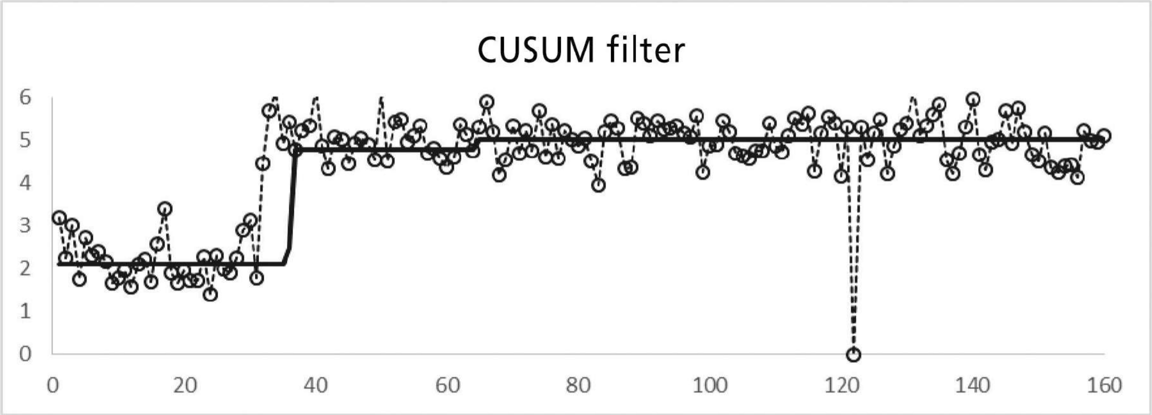


Figure 3. Characteristic performance of a statistical filter (three-sigma, 99 percent confidence) to a process step change and spike

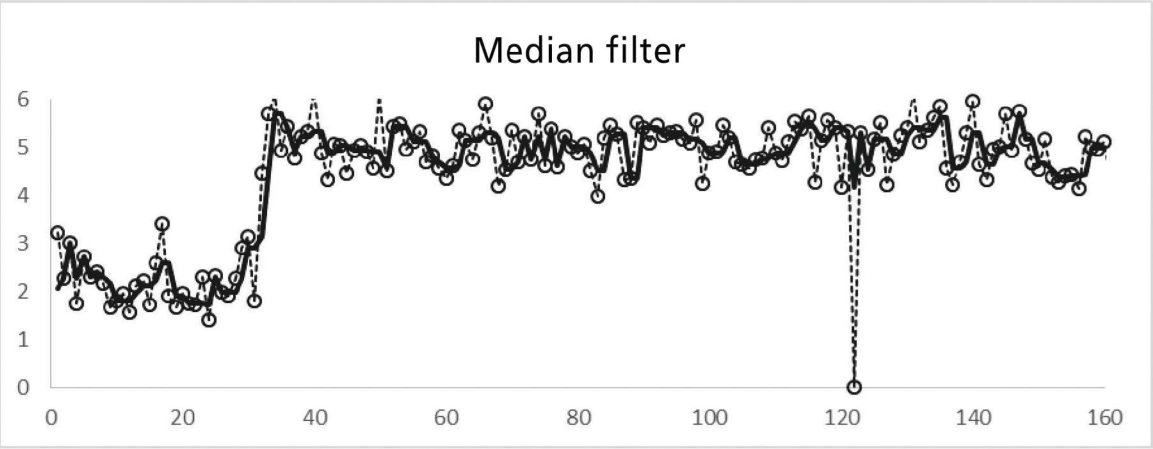


Figure 4. Characteristic performance of a median (middle of 3) to a process step change and spike

ity. However, adding a deadband or rate limiting to the output is also effective in tempering the controller, although such action is not self-adaptive to changes in noise amplitude. Statistical filters are also useful to temper process coefficient adjustment.

A statistically based filter moves rapidly when a change is confidently detected and holds a constant value in between. When the process noise amplitude changes, the responsiveness automatically changes. However, the code for this CUSUM filter is about 10 lines and requires that the noise be relatively compliant with the basis of independent sample-to-sample fluctuations. The user interpretation of the statistical trigger will be unfamiliar to many.

Kalman: The Kalman filter is a statistical filter that is significantly more complicated than other filters summarized in this article. It compares data to a model, then reports the value that has greater statistical confidence. Although common in the electronics and aerospace industries, where linear models are appropriate and fast computers are justified, it is not common in the CPI.

Outlier removal filters

Here the concept is that the signal is steady, but an occasional event happens to provide a one-time (or brief), wholly uncharacteristic value. This is often called an outlier, phantom, or a spurious event. The filter purpose is not to average, but to ignore that outlier, which might be related to occasional dropped data or an electrically induced spike. Electrical sources include voltage or current surges from a nearby lightning strike, radio communications (RFI), nearby motors starting up, or electric floor scrubbers. Loose or corroding wiring connections, sensors that receive mechanical shock, or dropped data packets in an overloaded communication system can also cause short-lived or one-sample outliers.

Median filter: The median filter reports the middle of the most recent values—not the middle in chronological order, but the middle in value. For instance, if the three most recent values are 5, 6, and 3, the middle value 5 is reported. Often, redundant sensors are used in which the middle of three measurements is taken as the process value, in a procedure termed *voting*. However, voting is a special case of parallel measurements at the same time. In a median filter, the middle-of-three is from a sequence of data. A median filter could be based on three, five, seven, or so sequential data. If you suspect that two outliers could happen sequentially, because of some common cause, then a median of 5 will reject them. The median filter does temper noise a bit, but the application intent should be to remove outliers.

Figure 4 illustrates the median filter (middle of 3) applied to the same set of data. Note:

- When the signal makes a step change at the 30th sampling, the filter has a delay of about half the number of data.
- The outlier at sample 120 is wholly ignored.
- Throughout, the vagaries of the signal substantially mimic the measurement.

Note: The median filter removes outliers and rapidly tracks real changes. However, the user must choose an *N* that is large enough to exclude persistent outliers. Masking outliers can misrepresent important features, and noise is not removed.

Data reconciliation: Here the concept is that a sensor, or several sensors, acquire a systematic bias, and the reported measurements are not only subject to random noise but also systematic error. Good and frequent calibration could eliminate this problem, but often continual instrument recalibration is not convenient. In data reconciliation, the objective is to use simple process models to back out the values of the systematic errors from the data. It is a powerful technique, but requires valid models, redundant process measurements, and online computing that is an order above the other algorithms discussed here.

Heuristic methods: These are user defined, as appropriate, and could be based on any number of data consistency or validation checks that a human observer might use to judge veracity. For instance, if a sudden change in one measurement correlates to a simultaneous or prior change in another, then the one-time effect may be interpreted as real, not an outlier. The logic is usually implemented as “if-then-else” rules that pass through valid data and perhaps flag what appear to be outliers. Flagged data could then be “thrown out” or ignored by process control applications, but still be retained for historian recording purposes.

The creation and management of large sets of if-then rules for data validation as well as other applications (e.g., real-time process diagnostics, intelligent alarming) is a strength of real-time expert systems. However, most commercial automation systems can easily handle the use of small to medium if-then-else rule sets.

Although mathematical equations are the basis of conventional filters, human logic statements can be powerful additional ways to "clean up" data. As a caution, it can be easy to generate conflicting heuristics. While expert systems can help, their use represents an additional paradigm for users to learn and support.

Other filters

Aliasing is when a stray, high-frequency signal confounds a sampled data signal. Sources include harmonics from rotating electrical motors, power transformers, and radio transmission. An anti-aliasing filter rejects the confounding signal. In many industrial platforms, an anti-aliasing filter is a simple first-order filter with a time constant set slightly faster than the base scan rate for the I/O system. This will mostly eliminate the effects of any signals with periods faster than what the controller can respond to and prevent them from being "felt" as a slower, longer period disturbance. High-quality input cards with appropriate anti-aliasing filters will eliminate radio effects for most common process signals.

There are many filters in the loop that may attenuate noise from various sources. For example, a thermowell acts as a filter to temper temperature fluctuations in the fluid when vapor and liquid are in transport. Lags in sensors, such as ion transport across the pH membrane, temper concentration fluctuations. Averaging in sample accumulation before analysis tempers fluctuation. The process engineer may have adjusted a derivative filter, tuned a valve positioner, or added deadband on a controller output or actuator. The process engineer may have selected signal damping effects on an orifice dP transducer. Additionally, many sensors in industry today come with their own microprocessor providing selected features. Some include embedded data filtering for which some adjustment (i.e., tuning constant) is available to customers.

Although mathematical equations are the basis of conventional filters, human logic statements can be powerful additional ways to "clean up" data.

While we acknowledge such diverse applications, this article focuses on techniques that are typically programmed or configured into process control or data historian computers for which users have significant discretion for their use and configuration.

Perspectives

- Filtering can be used to either temper noise or eliminate outliers. Use the right tool for the disparate applications.
- If the signal is noiseless (and void of outliers), then there is no need to consider filtering.
- Some applications (driven by regulatory considerations) may also indicate no use of filtering.
- If the noise level changes, then the user needs to adjust the filter factor to maintain the desired balance of noise attenuation to lag.
- Statistical filters automatically adapt to changes in noise amplitude.
- Filtering adds a lag or delay, which could impair control action, or require alternate controller tuning.
- Diverse filtering methods can be used in combination, such as a median filter to reject outliers, then the FoF to reduce noise.
- Filter effects and options are on nearly every device. Recognize where these might be. ■

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Automated guided vehicles improve production

Technological advances bring greater flexibility

By Bill Lydon

Driverless vehicles may be in the far-off future for consumers, but in the manufacturing industry the automated guided vehicle (AGV) is being used now to increase productivity and improve manufacturing flexibility and production flow. AGVs that use advanced navigation methods and that are linked with enterprise resource planning (ERP) systems and manufacturing execution systems (MESs) are becoming an integral part of synchronized and make-to-order manufacturing.

The advancement of navigation technologies has been an essential contributor to the increased use of AGVs. There are many types of AGV navigation technologies, but some are now less frequently used. AGV manufacturers generally consider the four following technologies for new equipment and installation.

FAST FORWARD

- AGVs increase work-in-process throughput.
- Modern AGVs can be part of a flexible manufacturing strategy.
- Modern AGVs become part of a synchronized manufacturing system directed by ERP or MES.

Magnetic navigation

Magnetic navigation for various light-duty AGVs typically uses magnetic tape for the guide path. One major advantage of using tape instead of wired guidance is that it can be easily removed and relocated if the course needs to change. It also removes the expense involved in restructuring the floor of the factory or warehouse. A limitation of this method is that the routes have to be fixed and well defined by the tape. If any obstacle is detected in front of the AGV, it stops and waits for the problem to be solved (e.g., the obstacle to be removed) before it restarts.

Laser-guided navigation

Laser-guided navigation is similar to an electronic eye. By means of reflectors positioned on the surrounding walls, the vehicle uses triangulation to determine its exact position, so it can carry out the required tasks in the operating area. The advantage of laser-guided technology is that it requires no floor work, as in the case of magnetic guidance systems. Additionally, route changes can be made easily via software updates to ensure maximum flexibility for company logistics.

Vision-guided vehicles

Vision-guided vehicles (VGVs) use optic sensors (cameras), in addition to other sensors, such as speed or laser sensors, to navigate. Software within the vehicle effectively builds a 3D map of its operating environment. This technology allows the vehicles to operate in automatic or manual mode for great flexibility.

Natural navigation

AGVs based on natural navigation technology do not require reflectors or markers, so they require less installation time and are easily integrated into existing systems. This minimizes the impact on current operations. In this type of navigation, LiDAR (light detection and ranging) is the main technology used.

Applying AGVs

Today AGVs come in all shapes and sizes. They have the capability to carry a range of items, from lightweight parts to large heavy loads like a complete engine. Typical applications include:

Work-in-process movement

Work-in-process (WIP) movement was one of the first applications where automated guided vehicles were used. It includes the repetitive movement of materials throughout the manufacturing process. AGVs can be used to move material from the warehouse to production/processing lines or from one process to another. Today AGVs are coupled with enterprise and plant production computer systems, so they can operate synchronized with manufacturing orders and production flow requirements.

Production parts delivery

AGVs deliver parts to machines and workstations based on production plans and real-time operations feedback to keep production flowing.

Pallet handling

Pallet handling is an extremely popular application for AGVs, because repetitive movement of pallets is very common in manufacturing and distribution facilities. AGVs can move pallets from the palletizer to stretch wrapping to the warehouse or to the outbound shipping docks.

Finished product handling

Moving finished goods from manufacturing to storage or shipping is the final movement of materials before they are delivered to customers. These movements often require the gentlest material handling, because the products are complete and can

Detroit Diesel makes extensive use of BLEICHERT Inc. AGVs, as the video illustrates.

Find video at:
www.automation.com/automation-news/article/detroit-diesel-an-80-year-journey-to-holistic-manufacturing

Lightweight AGVs are extremely flexible and can provide onboard data display for order information and instructions.
Source: 6 Rivers Systems, Inc.

be damaged from rough handling. AGVs operate with precisely controlled navigation and acceleration and deceleration, minimizing the potential for damage and making them an excellent choice for this type of application.

Trailer loading

Automatically loading trailers is a relatively new and increasingly popular application for automated guided vehicles. AGVs are used to transport and load pallets of finished goods directly into standard, over-the-road trailers without any special dock equipment. AGVs can pick up pallets from conveyors, racking, or staging lanes and deliver them into the trailer in the specified loading pattern. Some automatic trailer-loading AGVs use analytics software coupled with vision systems to view the walls of the trailer for navigation and coordinated trailer loading based on delivery routes.

AGVs now?

Automated guided vehicles have advanced technologically, and there are a number of advantages to automating using them to improve manufacturing operations. Advanced methods, such as laser navigation technology of the AGVs, help both avoid the requirement for in-floor wires (making them highly flexible with easily changed paths) and expand the system quickly without infrastructure investments. These new systems that are software directed allow an AGV with a problem to be replaced quickly with another unit.

Automated material handling technology can provide manufacturers many obvious and measurable benefits, such as decreased operating costs and increased throughput of materials, but they can be extended further.

Safety

Process safety is improved by eliminating the threat of people with handcarts. The manager at a large company that deployed AGVs told me it has reduced damage done by human-operated forklifts. Over time they have determined that the AGVs reduced product and facility damage.

Material traceability

Material traceability is automatically synchronized and tracked electronically with ERP systems—improving productivity, predictability, and consistency of material handling efforts at a reduced cost.

Manufacturing KPIs

Deploying AGVs connected in real-time with information systems in the plant provides immediate visibility of material and work-in-process flows and a record for accurate key performance indicators (KPIs).

Increased labor productivity

Delivering materials and work in process to the exact spot where they are needed saves the time required for personnel to retrieve materials from inventory locations. Manual material movement is not a high value-added activity. By applying AGVs, manufacturing employees have the materials and work in process when required, increasing productivity. Flexibility to alter the flow based on changing requirements allows employees to be repositioned to higher-value roles that require more specialized skills or the ability to handle complex tasks.

Lower work-in-process time

Using AGVs, work-in-process time can be lowered. This increases manufacturing throughput and contributes to better delivery performance, increasing profitability and customer satisfaction.

Just-in-time production

In highly flexible manufacturing applications where a synchronized production line is not practical, AGVs deliver parts for production orders to machines or manual workstations just in time—synchronized with production flow. The AGVs can also move the work and process to the appropriate machines or workstations in sequence. This approach leverages investments already made in ERP and MES. This can also be coordinated with companies applying 5S, a Japanese method to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.

In applications with particularly high variability, operators use smartphone-sized wireless handheld computers with a bar-code reader connected to the ERP system and linked to the warehouse management system. The operator simply scans a manufacturing order, his or her work center ID, and bill of materials for the order. The system will then deliver the materials to the workstation.

Application examples

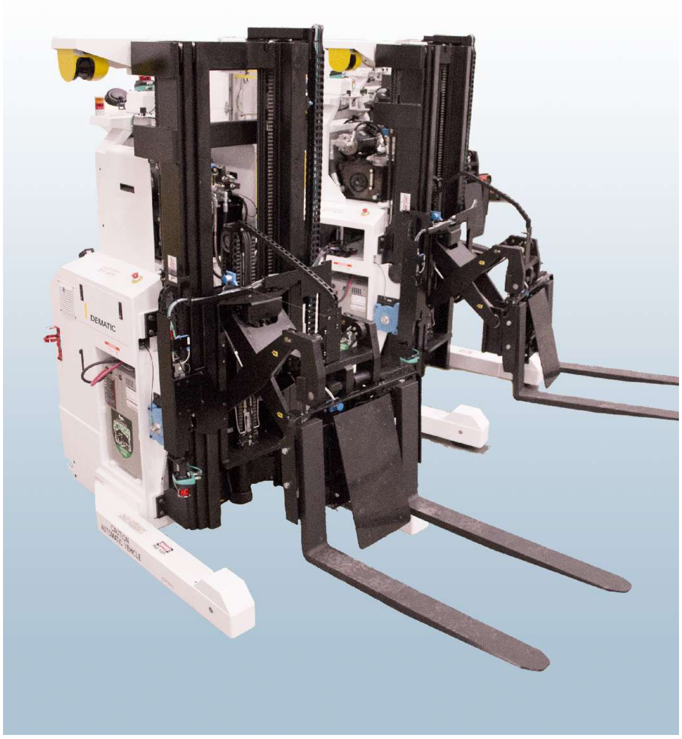
I had a discussion with a manager at a company that implemented automated guided vehicles to improve operations at manual workstations. The company implemented the Lean 5S method of workplace organization. The location of everything in the workspace was defined and clearly marked, and this ensured the efficient use of AGVs. The AGV was programmed to arrive at the workstation and stop, allowing the operator to take the required materials that it was delivering. If the workplaces were not organized in an orderly fashion, the workflow could be easily interrupted, as an AGV makes an automatic safety stop if something is in its programmed path.

The overall project goal was the implementation of a quality, systems-controlled, pull process that enabled more efficient retrieval and delivery of materials to work centers, enhancing production flow. The solution used AGVs that were directed based on production flow. The ERP system scheduled them to minimize repetitive material movements to and from the points of use. This approach met the flexibility required by the high variability of order types. There are a number of advantages cited using this approach:

- ensures correct material and batch deliveries to workstations
- delivers real-time traceable materials to workstations
- provides end-of-order reconciliation based on actual consumption

The results have been annual recurring savings due to vehicle automation and process simplification. The savings have been more than $5 million a year, at more than 40 sites.

I had the opportunity to tour the Detroit Diesel manufacturing plant in Redford Township, Mich. Detroit Diesel has made significant improvements to enhance its manufacturing. The flexible diesel engine production line is deployed using heavy-duty AGVs that each move a large engine block to workstations. The engine block is mounted so that it can be rotated for assembly operations by personnel. This setup was also part of implementing the Lean 5S method. ■



AGVs provide automated forklift functions to move heavier loads.
Source: Dematic Corp.

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View the online version at www.isa.org/intech/20180803.

Automating continuous process operations

ISA-106 for design and implementation of procedures

By Yahya Nazer, PhD, and Bill Wray, PE

FAST FORWARD

- ISA-106 provides a common basis of understanding of the benefits, best practice application, and language for continuous process industries.
- Procedures are important for consistency and quality operations.
- Systemizing procedures preserves knowledge and know-how of experienced people; this is important with the large numbers of retiring people.

ISA106 started with the goal of developing standards, recommended practices, and technical reports on the design and implementation of procedures for automating continuous process operations. The ISA106 committee has published two technical reports and is in the process of developing a standard addressing topics that include:

- models and terminology
- modularization of procedural steps to foster reuse and lower total cost of ownership
- exception handling for abnormal situations
- physical, procedural, and application models
- process unit orientation with operational perspective
- recommended best practices
- implementation of startup, shutdown, abnormal situations, hold states, and transition logic
- recommended target platform (i.e., control system versus safety system) for different types of procedures
- life-cycle management best practices
- training and certification best practices

The main driver for ISA106 is to enable the control engineer to implement:

- repeatable and optimized startup, run, state transition, and shutdown procedures
- abnormal situation management using additional control strategies
- intelligent alarming based on mode of operation
- equipment, devices, and controllers that are automatically enabled based on mode of operation
- redundant equipment (such as pumps) that can be automatically swapped for maintenance, run-time balancing, failure recovery, or other reasons
- control systems that allow operators to run a process unit as a unit instead of manipulating individual devices
- startup and shutdown procedures (which may be infrequent), including automatic sequencing of the plant (unit to unit)

Models and terminology

The first technical report written by the ISA106 committee, ISA-TR106.00.01-2013, *Procedure Automation for Continuous Process Operations – Models and Terminology,* complements the concepts described in several key ISA standards. It addresses the subject of procedural automation for continuous process operations and is focused on a collection of good practices regarding procedural automation in process operations and strategies for incorporating automated procedures into industrial automation and basic process control systems (BPCS). Other standards deal with the use of procedures in specific applications, among them batch processing and safety systems. Many of the fundamental concepts discussed in these standards are common to all procedures without regard to the context, but there are needs specific to continuous processes. These needs are addressed in the procedure requirements model, the procedure implementation model, and the physical model, as well as in the subclause concerning mapping of procedures to BPCS components.

The scope of the technical report is to provide a common basis of understanding of the benefits, best practice application, and language (including terms and definitions) that will allow organizations to apply procedural automation across the continuous process industries.

This report focuses on automated procedures that primarily reside on systems within the supervisory control, monitoring, and automated process control section of the production process. The committee did not intend to focus this technical report on procedure execution at the operations management functional level. It does also focus on continuous processes. However, the contents of the report may be used in other types of process control, such as batch or discrete. The technical report is intended to be applicable to process control activities within the BPCS and safety instrumented systems. Required safety instrumented functions should be analyzed and implemented in accordance with ISA-61511 (ISA-84).

ISA106 benefits

Benefit	Description
Improved safety performance	Automated procedures improve safety performance by providing: • consistent execution of correct procedures, reducing abnormal situations • improved responses to abnormal situations • increased operator awareness, including alarm significance • reduced personnel exposure
Improved reliability	Automated procedures reduce unintended damage to process equipment and aid in maintaining maximum production rates, minimizing recovery time after upsets, and avoiding shutdowns. (This also applies to equipment maintenance procedures, though not in this scope).
Reduced losses from operator errors	Automating procedures helps standardize them. A standardized approach reduces the likelihood of human error, which may contribute to or exacerbate an abnormal condition. It may also lessen the time to recover from abnormal conditions, so losses can be decreased.
Increased production by improving startups and shutdowns	Operations benefit from faster, safer, and more consistent startups and shutdowns by automating the procedural steps.
Increased production and quality via efficient transitions	Many operations require process transitions from one condition to another during normal operating conditions. Those changes include, but are not limited to: • raw material grade changes • finished product specification changes • intermediate product specification changes • execution of new target operating conditions Mishandled transitions occur frequently in the industry and can lead to major production losses. Automating procedures reduces transition times and variability.
Reduced losses through improved responses to disturbances	Automated procedures can be prepared for expected disturbances, reducing the time to return operations to desired steady-state conditions. Such procedures can also reduce the risk that such disturbances could escalate into an abnormal situation without careful operator intervention. In addition, correctly handling abnormal conditions may enable a process to run at degraded conditions rather than completely shutting down. Recovery from a degraded condition is often much faster than restarting a production line from a complete shutdown. The production output during a degraded condition may qualify as a lower-grade product.
Improved operator effectiveness	Procedural automation reduces the time an operator spends on repetitive tasks. Automated process actions can be programmed to take place at the optimal time for quality and efficiency, not only when the operator is available. In addition, the operator can use the time generated for more value-added activities, such as process improvement and avoiding abnormal situations.
Higher retention and improved dissemination of knowledge	The process industry faces serious challenges to maintain a knowledgeable workforce and to minimize variation in operator skills. Automated procedures based on best practices are an excellent way to retain the knowledge of the process and ensure consistent procedure execution. This is especially important for procedures that are not executed frequently.
Improved training	As knowledge is captured into best practices using automated procedures, the resulting documentation and code can be material for training new operators. It can be used to develop training simulator scenarios, so new operators can become qualified in a shorter time and experienced operators can stay up to date on their skills.
Improved insight into the process	By recording system and operator interactions, users can review and analyze data from every startup, shutdown, process transition, and abnormal condition recovery. This data analysis brings insight for continuous improvement opportunities in production efficiency and improved safety performance.
More efficient change control	A structured, modular approach to procedural automation minimizes production change control costs.
Reduced costs of enterprise adaptation	Once the standard structure for sequence control has been defined, implemented, and fully tested, it can be modularized into libraries of code, procedure, and documentation to allow easy cloning and replication with reduced maintenance requirements from one area to another and from one site to another within an organization. This also reduces dependence on the code's originator.
Common definitions and terminology	By defining and maintaining a procedural automation standard, engineering organizations have a common set of terms and definitions to describe the requirements for improvements and changes in procedural automation. This improves communications with engineering and procurement companies, system integrators, automation suppliers, and internal company departments.

Three models are defined for procedural automation of continuous process operations.

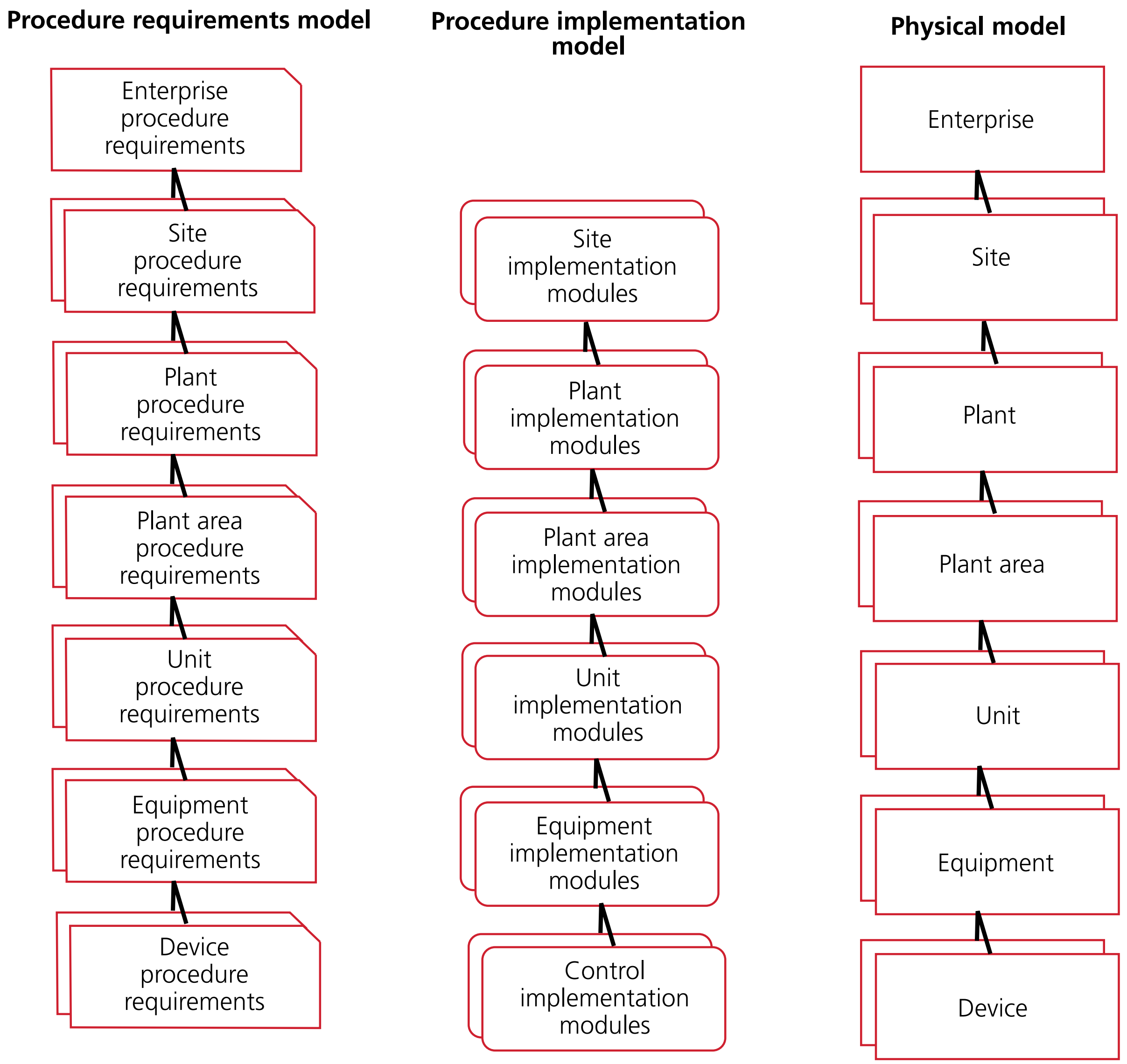
1. Procedure requirements model
   The procedure requirements model depicts how procedure requirements map to the hierarchy of equipment shown in the physical model.
2. Procedure implementation model
   The procedure implementation model serves as the connection between the procedure requirements model and the physical model, as illustrated below.
3. Physical model
   The physical model depicts how the ISA-95 role-based equipment model is applied to continuous process operations within this technical report.

The work of ISA106 is intended to provide a framework for building process operating knowledge into automated procedures.

Work processes

The work of ISA106 is intended to provide a framework for building process operating knowledge into automated procedures. This is especially important for such plant procedures as startup, shutdown, and product grade change—as studies have shown that plants are particularly vulnerable to safety incidents caused by inexperienced operators performing unfamiliar manual functions during such key procedures.

Building on the models and terminology of its first technical report, the ISA106 committee has completed a second technical report that describes work processes involved with automating procedures for monitoring and controlling continuous processes.



ISA-TR106.00.02-2017, *Procedure Automation for Continuous Process Operations – Work Processes*, applies to new process facilities and to control upgrades in existing facilities.

This technical report is not intended to instruct organizations on how to identify and justify projects or to provide the details of work processes, but rather to set forth a generic set of work processes to guide procedure automation project execution phases. The primary intended audience is technical managers, project managers, and engineering personnel responsible for the automation of continuous process operations in new and existing plants.

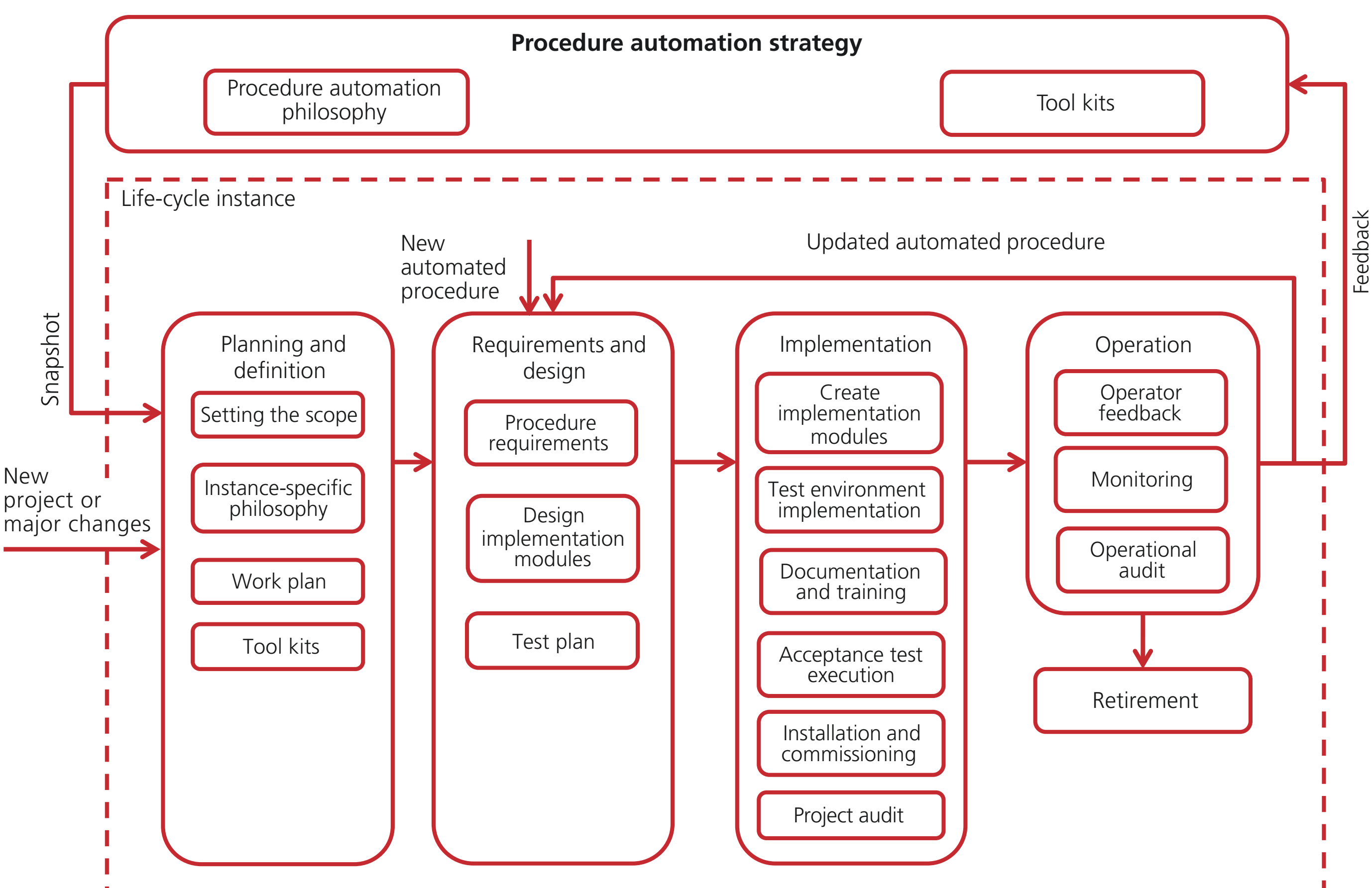
"The work processes used by end users are critical for the successful completion of capital projects and projects funded out of operating expenses," points out ISA106 member Dave Emerson of Yokogawa. "The new technical report provides a guide to how end users' work processes can be designed to account for the automation of continuous process operations. It reflects the combined knowledge and foresight of engineers from many different end users, automation suppliers, and consultants. The knowledge in this technical report can and should be used by owner operators to improve their own work processes, by automation suppliers to improve products and services, by consultants to help improve end users, and by automation suppliers to make the process industries safer and more efficient."

Integrating the life-cycle reference model and associated work processes into an organization's project methodology is a critical factor for achieving financial and operational success with procedure automation.

This technical report organizes work processes for developing and maintaining automated procedures into a life-cycle reference model in order to provide context to work processes and make them more sustainable. The life-cycle reference model described in this technical report is intended to be incorporated into an operating organization's project methodology, such as common gate-oriented or "V model" project methodologies.

Integrating the life-cycle reference model and associated work processes into an organization's project methodology is a critical factor for achieving financial and operational success with procedure automation. The life-cycle reference model and associated work processes may be scaled up, for large and "mega" projects, or scaled down for operational activities.

In the ISA-106 automated procedure



life-cycle reference model, the rounded rectangles represent the work processes, or their deliverables, that are directly related to the life-cycle of automated procedures.

The intended audience for this report includes technical and operations managers and engineering personnel who are responsible for the operation or automation of continuous process operations, members of engineering departments of owner operators, and engineering personnel of engineering and procurement companies, automation vendors, system integrators, and other process engineering practitioners.

Path forward

In the two ISA-106 technical reports, the committee focused on the current state of the continuous process industries. ISA106 is now working on a requirements-based standard. The models and terminology in the first technical report will be reviewed and revised as needed, and the committee will factor in the experiences and ideas gained in usage. The standard will also reflect the work processes set forth in the new technical report.

ISA106 is currently working on early drafts of the standard and welcomes new participants, especially end users to share their expertise and experiences. The committee currently has 168 members, including 25 voting members, with 45 percent of members representing owner-operator companies. The authors also acknowledge ISA106 secretary Charlie Green and editor Dave Emerson. For more information, contact ISA106 co-chairs Yahya Nazer or Bill Wray. To view or obtain copies of the two ISA-106 technical reports, visit www.isa.org/findstandards. ■

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Bill Wray, PE (wdwray@hotmail.com), co-chair of ISA106, began his career as a process engineer, later discovering his passion for process control. Wray was a founding member of World Batch Forum and served in various leadership roles, including chairman. He was the first chairman of the ISA95 committee, leading this effort to publication of the ISA-95 Part 1 standard. Wray is recently retired from Covestro LLC as a senior engineering consultant. He earned a BS in chemical engineering from Virginia Polytechnic Institute.

View the online version at www.isa.org/intech/20180804.

The state of MES
in the age of smart manufacturing

MES is now (or should be) viewed as a foundational enabler of manufacturing's digital transformation

By Patricia Panchak

As we have talked about MES through the years, we have been all over the map. Even now, if you ask half a dozen people the definition of a manufacturing execution system (MES), you will likely get six different answers. As we enter manufacturing's digital age, however, MES—or at least many MES capabilities—are increasingly recognized as critical components in a company's smart manufacturing journey.

"I think we're moving into the golden age of MES," asserts John Clemons, director of manufacturing IT at MAVERICK Technologies, acknowledging that he, and the others on the MESA International board, have been predicting it for "the last 30 years." He explains there are three reasons the turning point is at hand:

Maturity: In terms of tools and technologies, the MES products have become "better fits" for the market, and much more reliable.

Technology synergy: As multiple technologies converge, creating new possibilities for digital manufacturing, MES is being recognized as an important component. When combined with other technologies—cloud, Industrial Internet of Things (IIoT), data analytics, sensors, etc.—MES delivers more powerful benefits than ever before.

Better understanding: Manufacturers have gained a better understanding of the benefits of MES and, more importantly, are seeing that many of the benefits of MES remain untapped.

FAST FORWARD

- As real-time data collection, integration, and analysis continue to become increasingly critical to manufacturing business success, MES continues to become more integral to an overall smart manufacturing transformation.
- As multiple technologies converge, MES is being recognized as an important component.
- Manufacturers have gained a better understanding of the benefits of MES and recognize that many of those benefits remain untapped.

MESA President Mike Yost also notes that the more recent conversations about smart manufacturing, which relies on digital data and information, have played a key role. "It's sharpening the focus on what we've been doing for three decades," he says.

This resurgence in interest in MES is borne out in recent research that MESA conducted in partnership with LNS Research. Andrew C. Hughes, LNS principle analyst, said in a presentation at MESA's annual North American conference, "We're talking to quite a lot of companies that are thinking of implementing MES for the first time simply because they've realized that manufacturing data has to be part of their business." Companies that are trying to become more digital in the next two to three years—however they define that—are saying that MES is becoming a strategic part of that effort, he added.

Smart manufacturing connection

Still, "within manufacturing there's the sense we've been doing this forever," Clemons says, referring to the digital monitoring and control of plant floor processes. In a way, the concept of "smart manufacturing" is a misnomer, he says. "We've always been doing smart manufacturing; we haven't been doing dumb manufacturing," Clemons asserts. "From the very beginning MES has always been smart manufacturing, because it's always been about solving real problems on the factory floor."

Many manufacturers, he argues, started their smart manufacturing journey years ago—before we even called it smart manufacturing—by implementing MES or manufacturing operations management systems. For good measure, he points out that one could argue that the evolution of digital manufacturing can be traced back further, to computer-integrated manufacturing (CIM), or even further to the introduction of programmable logic controllers (PLCs) on the factory floor.

Much of the debate about MES' role in smart manufacturing revolves around attempts to describe the new technologies, which can be difficult considering all the constituencies. MES is broadly and hierarchically understood to be the "middle layer" in the technology stack, between plant-level process controls, such as PLCs, distributed control systems, and supervisory control and data acquisition, and the business systems, such as enterprise resource planning (ERP).

As MES technology has evolved, the boundaries between those layers have shifted. Many vendors seeking differentiation incorporated capabilities that were not originally part of MES. At the same time, other vendors offered vertical systems, such as those focused on quality, while insisting that these applications are something different from MES.

"I tell everybody there are many different ways to do anything you want in the MES space, and any given product that you buy overlaps with a dozen other products," Clemons says. For example, a manufacturer can buy a quality application, or can obtain quality components by buying a broader solution from Siemens, Rockwell, or SAP. Also, most of the control systems claim to offer quality components.

For the record, MESA's view is that "MES is not really intended to be any particular software solution; in most cases it's not even a single solution," Clemons explains. "In the broadest definition, MES is any kind of operational system that allows you to run the manufacturing plant from receiving to shipping." That includes "intelligence, reporting and analytics, and touching into supply chain and other areas," Yost adds.

This conversation about what MES is and does may seem academic, but it sits at the crux of understanding the future of smart manufacturing.

MES and ANSI/ISA-95 hierarchy

MES fits into the computer hierarchy as defined in the widely used ANSI/ISA-95 *Enterprise-Control System Integration* series of standards. ISA-95 is all about the automation interface between enterprise and control systems, and MES is part of this interface. ISA-95 provides normalization, including standard terminology and structure for the interface between enterprise and control systems. ISA-95 is fundamental for manufacturing automation and has been adopted worldwide as IEC/ISO 62264. It is also being adopted for new Industry 4.0 and Industrial Internet of Things applications. Key ISA-95 functions are:

- defines in detail a model of the enterprise, including manufacturing control functions and business functions, and its information exchange
- provides common terminology for the description and understanding of the enterprise, including manufacturing control functions and business process functions, and its information exchange
- defines electronic information exchange between the manufacturing control functions and other enterprise functions, including data models and exchange definitions

Further enhancing adoption, the B2MML XML implementation of ISA-95 provides a set of XML schemas written using the World Wide Web Consortium's XML Schema Definition (XSD) language that implement the data models in the ISA-95 standards. ■

One company's realization

That is what Trelleborg AB discovered as it launched its "production intelligence" (PI or π) initiative. (The company adopted "PI" as an umbrella term, otherwise known as smart manufacturing, Industry 4.0, or IIoT.)

Speaking at the recent MESA NA conference, Tomas Norbut, project manager of IT infrastructure and services at Trelleborg, said he discovered a disconnect in how the manufacturing and information technology (IT) departments perceived company readiness to embark on a digital transformation. The operations technology (OT) professionals running manufacturing thought it was ready, while IT determined it was not.

The difference of opinion, as he described it, was as follows: "Your processes could be very, very mature, but the abilities to digitize those processes can be very, very immature." That is not a knock against OT, he added, "We have a very well laid out manufacturing program, and they are very well invested within each of the [factories], and they were starting to shape the journey for PI." However, he said that while they had very clear concepts of the manufacturing world, they were unknowingly relying on buzzwords when they discussed digitization.

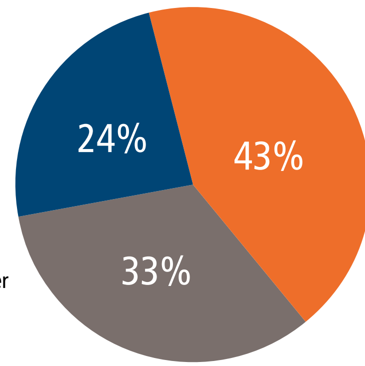
To "get everyone on the same page," Norbut first collaboratively worked to establish a common vocabulary, and to categorize and create a maturity model around the concepts, so everyone was speaking the same language. The next step was to survey the facilities based on that common understanding.

Significantly, survey results indicated that 57 percent of the companies' machines were MES ready. "I'm using MES as a catch-all term, because it can mean a lot of things to people," Norbut said. "But from a perspective of being able to connect your machine, gather data off of it, and dump it into some sort of system, that's what we categorized as 'MES ready.'"

The company will continue with this definition, even as it harmonizes MES capabilities across the company's 120 facilities, which have deployed various MES capabilities. "I don't envision one central stack," Norbut said. "I do envision some common functions and standardized features." Trelleborg will focus on "developing a common set of standards around what the data need to look like and how the data need to work."

Continuous improvement or strategic transformation?

Companies see smart manufacturing as...



MES as a foundation

Other companies say MES is a foundational element of their smart or digital manufacturing initiatives. Andrzej Goryca, senior enterprise systems manager at Virgin Orbit, one of the Virgin Atlantic companies founded by Sir Richard Branson, ascribes to this view.

The vertically integrated company builds rockets that launch small satellites into low-earth orbit. As a relatively young company—it has built about half a dozen rockets, so far—its goal is to design, build, and launch the rockets, while "at the same time we're striving to design, build, and launch our business," Goryca said. Its specific focus is on "getting us ready to build at rate and be able to support all the operations at rate."

"So with that vision and those goals, we are focused around creating digital threads—being able to digitize that whole chain, all the way from a launch event, which is our key event, and back all the way through test, integration, manufacturing, design, and all the way to the original requirements that drove how the vehicle should perform."

He explained where MES fits into the strategy to achieve this at the recent MESA NA conference. Put simply, he said, "MES is an enabler" of:

Digital records: "In our industry, you launch a vehicle and you have one chance; there's no plan B," Goryca said. "Proper controls are essential, so we'd rather not do it on paper; we'd rather have an additional record of it."

Cost analysis: As the company scales from building one rocket at a time to building to scale, it is important to understand how to do so while generating positive margin. Capturing, analyzing, and trending cost data for each build is crucial to this effort.

Repeatable processes: On the way to scale, MES helps the company identify and replicate what works, as well as controlling and revising what does not.

Better decision making: MES collects and analyzes the data, turning data into information, which help the "human in the loop" to make better decisions more quickly.

Ultimately, "we want to make sure we have the right systems for the right tasks," Goryca said, echoing Clemons' point by noting the plethora of potentially redundant applications. "We have a vision of one system, one user—to simplify and have everyone provided with the right tool to do their job."

Summing up, Goryca said the company plans on having MES in the manufacturing and quality space; ERP for planning in the supply chain, purchasing, procurement, and finance areas; and product life-cycle management and a few other systems in design engineering. Still, he asserted, "What's important is that they have to be connected in that digital thread."

Quantum leap or business as usual?

The varying views about MES explain some differences in how manufacturers view smart manufacturing, whether as the next step in an ever-evolving continuous improvement effort or as a strategic transformation.

The simple answer is both, according to recent research conducted by MESA and *IndustryWeek* to determine prevailing views about smart manufacturing.

Their survey found that 43 percent of respondents see smart manufacturing as an extension of their continuous improvement/innovation/lean initiatives, while 24 percent view it as a transformation strategy or new business model. A third of respondents said that it was not clearly one or the other.

For MESA's part, it is choosing to let industry tell what smart manufacturing is. However, even as Clemons and Yost assert they have been doing smart manufacturing—i.e., they have been connecting machines and gathering data from them for decades—they recognize smart manufacturing as disruptive innovation.

"This is the biggest catalyst for new possibilities that I've seen in my 30 years in manufacturing," Yost says. Though it is in some ways an extension of business as usual—the next step in continuous improvement or evolution of MES, "It's the opportunity to achieve a quantum leap."

The big caution, he advises, is to avoid the hype that is associated with the idea of smart manufacturing and taking that quantum leap: "If you don't know how to buy this stuff, if you don't know how to talk with vendors about what your business plans are and how to align the technologies to what your needs are, you're going to be pulled toward that shiny new coin, the shiny object, and you're going to be disappointed."

Understanding MES and smart manufacturing

Critical to understanding MES' role—or any other technology's role—in smart manufacturing, is that none of them are commodities. They cannot simply be plugged into an existing process to get immediate benefits—or, for that matter, to get them to work at all.

This is especially true about MES, according to Clemons. "MES is one of those solutions that you only get out of it what you put into it," he says. "If you think you're going to take delivery of MES and all your problems will be solved, that's not going to happen. That's a recipe for disaster."

He adds, "You've got to understand your operations; you've got to figure out what you need and the way you need to do it. If you're not doing it right, then dropping MES or anything else on top of it isn't going to make it better; it's probably going to make it worse."

It turns out, Clemons says, asserting MESA's long held point of view, that the adoption of MES or smart manufacturing is not as much about the technology as it is about people. It is not about figuring out what technologies to use and integrate. Rather it is about thinking through how your operation works and how to align people and technologies with that to achieve increasingly better results.

That means the obstacles to implementing MES or any smart manufacturing solution reside in the people, not the technology. "Manufacturers aren't used to buying technology solutions like this that aren't necessarily capital focused," Yost asserts. "So you can end up where the quality department will buy a quality solution; the maintenance department will buy a maintenance solution—the buying behaviors are set up in a very siloed way." This traditional way of operating as buyers and sellers causes difficulties in investing in solutions that, by definition, are about integrating and connecting across functional boundaries.

"Somebody has to be committed to saying, 'we're going to stop this fight,'" Yost says. "We're going to agree on metrics; we're going to adjust the way we pay people, so they don't have an incentive to protect 'their' data and metrics. We're going to be this boundaryless, tech-savvy organization."

This "people problem" extends to what has become known as the "IT-OT disconnect," which sums up the difficulty manufacturers have had in determining which group of professionals should lead their smart manufacturing initiatives. To this, Yost asserts MESA's view that the functional leaders who run your facilities—quality and maintenance leaders and plant managers—must be integral to the effort. "Taking those manufacturing people out of smart manufacturing decisions, that's a death knell," Yost says.

"We need to address those issues of how we work together, and how we work in our own departments, buy things and plan for technology," he adds. "You can't let the technology be the driver. The technologies are getting more and more capable all the time, but they still have to be the servants to the business leaders and business drivers."

That said, manufacturers need technology solutions to facilitate the gathering and analysis of data, and "MES—or at least elements of it—is that foundational solution, that core piece of the solution, whether it's called MES or not," Yost says. He acknowledges that some people would argue they do not need an MES as part of their smart manufacturing initiative, but counters that those people "are probably putting systems in place that we at MESA would put under an umbrella as being MES."

As real-time data collection, integration, and analysis continue to become more critical to manufacturing business success, MES continues to evolve to address the challenge—and to become more integral to an overall smart manufacturing transformation. Capabilities like MES in the cloud, MES as service, and mobile MES are becoming standard. ID technologies—whether 2D or 3D bar codes, RFID, or GPS—are coming together as part of MES solutions. Likewise, sensors are becoming smart devices, further expanding capabilities and benefits of MES and helping manufacturing operations become more responsive to the marketplace and to the business.

Put simply: MES has become a foundational element of smart manufacturing. Virgin Orbit—or any company—cannot create its digital thread or complete its smart manufacturing transformation without it.

All of this leads Clemons to conclude, "The state of MES is better than it has ever been, and I think the next 20 years are going to be pretty spectacular for MES." ■

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View the online version at www.isa.org/intech/20180805.

Guided wave radar for inventory tank gauging

Cut the cost, simplify the project, and expedite implementation

By Fawaz AlSahan, CAP

There are two internationally recognized standards covering tank gauging in atmospheric tanks. From the American Petroleum Institute, there is API MPMS chapter 3.1B and API MPMS chapter 7, and from the International Organization for Standardization, ISO 4266-1, ISO 4266-4, and ISO 11223. This article is based on API MPMS chapter 3.1B and API MPMS chapter 7, because these two documents provide detailed requirements for inventory applications. API MPMS chapter 3.1B mandates the following requirement for automatic tank gauges (ATGs):

The reading of an ATG to be used for an inventory application should agree with a certified measurement instrument within ±3 mm over the entire range of the ATG.

- The certified measurement instrument should be traceable to the national or international standards and should be provided with a calibration correction table.
- The overall accuracy of an ATG in inventory control service should be within ±25 mm.
- ATGs should provide security to prevent unauthorized adjustment or tampering.
- The level resolution of the transmitted signal is typically 1 mm.

Figure 1. Manual dip tape

FAST FORWARD

- There are different level measurement options for inventory tank gauging. Cost, schedule, and other challenges affect the final technology selection.
- GWR technology was tested in Saudi Aramco for inventory tank gauging with successful results.
- The Saudi Aramco Riyadh Refinery revised the project scope for implementing inventory tank gauging on 42 tanks, and ended up with a simple, cost-effective, and fast project implementation.

Conventional tank gauging solutions

There are five common automatic tank gauging solutions widely used for both inventory and custody applications.

Manual gauging

This solution is the reference for all other solutions, and it utilizes a dip tape. Manual gauging uses either the innage (from the top flange to the bottom of the tank) or ullage (from the top flange to the top liquid layer) method to measure the total liquid level inside the tank. API MPMS chapter 3.1A covers the procedure and requirement for manual gauging, which is normally three consecutive readings with a difference not exceeding ±3 mm.

Float and tape gauge

This solution uses a float attached to a spring via a perforated tape. The spring provides constant tension, which balances the float on the liquid level. The perforated tape is connected to a mechanical counter assembly.

Servo gauge

The servo gauge uses the displacement measurement principle. A small displacer (weight) on a measuring wire from a drum is accurately positioned and balanced in the liquid medium using a servomotor. These devices can meet the inventory and custody accuracy requirements.

Radar tank gauging

Radar tank gauging (RTG) is the most common solution for tank gauging. It used to be the Saudi Aramco standard tank gauging solution for inventory tanks. This technology is microwave-based, which measures the distance from the top connection to the liquid surface. The two available techniques are frequency modulated continuous wave (FMCW) and time-of-flight time domain reflectometry (TDR). These devices can meet the inventory and custody accuracy requirements.

Hydrostatic tank gauges

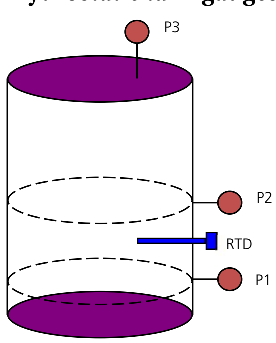


Figure 5. HTG

A hydrostatic tank gauge (HTG) system has up to three pressure transmitters and one temperature transmitter. Two pressure transmitters are installed close to the bottom of the tank and are used to calculate the density. A third transmitter measures the vapor pressure at the top of the tank to increase the accuracy.

Project initial scope and challenges

One recent tank gauging project at Saudi Aramco Company was scoped to install radar tank gauging with multiple points of temperature measurement on 42 tanks for crude and refined products. Three types of tanks are available: external float, internal float, and fixed-roof tanks. The main challenges addressed during the design stage were:

- Each RTG required excavation for running new and long cables for the signals and for the external power supply, in the large tank farm area.
- A nozzle size of 6 to 8 inches was required for every tank.
- A nozzle was required for the multiple spot temperature transmitter.
- Tanks with internal roofs had to be empty, cleaned, and ventilated to install the new stilling pipes. This meant at least three-to-five years to execute the project.
- New cabinets, hardware, and software installations in the process interface buildings were required, which could mean expansion of existing buildings or construction of new ones.
- RTG required factory acceptance testing (FAT), which adds to the project schedule and cost.
- The project execution would take years, including its high cost.

GWR technology for inventory tank gauging

Principle of operation

Guided wave radar (GWR) or time domain reflectometry is a two-wire microwave level instrument that transmits a radar signal down a metallic wave guide (single-rod/cable, twin rod, cable, or coaxial rod). The instrument principle of operation is time of flight.

$V = C / \sqrt{K}$

Where

V = pulse velocity in service

C = pulse velocity in air = 300,000 km/sec

K = dielectric constant

The signal transient time to and from the liquid surface will determine the level measurement.

GWR advantages

GWR technology has many advantages, which make it an attractive option for inventory tank gauging:

- The GWR level instrument is a two-wire transmitter and does not require an external power supply.
- GWR is a very economical choice in terms of capital and operating expenditures.
- GWR can be installed while the atmospheric storage tank is in service.
- GWR is "plug and play" and a maintenance-friendly technology.
- The GWR cable version can be extended up to 75 meters high.
- GWR is insensitive to dielectric changes and works for fluid with a low dielectric constant.
- GWR is available with different process connection types and sizes.
- A GWR rod/cable can be cut to fit the length (or height) required.
- A GWR instrument can provide both total hydrocarbon level and water interface level.

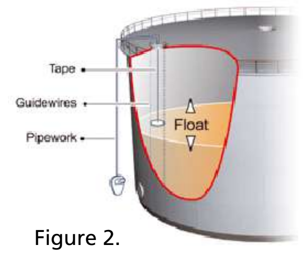


Figure 2. Float and tape gauge

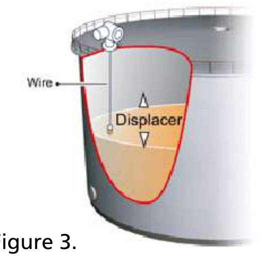


Figure 3. Servo gauge

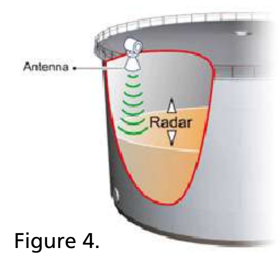


Figure 4. RTG

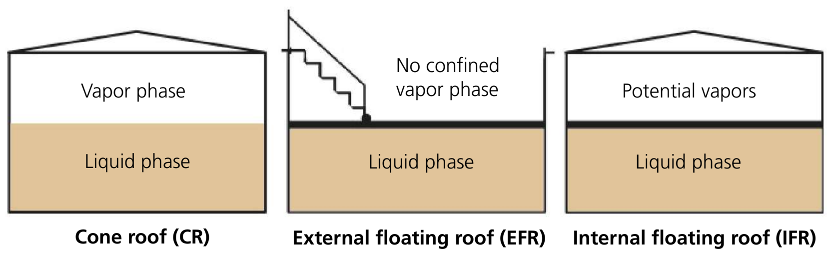


Figure 6. Three storage tank types

Tank #	Transmitter tag	Product	Tank construction	Gauge hatch size	Manufacturer
R-Y-T72	Z41-LI-3333	MTBE	External floating roof/12 meter	8 inch + stilling pipe	E+H
1Z0-D-006	Z41-LI-2222	Jet fuel	Internal floating roof/15 meter	8 inch + stilling pipe	VEGA
945-V6	Z41-LI-4444	Crude oil	Internal floating roof/18 meter	8 inch	E+H
R-Y-T70	Z41-LI-1111	MTBE	External floating roof/12 meter	8 inch + stilling pipe	VEGA

Figure 7. Pilot installation for GWR

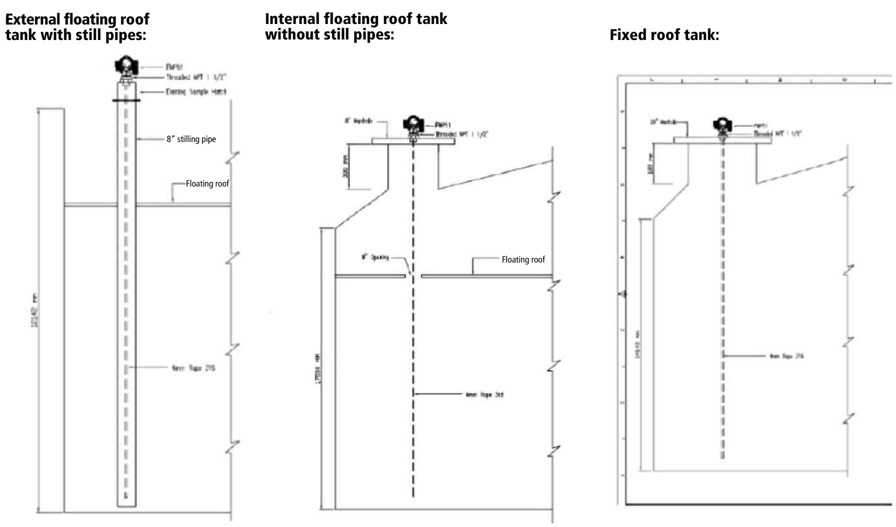


Figure 8. GWR installation options on different types of tanks

Figure 9. Installed GWR for piloting

- GWR has different and open communication protocols, such as analog 4–20 mA, Foundation fieldbus, and wireless.
- GWR can have an intrinsic lab accuracy between 2 mm and 3 mm, and a 25 mm installed accuracy depending on the vendor and measuring distance.
- GWR vendors can provide five-point calibration for each GWR.
- The technology is in compliance with all API MPMS chapter 3.1B requirements highlighted above.
- GWR will eliminate the conventional RTG proprietary hardware and system component.
- Due to its simplicity, a FAT is not necessary.
- GWR can be installed with or without stilling piping.

GWR piloting and test results

A plan was set to pilot four GWR level instruments from two different manufacturers on different types of tanks with different refinery products, and to monitor the performance over one year. Over this period, the operation team conducted frequent manual gauging (three times per test) to check the installed accuracy of the GWR.

Before proceeding with the field test, the selected vendors were asked:

- to confirm that the intrinsic accuracy of their GWR is within ±3 mm (±1/8 inch). Also, every vendor had to provide five-point calibration of each GWR to confirm the said accuracy. Both vendors provided the confirmation and data required.
- to provide a certificate of the reference-certified instrument, illustrating traceability to national or international standards. The vendors provided certificates for traceability to German accreditation body DAkkS.
- to confirm that the GWR transmitters have write protection. Both vendors confirmed and illustrated this feature for their GWR instruments.

It was also mutually agreed with the two GWR vendors to check and confirm the following after the installation and commissioning:

- the overall accuracy of the GWR, which should be within ±25 mm (±1 inch)
- the reading difference between the local transmitter display and remote DCS reading, which should be within 1 mm

Accordingly, four tanks were selected to proceed with the field trial. The figure 7 table highlights the data.

The sketches in figure 8 represent the installation setup for the GWR instruments on the three types of tanks (from the left: external roof, internal roof, and cone roof).

After commissioning, the echo curve was collected for each transmitter to confirm a strong echo for each GWR, with no loss of signal and no interference (figures 10 and 11).

Over one year, the refinery operation team conducted manual dipping to check the reading accuracy of the installed GWR instruments. The data over the year has clearly demonstrated that the accuracy is within the required ±25 mm for inventory tank gauging applications. A sample of the data collected is in figure 12.

Project scope revision

The successful results of piloting GWR for the inventory tank gauging application revealed a new and suitable solution for Saudi Aramco's Riyadh Refinery project. The project scope was revised to mandate GWR for the project and eliminate all the complexity and con-

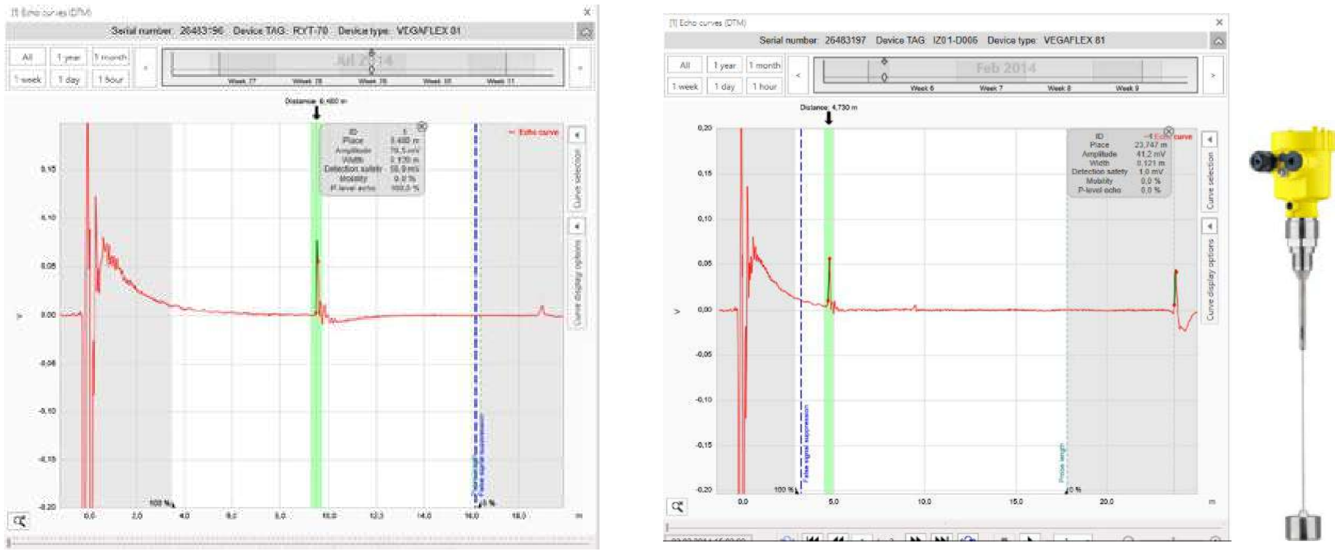


Figure 10. GWR echo curves on RYT-70 and IZ01-D006

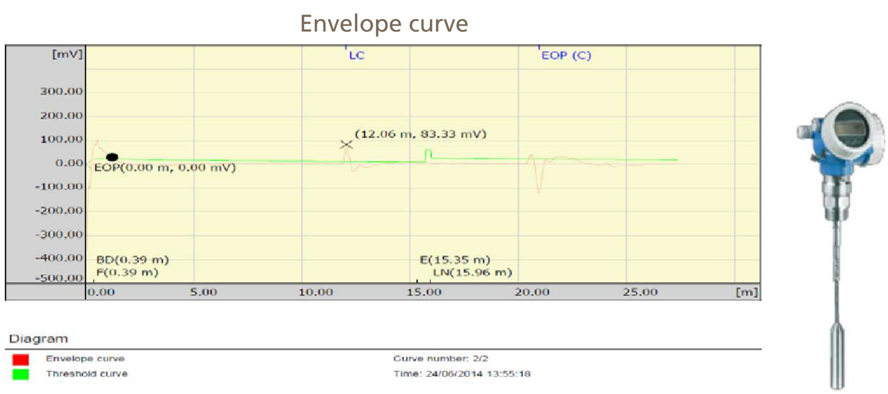


Figure 11. GWR echo curves on RYT-72

structability challenges. The vendor selection was biding based, since the GWR instruments from both vendors demonstrated a superior and equal performance. The project's final scope of work was revised as follows:

Measurement technology and setup:

- GWR shall be used for inventory tank gauging for the Riyadh Refinery project.
- For tanks with no stilling piping (e.g., tanks with a cone or internal floating roof), there is no need to install stilling pipes.
- For temperature measurement and since this application is inventory, a spot temperature sensor shall be used as it is allowed by API MPMS chapter 7.
- A pressure transmitter shall be installed at the bottom of each tank to assist in mass calculations.

Communication protocol: Foundation Fieldbus (FF):

- The existing FF segments in the refinery tank farm have been verified and found feasible to accommodate the new GWR instruments in this project.
- The existing asset management platform in the RR tank farm (i.e., PRM from Yokogawa) will be used for maintenance.

Tank inventory calculations: DCS shall be used, as it has the capability to perform the inventory calculations addressed in API MPMS chapter 12.1.1.

The Yokogawa Tank Inventory Management Module was configured as the existing DCS at the refinery. This step has eliminated proprietary hardware and software for the tank inventory calculations.

Economical solution

The journey of the Saudi Aramco tank gauging project has resulted in a simple, reliable, and highly economical system for inventory tank gauging. This solution demonstrated full compliance with API MPMS chapter 3.1B in terms of accuracy and performance. Moreover, it provides a versatile solution, which allows different hardware and communication protocols to be used and allows DCS as a platform for software inventory calculations.

It is important to highlight that GWR has fundamental rules set by the manufacturers for selection, installation, and commissioning. Following these rules will guarantee successful performance. Deviating from these requirements can generate unpleasant challenges and errors in measurement.

The GWR success story has also opened another opportunity for using two-wire noncontact radar for inventory tank gauging, as these noncontact radar instruments have the capability to meet the requirements of API MPMS chapter 3.1B. They can be very useful in applications like molten sulfur and asphalt.

This success story had an impact not only on the Riyadh Refinery project, but also on Saudi Aramco standards, which have been revised to specify

Figure 13. Tank inventory parameters and calculations in DCS

two-wire GWR for inventory tank gauging, as long as the vendors demonstrate a full compliance to API MPMS chapter 3.1B requirements.

Date	Tank #	Transmitter tag	Transmitter reading (M)	Hand dipping	Difference (mm)
8 Mar 2015	945-V6	Z41-LI-4444	10.752	10.765	13
	RYT-70	Z41-LI-1111	10.780	10.775	5
10 Mar 2015	D-006	Z41-LI-2222	10.790	10.782	8
	RYT-70	Z41-LI-1111	10.54	10.535	5
11 Mar 2015	RYT-72	Z41-LI-3333	5.564	5.562	2
	RYT-70	Z41-LI-1111	10.510	10.505	5
	D-006	Z41-LI-2222	9.162	9.161	1
18 Mar 2015	RYT-72	Z41-LI-3333	4.995	4.986	9
	945-V6	Z41-LI-4444	7.502	7.515	13
19 Mar 2015	D-006	Z41-LI-2222	10.876	10.871	5
	RYT-70	Z41-LI-1111	10.328	10.344	16
23 Mar 2015	RYT-72	Z41-LI-3333	10.946	10.938	8
	945-V6	Z41-LI-4444	14.018	14.029	11
26 Mar 2015	D-006	Z41-LI-2222	6.300	6.309	9
	RYT-70	Z41-LI-1111	10.188	10.198	10
2 Apr 2015	RYT-72	Z41-LI-3333	11.155	11.143	12
	945-V6	Z41-LI-4444	12.672	12.680	8
	D-006	Z41-LI-2222	3.975	3.990	15
	RYT-70	Z41-LI-1111	6.972	6.983	11
5 Apr 2015	D-006	Z41-LI-2222	13.731	13.725	6
	RYT-70	Z41-LI-1111	11.167	11.170	3
	RYT-72	Z41-LI-3333	7.479	7.473	6
	945-V6	Z41-LI-4444	11.647	11.654	7

Figure 12. Manual gauging compared to GWR reading

ACKNOWLEDGMENT

The author would like to acknowledge the support of the Saudi Aramco Riyadh Refinery management, and to acknowledge Riyadh Refinery automation engineers Fawaz AlHadlaq and Khalid Batoq for their assistance in preparing this article and their commitment to conducting the pilot testing and building a new milestone. ■

ABOUT THE AUTHOR

Fawaz AlSahan, CAP (Fawaz.sahan@aramco.com), is the chairman of Saudi Aramco instrumentation standards. Fawaz is a certified engineering consultant (SCE) with 20 years of experience in instrumentation and automation. Fawaz has delivered many technical papers and presentations, taught several courses, and holds three patents.

View the online version at www.isa.org/intech/20180806.

RESOURCES

API MPMS chapter 3.1B, *Standard Practice for Level Measurement of Liquid Hydrocarbons in Stationary Tanks by Automatic Tank Gauging*

API MPMS chapter 7, *Temperature Determination*

API MPMS chapter 12.1.1, *Calculation of Static Petroleum Quantities-Upright Cylindrical Tanks and Marine Vessels*

ISO 4266-1: *Measurement of Level in Atmospheric Tanks*

ISO 4266-4: *Measurement of Temperature in Atmospheric Tanks*

ISO 11223: *Measurement of Content of Vertical Storage Tanks by Hydrostatic Tank Gauging*

SAES-J-100 Process Measurement Standard

What is profitable safety?

By Gary Freburger

How often do you hear the words "safety" and "profit" in the same sentence? For many automation professionals, safety and profitability are diametrically opposed. Because a manufacturer's primary business objective is to create profits, protecting the safety of the plant's people, assets, and environment is often seen as a necessary cost of doing business. Safety is not usually part of the profitability calculation. Instead, industrial environment, health, and safety (EH&S) teams are viewed as adjunct organizations—cost centers that are not part of the mainstream business. That has made their job unnecessarily challenging. All of that is about to change.

With today's technology and data analytics, we now understand that the safety of the operation can have a direct, positive impact on the operational profitability of the plant. By viewing EH&S as a profit center instead of a business cost, new levels of safety and profitability can result.

By now we are all aware that Industry 4.0 and the Industrial Internet of Things are redefining how manufacturers control the performance of their industrial assets and operations. Technology advancements are enabling companies to shift from managing their business performance month to month or on other artificial schedules to controlling it in real time. Smarter, more autonomous equipment assets, and a workforce that is empowered to make better business decisions, mean plant managers can continuously control critical business variables and risks to maximize process productivity, performance, and even the profitability of the operation, safely.

Today, almost every industrial safety operation is performing suboptimally when it comes to the potential business value it can generate.

Today, almost every industrial safety operation is performing suboptimally when it comes to the potential business value it can generate. For decades, industrial professionals have recognized the high cost of unexpected events, such as fires and explosions, on productivity. Damage, be it to the equipment, facility, or environment, causes business interruption and skyrocketing insurance premiums. The cost to public image and trust can be monumental. Industry has responded by implementing functional safety programs, such as installing safety instrumented systems (SISs) that detect pending unsafe conditions and take corrective actions automatically. These systems have helped effectively avoid predefined unsafe events and are a huge step forward. But they are just a piece of the potential operational profitability improvements an effective safety control solution can produce.

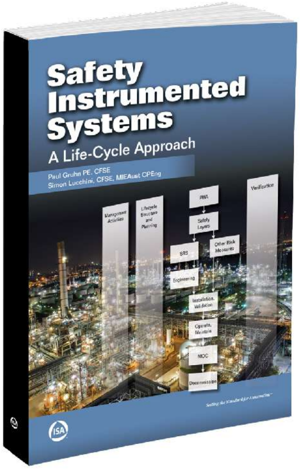
Modern safety systems can now quickly gather and analyze data, thereby driving rapid, highly accurate operating and business decisions in real time. Predictive analytic algorithms can be configured to identify looming threats to the safety of the plant's people, assets, and production, allowing operators to act before anything happens. By leveraging process safety controllers and SISs that meet stringent safety, cybersecurity, risk reduction, and continuous operation requirements, industrial safety professionals can create a closed-loop safety model and accurately predict when safety risk factors will exceed accepted thresholds, thus avoiding incidents while helping plant operators determine how hard they can safely push the plant's profitable performance.

The future of industrial safety is upon us. Increased operational profitability can be realized by taking control of real-time safety variables, and it is bringing the EH&S function into the mainstream of industrial business processes. There is a move away from traditional functional safety, which is reactive by nature, to a more holistic approach focused on the three P's of safety: productivity, performance, and profit. Advancements in hardware and software, like real-time control and predictive analytics, are unlocking new performance and value and allowing safety personnel to do things never previously possible. This allows safety operations to align even better with the strategic goals of the business to boost profitability. Not only can safety and profit peacefully coexist, they can also thrive together as an integral component of the industrial profit engine. That is profitable safety. ■

ABOUT THE AUTHOR

Gary Freburger is president of Schneider Electric's Process Automation business. He was previously COO for both Invensys Operations Management and Invensys plc, as well as the senior vice president, global operations, for Invensys Controls. He holds a BS in industrial management and an executive MBA. He is also a certified Six Sigma Black Belt. Send questions and comments to Christine Gandolfi (Christine.Gandolfi@schneider-electric.com).

Safety Instrumented Systems: A Life-Cycle Approach



ISA has published a new book that covers the entire life cycle of safety instrumented systems—including specification, design, analysis, programming, installation, maintenance, and change management. *Safety Instrumented Systems: A Life-Cycle Approach* by Paul Gruhn, PE, CFSE, and Simon Lucchini, CFSE, MIEAust CPEng, explains the significance and value of the ISA/IEC 61511 standard in improving functional process safety and gives important practical guidance and real-world case studies.

"To properly design, install, commission, and operate a safety system, you have to align the performance requirements of the standard with how process plants operate and how projects are executed," points out Lucchini, chief controls specialist and Fellow in Safety Systems at Fluor Canada and the Safety Systems Committee chair of ISA's Safety and Security Division. "Safety needs to be integrated into the design rather than 'bolted on' at some late stage of the project. This book helps guide functional safety engineers and others involved in process industry safety to the right decisions about safety systems at the right time." ■

New CAPs and CCSTs

Qualifying for and passing one of ISA's certification exams is a noteworthy accomplishment. The exams are rigorous and require a solid command of various disciplines in automation and control. Below is a list of individuals who have recently passed either our Certified Automation Professional (CAP) or one of the three levels of our Certified Control System Technician (CCST) exam. Congratulations to our new certification holders! For more information about the ISA CAP and CCST certification programs, please visit www.isa.org/training-and-certifications/isa-certification.

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Level 1

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Southern CA
U.S.

Dusty R. Powell
Geo Specialty Chemicals
U.S.

Luat D. Nguyen
U.S.

Erik M. First
U.S.

Dylan J. Thomas
U.S.

Ryan J. Frye
University of Michigan Central
Power Plant
U.S.

Ronald A. Moore
U.S.

Robert A. McConnachie
Siemens
U.S.

Bruce A. Debore
U.S.

Andrew Lowell
U.S.

Stephen M. Robertson
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Kevin C. Peavy
U.S.

Leah M. Carling
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Matthew J. Abrell
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Christopher J. Harvey
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Megan L. Johnson
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Aux Sable Liquid Products LP
U.S.

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Union Sanitary District
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Andrew Kolbenschlag
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Craig A.H. Johnson
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Scott A. Mumm
Flint Hills Resources
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Kyle M. Kaminski
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U.S.

Shervin Kermanshachi
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U.S.

Alexander J. Kuchta
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Andrew H. Abramson
U.S.

Ameer Ashik Mohamed Umar
Norway

Won T. Bernhardt
Linde
U.S.

Ali Fazian
Intech Process Automation Inc.
U.S.

Charles Sheets
Matrix Technologies
U.S.

Scott J. Sheridan
U.S.

Ahmed M. Altunisi
Saudi Aramco Oil Co.
Saudi Arabia

Jigneshkumar B. Parmar
Saudi Arabia

John D. Hasenstab
Quantum Solutions Inc.
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Wei Quan Lim
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Joseph L. Iuliucci
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Gettle Inc.
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Randall L. Franklin
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Carter R. Farley
Instrulogic
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Andy Malcolm
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Shehper Afroze Rana
Intech Process Automation
Pakistan

Trent J. Hebert
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Kunal C. Raithatha
Aecom
U.S.

ISA Certified Automation Professional (CAP) program

CAP question

"Slip" in an AC induction motor is defined as:

A. synchronous speed minus no load speed
B. difference between speed of stator field and rotor speed
C. rated speed plus synchronous speed
D. speed at which motor develops torque

CAP answer

The correct answer is *B*, "difference between speed of stator field and rotor speed." Slip is usually expressed as a percentage, and varies by motor, from nominally 0.5 percent for very large motors to about 5 percent for small, specialized motors. If n_s is the stator electrical speed and n_r is the rotor's mechanical speed, the slip, *S*, is defined by:

$$S = (n_s - n_r) / n_s$$

Motor rotation is developed in an AC induction motor through the effects of a moving magnetic field. As the speed of the rotor drops below the stator speed, or synchronous speed, the rotation rate of the magnetic field in the rotor increases, inducing more current in the rotor's windings and creating more torque.

Slip is required to produce torque. Under load, the rotor speed drops, and the slip increases enough to create sufficient additional torque to turn the load. A very efficient way to control slip is to use a variable frequency drive.

Certified Automation Professionals (CAPs) are responsible for the direction, design, and deployment of systems and equipment for manufacturing and control systems.

References:

Trevathan, Vernon L., *A Guide to the Automation Body of Knowledge, Second Edition,* ISA, 2006.

Dixon, P. (2016, September). "The velocity of PID." *Control Engineering.*

ISA Certified Control Systems Technician (CCST) program

CCST question

An analog multimeter is a very useful calibration device, but it will not determine which of the following parameters?

A. current
B. voltage
C. resistance
D. frequency

CCST answer

The correct answer is *D,* "frequency." An analog voltmeter works by passing a current through a coil that is suspended between two permanent magnets. By selecting the different functions with the selector switch (ohms, volts, amps), different resistors are placed into the circuit, and the quantity to be measured is determined from Ohm's Law.

Frequency cannot be measured with an analog meter multimeter, because the moving coil construction of the analog multimeter meter is suited only for determining quantities by application of Ohm's Law. A more specialized piece of equipment, such as an oscilloscope or digital multimeter is required to determine frequency in an electrical AC circuit.

Certified Control System Technicians (CCSTs) calibrate, document, troubleshoot, and repair/replace instrumentation for systems that measure and control level, temperature, pressure, flow, and other process variables.

Reference: Goettsche, L. D. (Editor), *Maintenance of Instruments and Systems, Second Edition,* ISA, 2005.

Control valve noise estimating made easy

By Hans D. Baumann, PhD, PE

Understanding and reducing noise from control valves is an important consideration for process facilities, especially those close to residential areas. After years of working with this issue, the author developed a simple, graphical method to estimate water noise.

The underlying algorithms were found based on fundamental laws of fluid mechanics and acoustics, which enable the calculation of the sound levels of turbulent or cavitating water, and thereby simplify the International Electrotechnical Commission (IEC) standard method, while at the same time improving accuracy. A simplified graphical method can be a handier alternative to a computerized method. Although this method, as exhibited, is valid only for water, it could be modified for other fluids as long as the specific gravity and sonic velocity are accounted for.

The results are three graphs (A, B, and C), which condense the equations of the underlying mathematics. The first graph, A, shows sound levels as a function of the given downstream pipe diameter either in inches or in millimeters and as a function of the relative flow capacity (Cv/D^2). (*D* is in inches, or 0.0016 x d^2 if *d* is given in mm). The graph also incorporates the pipe's transmission loss based on schedule 40 pipe (for schedule 80, see below.)

The next step is to consult graph B based on the absolute inlet pressure to the valve either in psia or bar absolute. Add the dB(A) numbers found to the numbers given in graph A and proceed to graph C.

Go to graph C. Before you can read the numbers, find the valve's pressure ratio, where X = (P1 – P2 / P1 – Pv), where *P1* is the absolute inlet pressure, *P2* the outlet pressure, and *Pv* the vapor pressure of water (0.4 psia or 0.03 bar absolute at 70°F). This graph incorporates both the turbulence (blue) as well as the cavitation (red) sound level components of water. First, consult your valve's catalog information to find the *Xfz* (incipient cavitation) factor for the chosen valve and valve travel. If unknown, check the table below for an approximate value. Take your pressure ratio factor *X* (see above) and multiply it by 10. Now go to the bottom of graph C. If *X* is smaller than *Xfz*, then go to the blue line and read the corresponding dB(A) values on the left. If *X* is larger than *Xfz*, go to the red lines (indicating you have cavitation) and read the dB(A) numbers corresponding to the red line based on your given *Xfz* number and intersecting with the 10X line.

Now add all dB(A) numbers from A, B, and C, and you will have the estimated sound level 1 meter from the pipe wall. This method is based on the mathematical equations shown in the resources and is considered accurate to within ±5 dB(A).

Here are some modifiers to note, if applicable:

If your pipe is schedule 80, add 4 dB. In case this is a rotary valve, add 3 dB to the total.

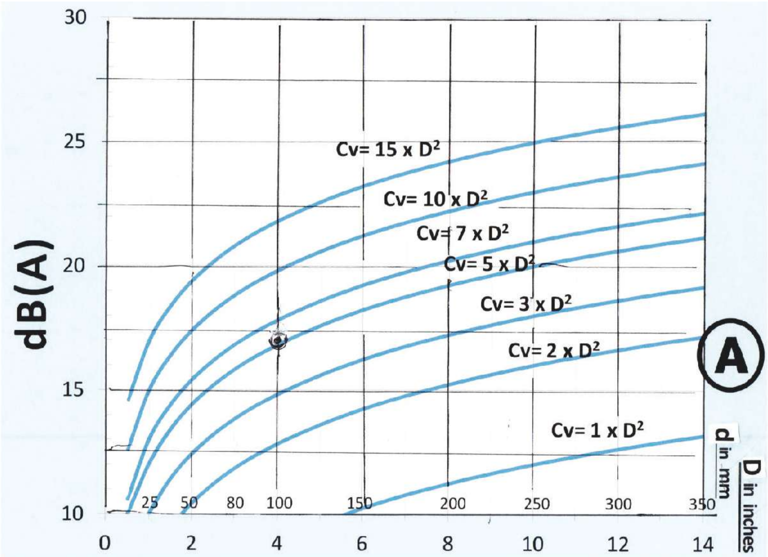
If your FL factor is different from 0.7, then add the following ΔFL numbers:

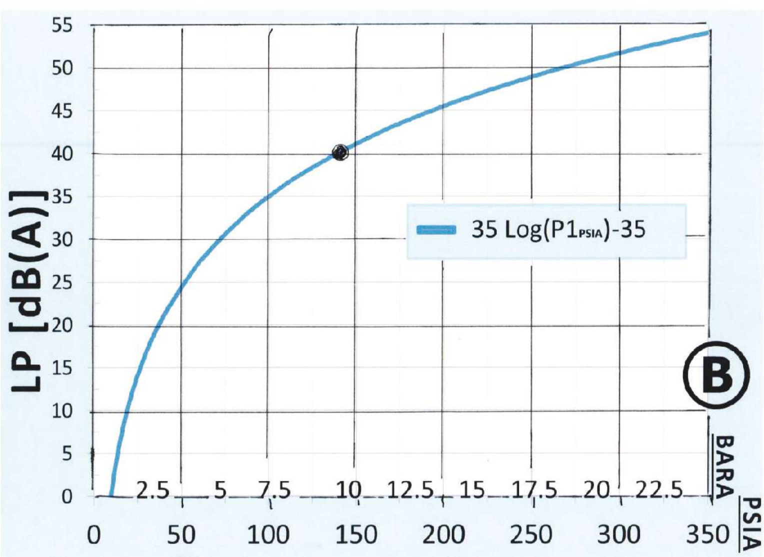
FL	0.5	0.6	0.7	0.8	0.9	1
ΔFL	–4.4	–2	0	1.7	3.3	4.6

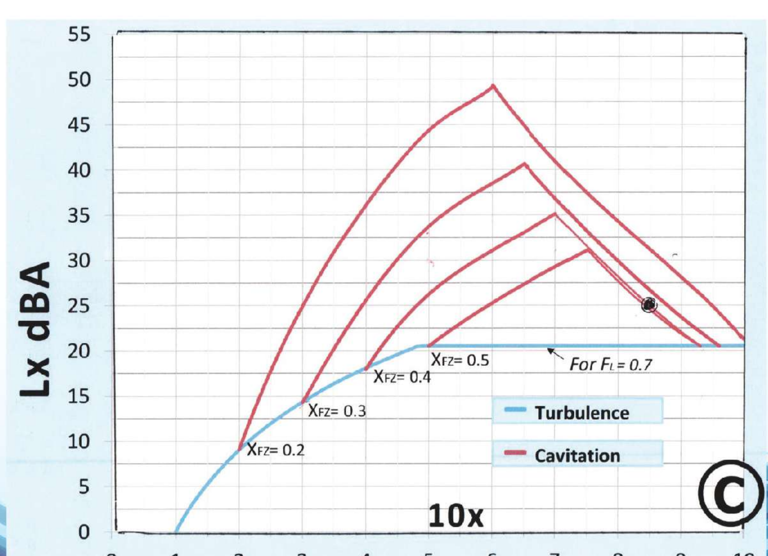
In cases where your fluid is something other than water, add the following factor N_L = 20log (1448/Ci_{fluid}) + 15log (Þ$_{fluid}$ / 998), where Ci_{fluid} = fluid speed of sound (ft/sec) and þ$_{fluid}$ = density of fluid (lbs/ft³).

Tabulation of Xfz factors

CV/D^2 (D in inches)	3	6	9	12	15	18	21	24	27	30
$Cv/d^2 \times 10^3$ (mm)	4.64	9.3	14	18.6	23.3	28	32.6	37.2	42	54
Globe valve, parb. plug	0.78	0.68	0.49	0.30						
Butterfly valve	0.45	0.30	0.23	0.21	0.20	0.19	0.18	0.17	0.16	0.15
Segment ball valve	0.46	0.30	0.22	0.20	0.18	0.17	0.15	0.13	0.12	0.19







Test data example:

A size 4-in (100-mm) globe valve,
P1 = 145 psia (10 bar), P2 = 22 psia (1.5 bar),
Cv = 93.5, FL = 0.9, rw = 0.25,
X = 0.85, and Xfz = 0.3

From the graphs:

A = 17 for 4 in = 100 mm (use 5.8 = Cv/D^2 or 5.8 = 695 Cv/d^2), d = mm
B = 40 for 145 psia, or 40 for 10 bar(a)
C = 25 intersection of X = 0.85 and Xfz of 0.3
Add 3.3 dB(A) for FL = 0.9 (see above)
Total estimated sound level per the graphs = 85.3 db(A).
Results of computer equations = 87.4 dB(A), stated test result was 86 dB(A). ■

ABOUT THE AUTHOR

Hans D. Baumann, PhD, PE (baumannh@comcast.net), a former vice president of Fisher Controls and Masoneilan Co., was founder of the Baumann Valve Co. He is credited with more than 100 U.S. patents and wrote eight books (among them the *Control Valve Primer*). His honors include being an honorary member of ISA, ASME, the Fluid Controls Institute, and the Spanish Chemical Engineering Society. He was named one of 50 most important innovators and is a member of Sigma Xi, besides being an inductee of the Automation Control Hall of Fame. For many years, he represented the U.S. at the IEC International Standards Committee on control valves.

RESOURCES

"The Elusive Strouhal Number"
www.valve-world.net/pdf/the-elusive-strouhal-number.pdf

IEC 60534-8-4, *Prediction of Noise from Hydraulic Fluids*
https://webstore.iec.ch/publication/23315

Control Valve Primer
https://www.isa.org/controlvalveprimer

The importance of network design

By Josh Glass

In this ever-evolving world of interconnected enterprises, it has never been more important to consider network design when developing new systems or retrofitting legacy systems into the larger enterprise network. Executives need data at their fingertips to make decisions at a moment's notice, but sometimes organizations do not consider what they should to ensure the security of the network delivering that data. The goal is to have centralized data while keeping the underlying systems separated in a way that enables defense in depth and avoids widespread attacks echoing through the entire enterprise.

In our experience, there are two typical approaches to accomplishing these tasks. The first is the simpler, hardware-focused method of isolating networks through physical separation. Companies separate disparate network traffic into separate physical wires. A benefit of this design is that replacing network equipment is very simple and straightforward. Several issues can arise, however, when the number of separate physical networks increases and there is a desire to have them functionally act as one single network. The separate network approach adds unnecessary complexity, as computers need connections to multiple networks to enable communication in modern plant landscapes. The physically separate networks can quickly become a large web of interconnected computers, which could let a virus run rampant if not designed properly, as seen in the previous year's attacks. Furthermore, if advanced features of domains are desired, such as a domain name system, most organizations have a hard time resolving all devices without statically assigning everything, which can be difficult to maintain.

In contrast to the physically separated approach is the use of virtual local area networks (VLANs). This approach consists of using the same physical "wire," but marking the traffic with different identifiers to keep the traffic routes separate. Each virtual LAN is defined at the data link layer of the OSI model. Due to the added complexity of switch configuration, a networking expert is required to configure the network based on design requirements.

Despite the increased cost of design and network expertise, in our experience there is a considerable cost savings when implementing a new network as opposed to the physically separate option. The slight increase in design cost is dwarfed by the decreased hardware cost.

The goal when doing a network implementation project for control networks is to ensure that the network has as few attack vectors as possible. The risk is weighed to determine how interconnected the control network will be with the enterprise, leading to a defined network architecture. Risk is also factored in when determining whether to go with a physical or virtual LAN (or potentially a hybrid, as we see on many projects). If the singular goal is total isolation of the control network, then physical separation is the clear choice. However, due to expanding enterprises and connected devices, complete control network isolation is becoming very difficult to maintain (although we have seen some companies manage large networks in this manner). We have executed several projects that involve nothing more than untangling disparate networks and implementing a comprehensive network strategy. In cases like these, the ability to create a VLAN to keep network traffic separate becomes cost effective and can be designed in a way that mitigates attack risk.

In our experience, we have seen all these strategies employed to create control networks. It typically boils down to the risk that an organization is willing to accept coupled with past experiences and desired end states. The best advice is to evaluate the risks versus the costs of different network solutions and choose a design philosophy that meets security requirements without hamstringing your team. For example, to design a new pharmaceutical control system network from a greenfield state, it is beneficial to gather all operation technology (OT) and information technology (IT) personnel together to design the network as a team. That way both sides have their requirements met (or are at least cognizant of the reasons they cannot be met) and have a stake in the final design.

Executives need data at their fingertips to make decisions at a moment's notice, but sometimes organizations do not consider what they should to ensure the security of the network delivering that data.

When planning for a project, we usually suggest that the network be physically separated from the enterprise network and have at least a demilitarized zone (DMZ) separating the two networks from each other. There would be two firewalls on either side of the DMZ to control traffic and create a deny-all rule by default, only allowing what is absolutely necessary to pass through networks. Typically, we design it such that the network traffic only flows up from the control network to the DMZ, and if necessary to the enterprise. There are several ways to approach a networking project but having a plan and buy-in from both sides is the best way to begin. ■

ABOUT THE AUTHOR

Josh Glass (Glassj@panaceatech.com) is a network automation engineer for Panacea Technologies, Inc. He is passionate about designing, implementing, and supporting secure network-focused automation projects for the regulated industries. Panacea Technologies, Inc., (http://panaceatech.com) is a member of the Control System Integrators Association (www.controlsys.org).

ISA84 approves IEC 61511, moves ahead on key supporting guidelines

ISA84, Instrumented Systems to Achieve Functional Safety in the Process Industries, has approved the newest edition of IEC 61511 as ISA and American National Standards Institute (ANSI) standards. The new standards will be designated in the U.S. as ANSI/ISA-61511, *Functional Safety – Safety Instrumented Systems for the Process Industry Sector,* Parts 1–3. The standards set forth requirements for the specification, design, installation, operation, and maintenance of a safety instrumented system (SIS) so that it can be entrusted to achieve or maintain a safe state of a process.

ISA84 developed the original ISA-84.01 standard on which the first edition of IEC 61511 was based. This new edition of IEC 61511, developed under IEC SC65A/MT 61511, was approved by ISA84 without modification—but not without concerns from several ISA84 members about the guidance and interpretation of IEC 61511-2, Part 2: *Guidelines for the Application of IEC 61511-1.* For that reason, ISA84 prepared a special foreword to ANSI/ISA-61511-2 that refers users to several ISA84 technical reports for guidance on the same topics. Those technical reports include:

- ISA-TR84.00.09-2017, *Cybersecurity Related to the Functional Safety Lifecycle,* provides guidance on integrating the cybersecurity life cycle with the safety life cycle as they relate to safety controls, alarms, and interlocks, inclusive of safety instrumented systems. The scope includes the work processes and countermeasures used to reduce the risk involved due to cybersecurity threats to the industrial automation and control system network.
- ISA-TR84.00.08-2017, *Guidance for Application of Wireless Sensor Technology to Non-SIS Independent Protection Layers,* addresses wireless technology-based sensors that are used in independent protection layers (IPL) providing a risk reduction factor of less than or equal to 10 (non-SIS IPL) by the authority having jurisdiction (typically the owner/operator or local regulatory authority), and establishes guidance and considerations for their utilization in the process sector.
- ISA-TR84.00.07-2018, *Guidance on the Evaluation of Fire, Combustible Gas and Toxic Gas System Effectiveness,* is expected to be published in September 2018. It addresses detection and mitigation of fire, combustible gas, and toxic gas hazards in process areas. It clarifies information to be considered when developing a performance-based FGS design—including integrating the design activities into relevant portions of the safety life cycle model for safety-critical controls.
- ISA-TR84.00.05-2009, *Guidance on the Identification of Safety Instrumented Functions (SIF) in Burner Management Systems (BMS),* is currently being updated by ISA84. It is intended to identify any SIFs within typical burner management systems for common operating modes of fired equipment (such as pre-firing, light-off, shutdown, and normal operation) and to provide examples of typical safety assessments for boilers (single burner), fired process heaters (multi-burner), thermal oxidizers, oil heater treaters, and glycol reboilers.

Three additional technical reports currently in development by ISA84 will provide guidance related to specific phases of the SIS life cycle:

- ISA-TR84.00.02, *Safety Integrity Level (SIL) Verification of Safety Instrumented Functions,* will support the calculation of the average probability of failure on demand as required by ANSI/ISA-61511-1, providing guidance on (a) assessing random and systematic failures, failure modes, and failure rates; (b) understanding the impact of diagnostics and automation asset integrity activities on the SIL and reliability; (c) identifying sources of common cause, common mode, and systematic failures; and (d) using quantitative methodologies to verify the SIL and spurious trip rate.
- ISA-TR84.00.03, *Automation Asset Integrity (AAI) of Safety Instrumented Systems (SIS),* will provide guidance on establishing an effective AAI program that demonstrates through traceable and auditable documentation that the SIS and its equipment are maintained in the "as good as new" condition.
- ISA-TR84.00.04, *Guidelines for the Implementation of ANSI/ISA-61511,* will provide an overview of the SIS life cycle with references to annexes containing more detailed guidance on various subjects. It will also provide an end-user example of "how to" implement ANSI/ISA-61511.

Also of note

ISA84 and IEC will seek closer, more direct collaboration on future editions of IEC 61511 through establishment of an official liaison between ISA84 and IEC SC65A/MT 61511.

The next meeting of ISA will be 5–7 November 2018 at Wood (formerly Wood Group Mustang) in Houston. This will follow ISA's 2018 Process Control and Safety Symposium and Exhibition (PCS), also in Houston, on 30 October – 1 November (www.isa.org/pcs2018). Experts from any country are welcome to join the ISA84 committee by contacting standards@isa.org.

To view or obtain the published technical reports described above, visit www.isa.org/findstandards. ■

Magnetostrictive measuring system

The BTL7-T500 has a range of applications and operates safely in explosion hazardous areas of Zone 0 and Zone 1. This means, for example, it can also be used for continuous level measurement in refinery tanks.

It has a Profibus interface for flexibility, and the position measuring system can be adapted. A single cable suffices for hookup (bus-in-out, power). The noncontact magnetostrictive measuring system in the stainless-steel housing with IP67 protection is insensitive to contamination, and also shock rated to 100 g. It withstands vibration up to 12 g.

BTL linear magnetostrictive transducers in the rod style, installed in hydraulic cylinders, have for decades operated reliably in demanding application areas. The magnetostrictive operating principle allows it to be installed in hermetically sealed housings; the position information is transmitted without contact via magnetic fields through the housing wall into the interior of the sensor.

Balluff
www.balluff.com

Heartbeat Technology for transmitters

The Heartbeat Technology with Liquiline CM44 and CM44R transmitters is for use with Memosens pH and conductivity sensors. Heartbeat diagnostics' continuous analysis of transmitter/sensor system health during operation helps companies recognize related events when they occur. The diagnostics follow the NE-107-standardized, NAMUR-compliant message structure for categorized event severity levels with remedy instructions provided for operations or maintenance.

Monitoring minimizes the probability of a sudden breakdown or failure of the measurement point and helps define when maintenance is needed. For example, detecting increased glass impedance in the pH sensor may indicate broken glass. In a conductivity sensor, if the coil current is out of range, there may be a short circuit or broken wire in the sensor.

Heartbeat Verification permits a measurement point to be assessed at any time *in situ,* without removing the sensor or shutting down the process. This qualitative function checks the entire measurement loop, verifying sensor and transmitter performance. Verification results are provided via an audit safe report that the transmitter automatically generates. The report is saved in PDF format and can be preserved on an SD card for transfer to a computer. These reports can be used for regulatory, quality or safety documentation.

When the Liquiline transmitter is connected to a PLC, SCADA, or distributed control system via fieldbus digital communications, Heartbeat Technology gives the host system a range of sensor information that can be combined with process data to identify trends. This information, along with key performance indicators, can be used for process optimization and predictive maintenance. The monitoring information is available over Profibus DP, EtherNet/IP, Modbus TCP, or Modbus 485 protocols.

The monitoring technology is now available as an option in Liquiline CM442, CM444, and CM448 transmitters and all DIN-rail mount versions. It works with Memosens pH and conductivity sensors and Liquistation CSF34 and CSF48 samplers. In the future, it will be available in oxygen, turbidity, nitrate, chlorine sensors, and Liquiline System CA80 analyzers.

Endress+Hauser
https://www.us.endress.com/en

Wired HART vibrating-fork level detector

The Rosemount 2140 is a wired HART vibrating-fork level detector. With smart diagnostics and remote proof-testing capability, the device detects level while helping increase safety and efficiency of both plant and workers. The detector is suitable for applications with high temperatures and harsh conditions and operates with flow, bubbles, turbulence, foam, vibration, sediments content, coating, liquid properties and product variations. It can be used to monitor not only liquids but also liquid-to-sand interface, which enables the buildup of sand or sludge deposits in a tank to be detected.

Compatible with the HART 5 and HART 7 hosts, the detector enables operators to continuously monitor electronic and mechanical health. Frequency profiling functionality immediately detects any buildup, fork blockage, or excessive corrosion, indicating maintenance may be required and allowing it to be scheduled during periods of downtime. In addition, power advisory functionality monitors voltage and current drawn over the device's lifetime with a process alert for potential problems, such as corrosion.

An optional integral LCD display shows switch output states and diagnostics, so an operator can inspect the device locally. Also, selectable media density and media learn functions help configure appropriate density settings to calculate and maintain consistent switching points in fluids of unknown properties, so the device always switches.

Emerson Rosemount
www.emerson.com

Rotary paddle bin level indicator

The SE3 series rotary paddle bin level indicator is for point-level switch applications of bulk solids, including powder and granular materials. This rotary paddle unit has a powder-coated aluminum enclosure rated IP65 and NEMA 4X and available local LED indication. The SE3 compact rotary paddle unit is available in a variety of configurations, including standard, high temperature, and reinforced shaft extended versions to handle applications in many industries.

All units are available with a choice of power supplies, including 110 VAC, 220 VAC, 240 VAC, 24 VAC, and 24 VDC. Paddle options include polycarbonate and stainless-steel paddles. All units include a prewired electrical cable. Standard length is 11.8 in (300 mm), and it can be provided in lengths up to 16.4 ft (5 m). The SE3 compact rotary paddle bin level indicator is suitable for small hoppers and bins.

Aplus Finetek

http://aplusfine.com

Level switches

The LBFH and LBFI level switches with IO-Link and ATEX approval have IO-Link interface, so the user can automate the configuration of sensors. ATEX also enables the use of commercially available barriers. The sensors are suitable for hygienic and industrial applications.

Because of the IO-Link integration, the level switches are Industry 4.0 ready. With the communication interface, each application can be configured using standard network components. This ensures duplication of the system and device replacement without additional programming. Diagnostic data can be called up and evaluated at any time.

The LBFH and LBFI level switches meet the criteria for ATEX categories 1 and 2 for gas and dust. The reduced current consumption of their electronics means that standard barriers can now be used in addition to the company's barriers, helping them integrate into existing plants.

Two switching outputs make it possible to set independent trigger thresholds. This means two different process steps, such as production and cleaning, or two media groups, such as water and oil, can be monitored with one sensor. Additionally, the two switching outputs facilitate a plausibility check of the sensor. A complementary trigger point setting ensures wire breaks are reliably detected, thus guaranteeing effective monitoring of all programs.

Both variants are suitable for use in temperatures up to 135°C, while the variant for hygiene applications also has SIP capabilities.

Baumer

www.baumer.com/us/en

Level transmitters

LMT transmitter on KM26 magnetic level guage

LMT transmitter with 2-float magnetostrictive level sensor

The K-TEK LMT series of magnetostrictive level transmitters increases the ease of use, safety, and reliability of the AT series of transmitters. The LMT has a two-wire common transmitter, an integrated setup menu, advanced diagnostics with waveform display, and signal conditioning.

The LMT is available as an insertion style "wetted" transmitter (LMT100) with probe lengths up to 22.86 m (75 ft) in length, or as an externally mounted, nonintrusive version (LMT200) for use with the KM26 magnetic level gauge or any other float and level chamber.

The LMT200 externally mounted transmitters provide users with installation flexibility and modification. They can be changed from top to bottom mount or from left of chamber orientation to right with no modification of equipment required. The first phase of the LMT series comes with 4–20 mA HART output. Later phases will be available with FOUNDATION Fieldbus and Profibus PA.

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datafile

Datafiles list useful literature on products and services that are available from manufacturers in the instrumentation and process-control industry. To receive free copies of this literature, please contact each manufacturer via their provided contact information.

USB HART MODEM

The HM-USB-ISO USB HART modem meets industry standards for USB and HART connectivity. The small size, light weight, and durability of the HM-USB-ISO make it ideal for portable use. Operating power is derived from the USB connection. An easily installed Virtual Serial Port driver allows use in any Windows-based application.

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Sample of Jobs Available at Jobs.isa.org

See more at Jobs.isa.org, where you can search for available jobs or advertise positions available within your company. ISA Members post resumes at no charge.

Process automation engineer

Lotusworks: The engineer in McPherson, Kan., will support process control systems in a manufacturing environment with an emphasis on quickly implementing programming solutions to resolve operational problems. The engineer will analyze process data, integrate business systems with line control to automate machine operation, and establish structured reports. The position requires a BS in electrical, computer, mechatronic, robotics, or electromechanical engineering and at least three years of manufacturing experience . . . see more at Jobs.isa.org.

Product cybersecurity specialist

Karl Storz Endoscopy: The specialist in El Segundo, Calif., will be responsible for responding to all customer requests for security-related documentation and providing recommendations to improve the company's processes and products. The specialist will assume a lead role for all technical and cybersecurity questionnaires and will effectively build relationships with various internal departments. Qualifications include a BS, a minimum of three-to-five years of cybersecurity experience, technical competency in product systems security, and knowledge of security issues and vulnerability trends. Experience in healthcare IT, risk management, or data privacy is a plus . . . see more at Jobs.isa.org.

Automation engineer

GHD: The company is looking for automation engineers to be based out of either its Buffalo, N.Y., or Baton Rouge, La., offices to design, develop, and execute automation engineering activities in industrial facility projects. The engineer will be accountable for the successful development and execution of automation projects. Responsibilities also include electrical design, communicating with external and internal stakeholders, and developing drawing packages and detailed technical documentation with specifications. The successful candidates will have a BS in electrical engineering or a related engineering discipline and a minimum of five-to-10 years of experience with industrial automation projects with a preferred five years of chemical or oil and gas experience. A PE license is a plus . . . see more at Jobs.isa.org.

Director of sales

Wuzhong Instrument Co.: The director, based in Ladera Ranch, Calif., will bring valve products to the North American market and be responsible for the annual sales target. Ten or more years of marketing/sales experience of ball, butterfly, and control valves in the industrial market is required . . . see more at Jobs.isa.org.

Junior electrical engineer

Integration Innovation, Inc.: The company seeks a junior electrical engineer to support the Naval Research Laboratory (NRL), Tactical Electronic Warfare Division, in Washington, D.C. The engineer will support NRL through development and maintenance of the electronic warfare simulations and components of the simulations. The engineer will design, construct, and verify simulator control panels and software simulations. Requirements include a BS in electrical or aerospace engineering, two years of experience (or a master's degree), and proficiency in C/C++, Python, PHP, Linux, and RTOS. A current top security clearance with tier 5 background investigation is required . . . see more at Jobs.isa.org.

The next big controversy: Who owns the data?

By Michael Kanellos

ABOUT THE AUTHOR
Michael Kanellos (mkanellos@osisoft.com) is a technology analyst and manages communications for OSIsoft, where he tracks how technology trends will impact business. He has written for more than 20 years for CNET, Greentech Media, *Forbes*, *Wired*, and other publications. He has also worked as an attorney, a census bureau enumerator, and a busboy in a pancake house.

A year ago an acquaintance was excitedly telling me about his company's new business plan at a mixer at the IoT World Conference. The company—a worldwide contract manufacturer—was going to become a data broker. The company would retain rights to the data generated by equipment it produced. It would then use this data to analyze and improve products or anonymize it and sell it to third parties. Right about then, another acquaintance from a brand-name manufacturer sidled up. "Like hell you will," the brand-name manufacturer bellowed. "You work for me. It's my data."

Expect to hear some variant of this conversation every few days for the next several years. Silicon Valley is currently bonkers about data brokerages, and for good reason. The company that coins the magically delicious way to harness data will achieve vast wealth and fame. Data is also a low capital business. OK, Uber is still losing money on every ride, but in industry there are already sterling results. Companies like Syncrude and Duke Energy have saved millions through service. Caterpillar has launched CAT Connect, a value-added service. Aurelia Metals achieved payback on analytics in 12 days by boosting gold production by 1 percent or about $750,000.

Unfortunately, the one thing many tech execs were counting on—that no one else would figure out the value of data before they locked it up—is clearly not going to happen. Manufacturers, end users, and others already know their information is valuable, and they are not going to relinquish it freely. No more IBM giving Microsoft free rights to resell DOS, or Intel getting the blueprints to the microprocessor back as an afterthought.

"Why should we be paying for the data? Why shouldn't OEMs [original equipment manufacturers] pay us, the operators, for the data?" said Gavin Hall of Petronas, the Malaysian oil company at a recent event. Petronas was showing off PROTEAN, a homegrown analytics tool. "Perhaps we need to change the business model."

Lockheed Martin's Don Kinard at this year's IoT World agreed. Lockheed might own the information and data regarding the shape of a wing, but the government typically owns the engine performance data. "They own it, mostly. They paid for it," he said. In some countries, sensitive data ownership will be mandated by law.

So does that mean digital transformation is dead? No, what it means is that the business model for sharing and using data will likely be different from what we have seen in the past. "Industry clouds" are an example of how the data industry might evolve. In industry clouds, companies share their (anonymized) data with an independent third party. Because they have access to data from multiple vendors, the third party can more quickly fine-tune its algorithms and achieve relevant results quicker.

The catch? Often, these industry clouds are owned by manufacturers and others generating the data. Clarient, a company that helps seek out financial fraud, was formed and is owned by six major banks. Sage Insights, incubated by John Deere, provides data services to farmers. Likewise, you will see large companies like IBM buy companies with large data stores to help animate their algorithms: Big Blue's Weather Channel purchase derived as part of its push into agriculture.

You will also likely see concepts come from real estate law. One of the first things you learn in real estate law is that ownership is rarely exclusive. Cities and counties own easements for water and sewer lines over a property. Leases often deliver more rights than a contract. A piece of property is a bundle of rights rather than a plot of dirt.

In the same way, manufacturers will provide access to their data in exchange for services, or for proportional interests in second-generation data produced through analyzing their original core information. Utilities will provide raw information to service providers for free but might be able to charge advisory services based on insights from that information for a fee. Consumer data is owned by consumers, says Bruce Edelston at Southern Company, but utilities get access to some of it, so they can perform their operations, while third parties will need consent. Metadata will be segmented from raw data and machine data from design.

The rule book will be massive, but in the end, it will make both OEMs and their customers happy. ■

Manufacturers, end users, and others already know their information is valuable, and they are not going to relinquish it freely.


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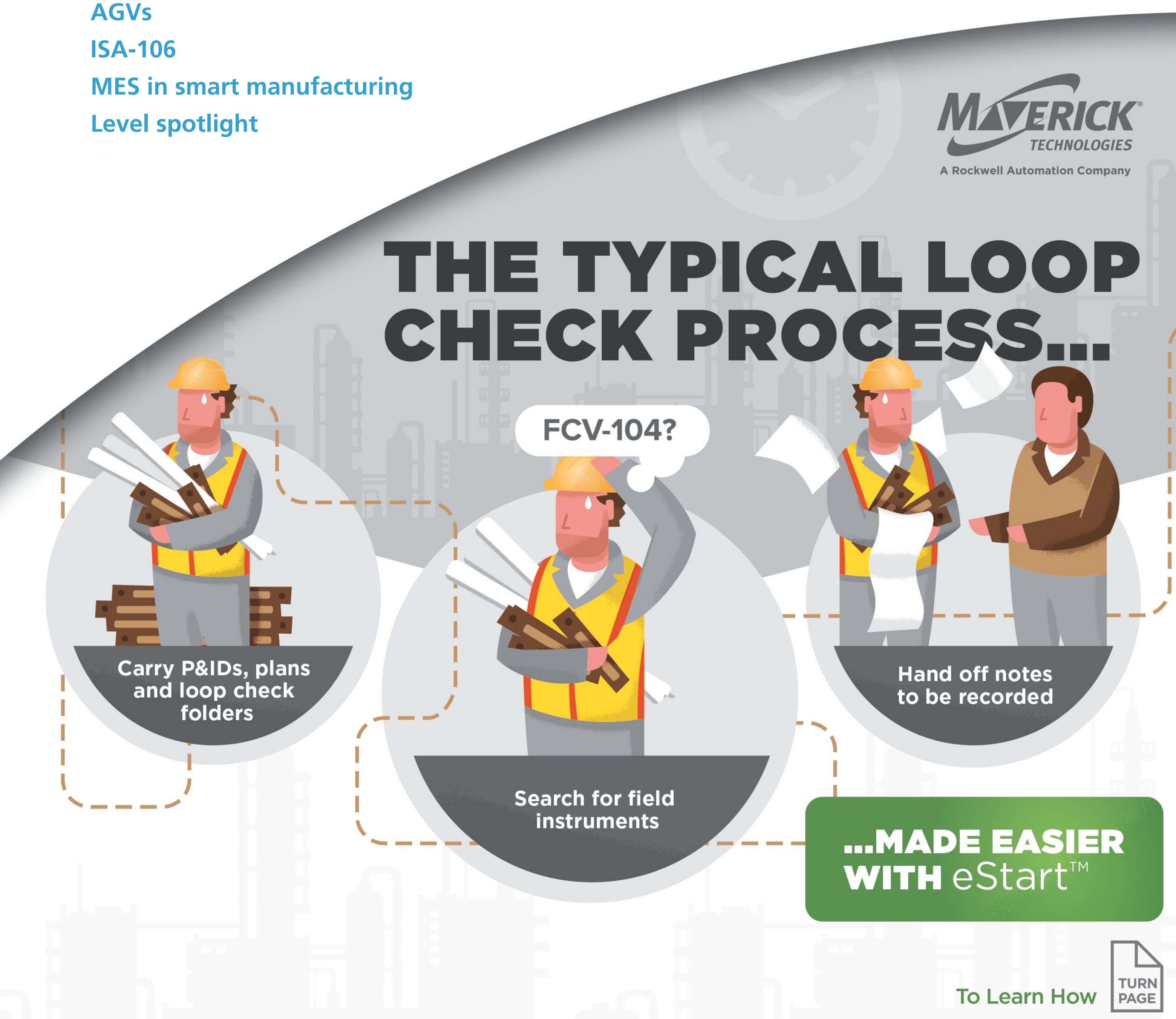

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