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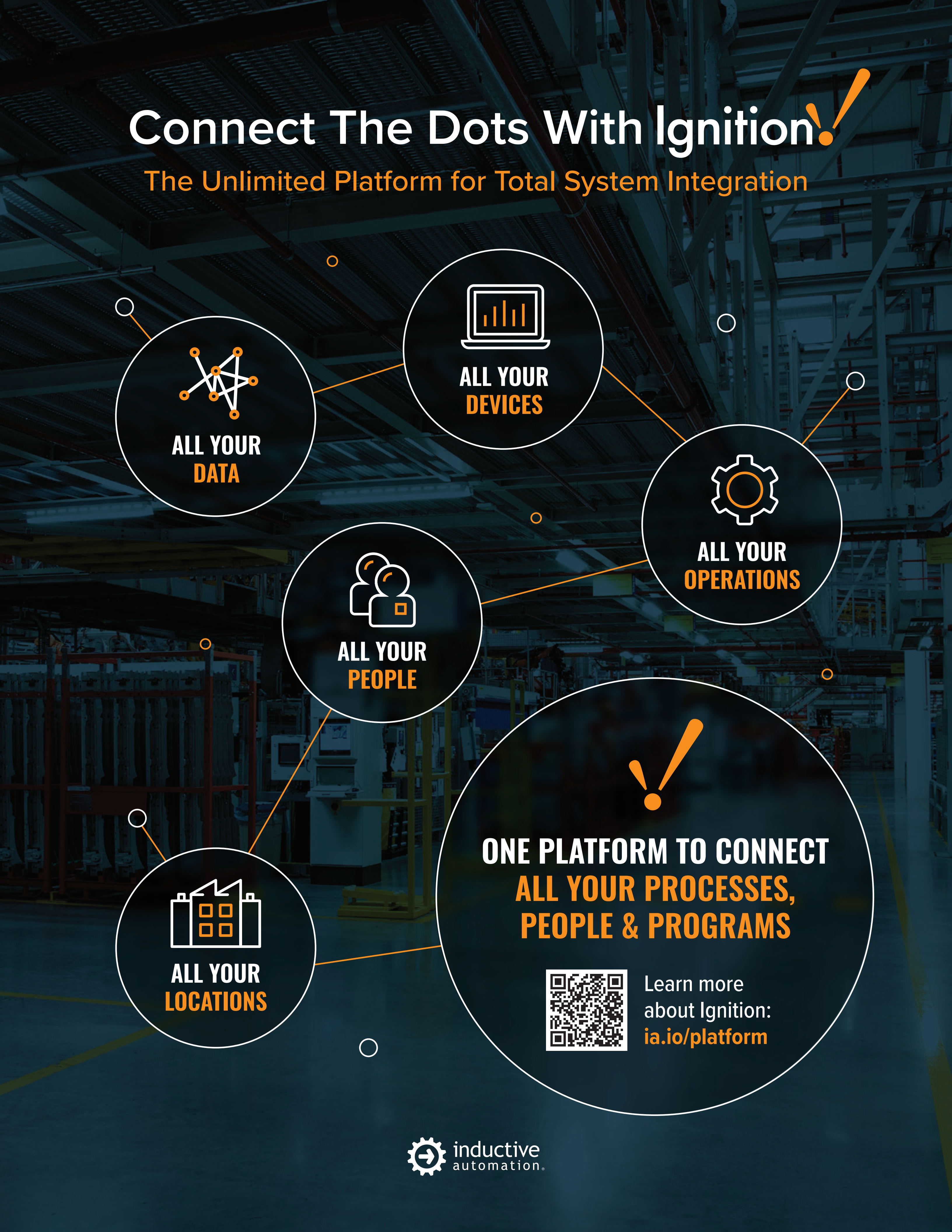
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FEATURES

DEPARTMENTS

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Navigating Industrial Workforce Transitions

By Renee Bassett, *InTech* Chief Editor

The Silver Tsunami. The Gray- to-Green Transition. The Great Retirement. No matter what you call it, most experts agree the global workforce is in the midst of an evolution. Across industries and geographies, Baby Boomers are retiring—or changing jobs while choosing to work longer—and forcing companies to adapt. Perhaps nowhere is that truer than within the manufacturing, industrial and engineering sectors.

Today a large chunk of the workforce is occupied by Baby Boomers (19%), Generation X (35.5%), and Millennials (39.4%). With over 10,000 Baby Boomers per day reaching the age of 65, the youngest workers— Generation Z—will constitute about 30% of the workforce by 2030.

According to the U.S. Bureau of Labor Statistics, People born from 1957 to 1964, the latter years of the baby boom, held an average of 12.4 jobs from ages 18 to 54. Nearly half of these jobs were held from ages 18 to 24. As a generation growing up without the internet and used to working with their hands, boomers thrive in the installation, transportation, and engineering industries. They are also more likely than any other generation to have attended college, and nearly two-thirds have a degree.

Younger workers, on the other hand, "grew up in a world where the internet made goods and services readily available—often instantly or with same-day delivery—and allowed them to conduct much of their social lives online," says McKinsey. These workers—the "green" contingent—tend to have a different conception of the employee–employer relationship than do older employees in the "gray" group.

Previous ways of working and interacting between employers and employees are being disrupted by Gen Z's entry into the workforce because of different expectations regarding atmosphere, culture, and support at work, according an article from Johns Hopkins University. McKinsey's global research shows that six factors are particularly important to younger industrial workers:

- an easy application process with clear communication and a quick time to hire
- rapid career progression and clear performance feedback
- the ability to work in a hybrid workplace (at least in nonmanufacturing roles), with face-to-face interactions primarily reserved for situations where they clearly add value
- the option to explore multiple employers or even multiple careers
- a strong focus on diversity, inclusion, and sustainability, including a workplace that allows for self-expression and sanctions noninclusive behavior.

It may also help to remember that this evolution of the workforce is nothing new. In 1955, the US Congress held hearings on "Automation and Technological Change" and its associated impact on jobs. Chief among its findings was that the US was "faced with a threatened shortage of scientists, technicians, and skilled labor." The more things change....

Reliability Through the Lens of Sustainability

By Peter Chin

It is well known throughout industry that a high degree of reliability is required for process plants to achieve maximum availability and reduce unplanned events. However, not everyone may initially connect improved reliability to enhanced sustainability.

Poor reliability and excessive downtime negatively impact sustainability in myriad ways. Devices, such as relief or isolation valves, that do not operate as required can result in emissions to the atmosphere that directly degrade sustainability. These emissions may result in product losses and other waste that also affect sustainability.

Other device failures may result in downtime, which also negatively impacts sustainability. For batch processes, entire production runs can be lost; energy and other resources must be expended to replace the batch and to dispose of waste. This is particularly problematic for batches with long processing times and very high value, as is often the case in the life sciences industry.

Poor reliability also affects continuous processes—resulting in lost production, wasted energy, and excess use of raw materials—as well as the need to reprocess resources to upgrade or replace product.

In both cases, even more energy is required for restarts, as both batch and continuous processes are designed to run at maximum efficiency when there are no interruptions. Some of these failures may result in the need to perform maintenance on equipment or production units, expending more energy and resources, and increasing a plant's carbon footprint.

Fortunately, there are ways to address these and other related issues. Most fundamentally, one can make product reliability a key consideration when selecting measurement and final control devices in every part of the production system. This is especially important for valves, as these are routinely exposed to process media and the elements, and often contain multiple moving parts.

As new plants are designed or existing facilities upgraded, it is crucial to consider using devices that will improve reliability, such as smart instruments and valves. Technological advances in valve automation and monitoring can provide the information needed to facilitate predictive or preventative maintenance. When applied to critical processes and key equipment, these types of advances can reduce unplanned downtime.

Adding or upgrading field devices has typically required additional wiring from each device to the automation system, which is often quite costly and time consuming, and may require downtime. These issues can be addressed in two ways.

Many field devices are now available in wireless versions, eliminating the need for field wiring. When wiring is required, it can often be connected to flexible I/O mounted in the field, so home run wiring to the automation system in the control room is not needed.

Finally, all field devices should be maintained correctly to ensure maximum uptime. Many process plants operate with reduced staff, so field device maintenance may require engagement with a service provider, typically a vendor, preferably available 24/7/365 worldwide. Ideally, this vendor will provide advice to plant personnel, with onsite assistance available as required. New advancements in virtual reality can link service provider experts with process plant personnel, which is particularly useful where access to certain locations may be challenging at short notice. Some vendors can monitor field devices remotely with a team of experts, adding further value.

Devices that do not operate as required can result in emissions to the atmosphere that directly degrade sustainability.

These solutions will become ubiquitous as more field devices are digitized, and as newer models of existing digital field devices become more intelligent. These devices will take advantage of more powerful networking technologies, both wired and wireless, for both on-premises and cloud-based connections. This improved connectivity will result in lower storage costs for data, along with easier and more secure remote access. These advances will increase reliability and uptime, and in turn deliver sustainability improvements.

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What Control Engineers Should Know About Industry 4.0

A steel industry example shows how the two disciplines intersect.

By Charlotta Johnsson, Margret Bauer, and Kristian Soltesz

Control engineering is a well-established discipline with a long and prominent history[1]. It is diverse in its applications but has a strong unifying core to it: the notion of dynamic systems and control theory. Many engineers will have encountered it as part of their education, as control engineering courses are taught to electrical, mechanical, chemical, aerospace, and industrial engineers. Quite often, though, this is the only time that engineers consciously encounter the subject of control systems.

While control engineering is rooted in mathematical theory and tools, Industry 4.0 relies on a variety of technologies. Industry 4.0 is a new and still-evolving paradigm in which digitalization is expected to revolutionize industry and core technologies are still emerging. The term was coined in 2011 by a German government taskforce and has been adopted by the World Economic Forum (WEF)[2]. Its concepts are known to engineers, corporate managers and policy makers, but it can be difficult to grasp and define.

In this article we address the intersection of control engineering and Industry 4.0 by examining the underlying methods and technologies as well as one vertical industry—steelmaking—so readers can discover how control engineering is helping to drive the development of this new production era of Industry 4.0.

History and definitions

Industry 4.0, the fourth industrial revolution, is now roughly 10 years old and there is increasing agreement and clearer definitions of what it comprises. The first three industrial revolutions had concrete drivers: mechanization, electrification, and the advent of computers. Industry 4.0 has no single technology association; several technological advances and design principles drive it. Its underlying principle is digitalization.

Originally, there were nine pillars or technologies on which the vision of Industry 4.0 relied. These technologies have been adapted somewhat but the originals introduced in 2011 include: simulation; cyber-physical systems (a computer system in which a mechanism is controlled or monitored by computer-based algorithm); robotics; and artificial intelligence (AI), big data and data analytics.

So why is control not listed as one of the important technologies of Industry 4.0? One answer is that control engineering itself could have been singled out as a technological driver because control is one aspect of most—if not all—pillars. Another reason is that control engineering and Industry 4.0 terms overlap but address different functions in different applications.

As shown in Figure 1, control engineering relies on several—mostly mathematical—tools and techniques such as system analysis, state estimation, and modeling and simulation to perform different types of control including optimal, adaptive, linear, non-linear and intelligent. Similarly, Industry 4.0 uses its core technologies

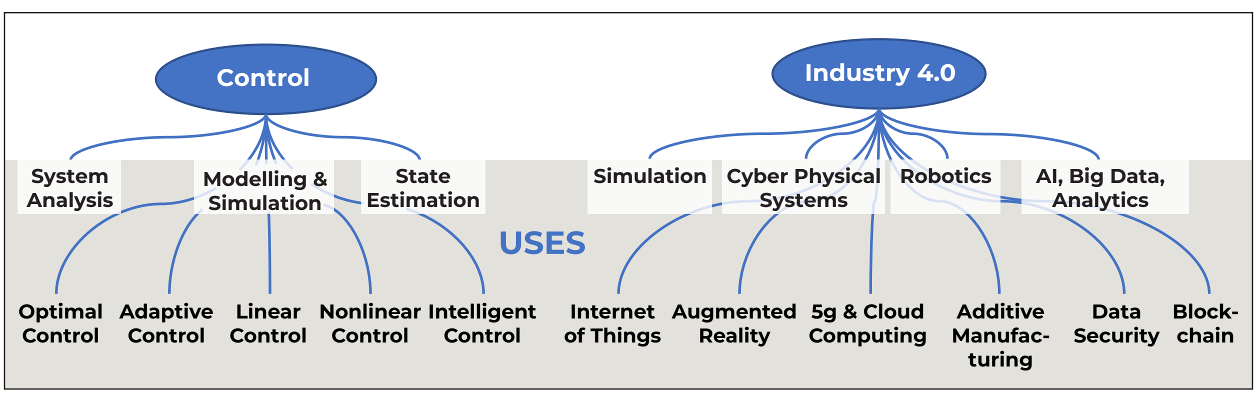


Figure 1. Control engineering uses technologies or techniques like systems analysis, modeling/simulation and state estimation to perform or enable various types of control. Similarly, Industry 4.0 uses its core technologies and techniques to enable new technologies that can be applied to manufacturing and industrial processes as well as to consumer products, financial services and more.

and techniques to enable new technologies that can be applied to manufacturing and industrial processes as well as consumer products, financial services and more.

With simulation used by both control engineering and Industry 4.0, and one could easily jump to the conclusion that this is the most obvious intersection of the two areas.

Control Engineering: Key Points for Industry 4.0 Practitioners

At the core of control engineering lies the task of making a physical quantity follow a desired trajectory over time. Many separate aspects of control engineering are required to make this happen: modeling, analyzing and simulating the system, selecting sensors to measure or estimate variables, finding an actuator, and designing a controller.

The time-varying behavior of a process, modeled by a dynamic system, can be found in many aspects of engineering and beyond, thus making control engineering a truly multidisciplinary subject. Other aspects of control engineering include implementation and assessment of the performance of a control system. Control engineering is sometimes referred to as control systems, feedback control, or automatic control. For brevity, in this article we also refer to control engineering as simply "control."

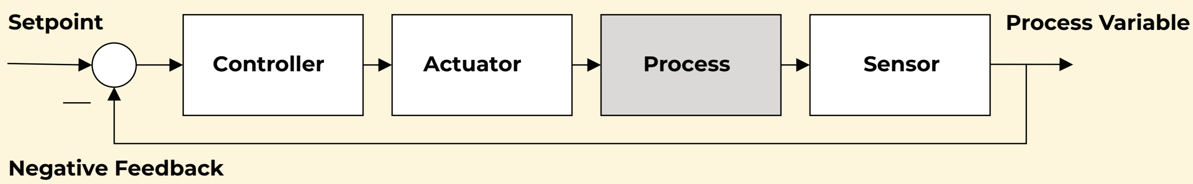
Three important building blocks make up a control system: the sensor, the actuator, and the controller itself. These blocks are arranged in a feedback loop, comparing the process variable to a desired setpoint. In its most trivial form, a human can act as all three building blocks: Eyes and ears are sensors, manual interventions by hand are the actuator, and the brain is the controller. In the most complex form, the three building blocks are substituted with automatic actions, electronic sensing, and optimized software.

Control engineering is a hidden technology; it can be found almost everywhere, often without anyone (except the control engineers) knowing about it. Without control, many technical applications would not work, implying that control engineering is of great importance in our lives.

While functioning control systems can operate under the radar, control systems that fail are very visible: airplane crashes, nuclear power plant meltdowns, and autonomous vehicles going astray are some examples of failed control systems.

Control engineering is always a means to an end, such as keeping the temperature in a reactor constant to produce a new product. No one does control engineering because they want a control system; there is always a purpose.

BUILDING BLOCKS OF A CONTROL SYSTEM



The important building blocks in a control system are sensor, actuator, and controller. They are arranged in a feedback loop, comparing the process variable to a desired setpoint.

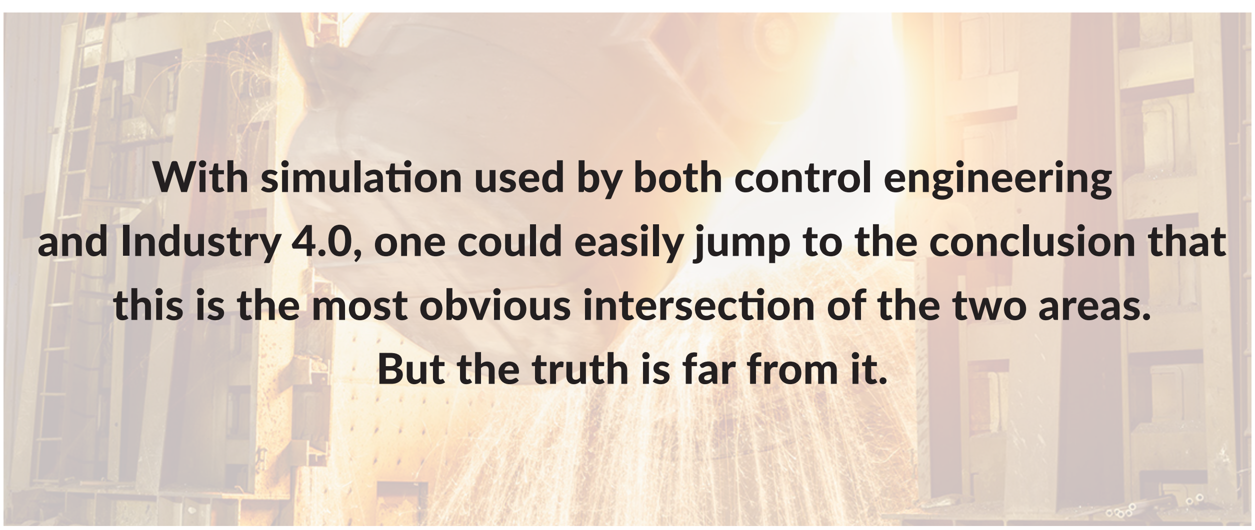
But the truth is more complex. The different mathematical models that underlie a simulation need to be distinguished. Are they dynamic models relating to the driving of a vehicle? Are they modelling the body of a car? The first concerns control engineering, the second does not.

The narrow aspect of individual control strategies separates them from the broad application of new Industry 4.0-related technologies like Internet of Things, augmented reality, 5G/cloud computing and the rest. In fact, unlike control engineering, Industry 4.0 has gained so much traction that it has entered the consciousness of the general public. As the new technologies' spawn are applied to more than just industrial production, the term has grown beyond its original definition.

For example, a cell phone app that allows you to book an apartment in your city or autonomous robots delivering food or packages is not an example of the latest industrial revolution. But their developers are using the Industry 4.0 technologies to enable them. Simulation, robotics and AI/data analytics are being not just to produce smart phone or delivery robots, but they are being used within manufactured products.

On that point, Industry 4.0 is similar to control engineering. In the automobile industry, for example, Industry 4.0 technologies and concepts affect the actual manufacture and assembly of cars. But "control engineering" in the automotive industry often concerns the development of algorithms for speed control, shock absorption, and so on within the car—which is not necessarily related to the production of the vehicles.

It is impossible to list all the applications of control in every Industry 4.0 technology. The reason is not only the fuzzy nature of Industry 4.0 definitions, but also the complex structure of modern production technology and the different applications of control specific to different vertical industries. So here we will examine one metals industry example for which control engineering is crucial: steelmaking.



With simulation used by both control engineering and Industry 4.0, one could easily jump to the conclusion that this is the most obvious intersection of the two areas. But the truth is far from it.

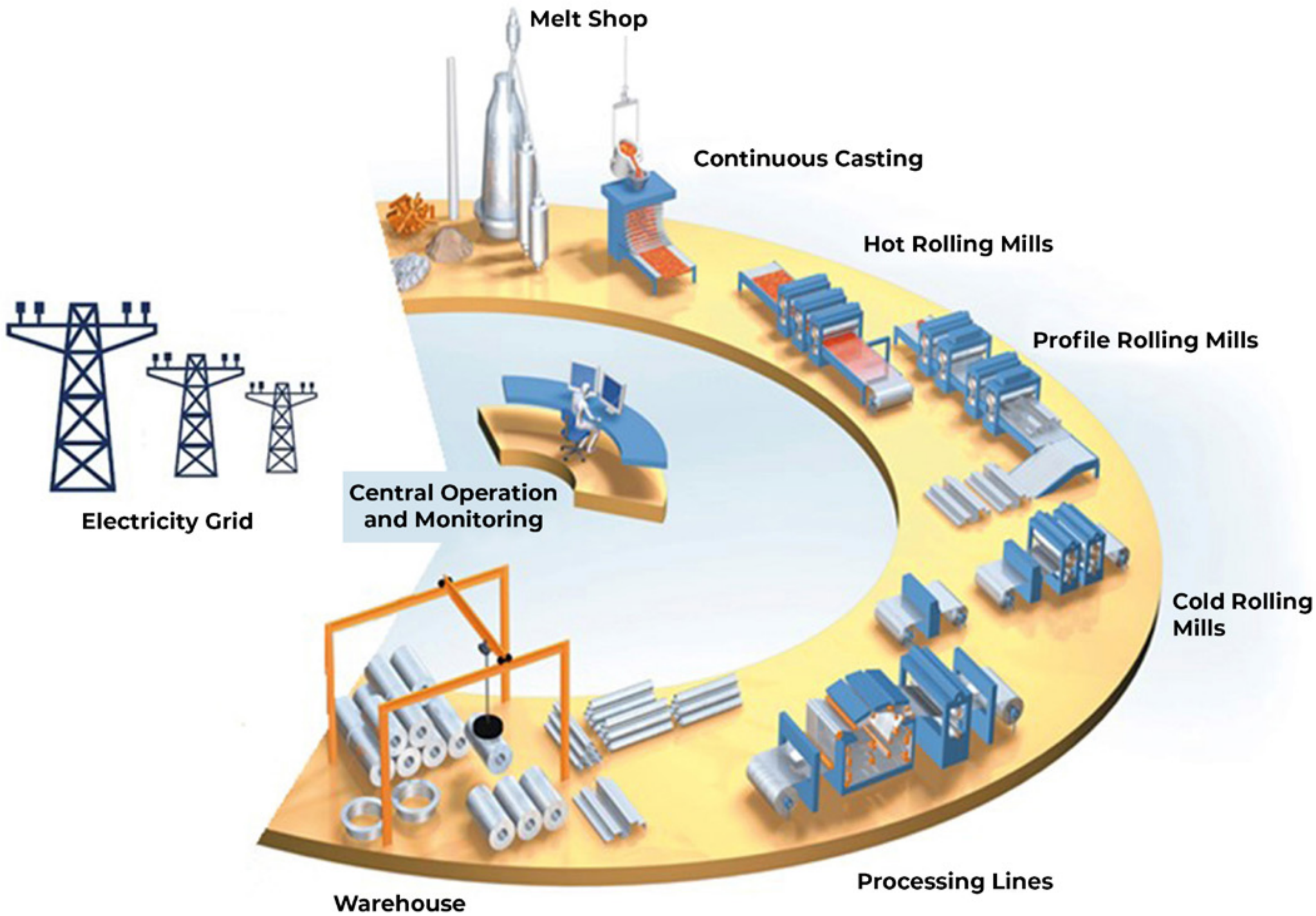


Figure 2. The steelmaking process is made up of continuous processing steps sequenced that require a large amount of energy and thus integration with the electricity grid. *Source: Journal of Cleaner Production[4]?*

An application viewpoint: steelmaking

An entry point to understanding the intersection of Industry 4.0 and control is to focus on an industry and different applications within it. We chose the metals industry for several reasons:

- First, the steelmaking process is made up of consecutive processing steps that are similar across the globe.
- Second, while the processing steps are continuous, they are sequenced discretely, resulting in a variety of operating practices.
- Third, a large number of resources and amount of energy is required during the production stages. As a result, sophisticated process optimization and improvement schemes are important and financially worthwhile.

Figure 2 shows the standard steps in a steelmaking process: In the melt shop, scrap metal or iron ore is melted in a furnace and various chemicals are added before the melted material is cast continuously. Slabs of metal are then formed into long sheets of metal in a hot rolling mill. The metal sheets are rolled out further in a profile or cold rolling mill. The surface of the sheets is further treated chemically and mechanically before storing them in a warehouse for further use in cars, ships, or household appliances. Because of the large and precise amounts of energy required, the stages of the steelmaking process require integration with the electricity grid.

All the processing steps, from melt shop to warehouse, require individual control solutions, as shown in Figure 3.

Control in continuous casting is related to the level of molten steel as the ladle is emptied into the tundish. Controlling the level is critical for high-quality steel and, while level control is a standard application, it is hard to measure the level in the tundish and empty the ladle according to the control instruction.

Hot and cold rolling mills also require control of the mass flow, the gap of the rollers, and control of the motor speed. While these individual control objectives are achieved with feedback as well as feedforward control strategies, there is also a need for multivariate control as an overarching strategy in the cold rolling mill[5].

The control aspects—implemented in an industrial control system—interact directly with the process. They are shown at the bottom of Figure 3. Other automation solutions that involve feedback elements and decision making over different time scales are depicted on top of the basic control layer.

For example, scheduling solutions calculate which batch will be produced at what time on a specified piece of equipment. Energy management solutions are concerned with managing the overall use of electricity or other sources of energy such as heat. Anomaly detection is important for quality management

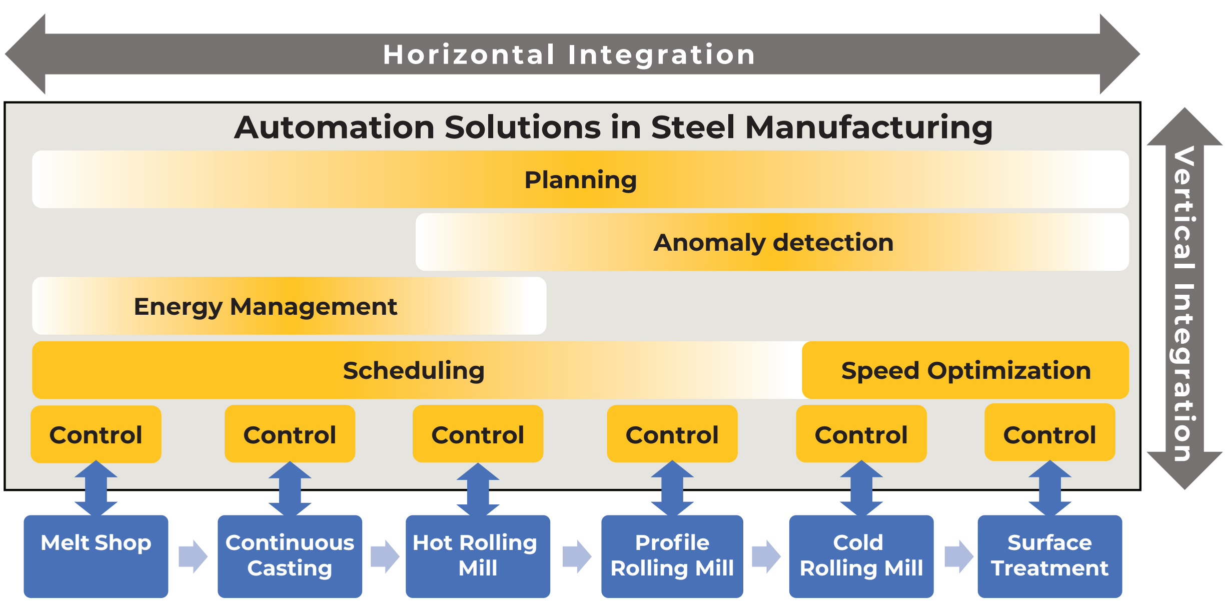


Figure 3. The typical automation applications in steel manufacturing are shown in orange over the various process steps, shown in blue.

Industry 4.0: Key Points for Control Engineers

Industry 4.0 refers to the increase in automation and digitalization in manufacturing and production processes and process industries. It reaches beyond earlier industrial innovations like the introduction of the steam engine, electricity, and computers—all of which have significantly changed industry in past "industrial revolutions."

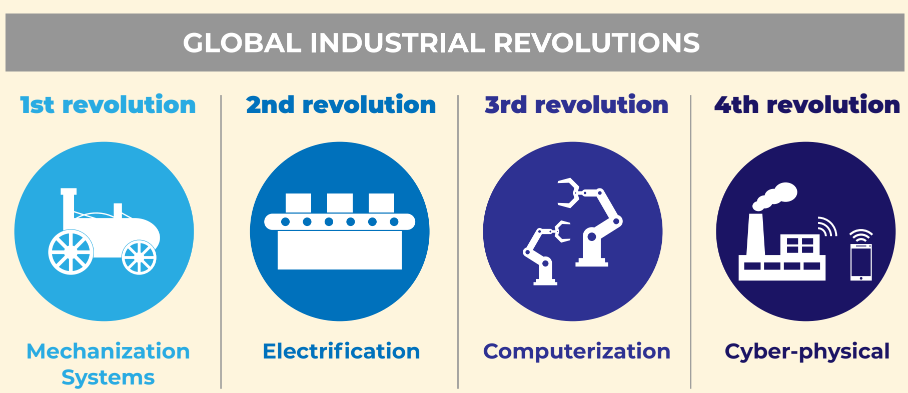
In each industrial revolution, new disruptive technologies appeared and paved the ground for a new wave of innovations. When the effect of the innovations was large enough, it revolutionized the norm of how things were seen and done. These revolutions also had a great positive impact on nations' economic growth and living standards.

When it was first introduced in 2011[1], by a strategic think tank of the German government, Industry 4.0 had nine underlying pillars: the Internet of Things (IoT), augmented reality (AR), simulation, additive manufacturing, system integration, cloud computing, autonomous systems, cybersecurity, and big data analytics.

The diversity of these technologies shows the complex and nebulous nature of Industry 4.0, but uniting all pillars is the increased "digitalization" of processes and the resulting availability, interchangeability, and connectivity of information. One uniting aspect of Industry 4.0 technologies is connectivity. It is now possible to connect machines and operational systems, locally and remotely, and exchange data, commands and information among different systems. The data and information existed before, but it was difficult to integrate and use.

There is criticism that Industry 4.0 may only be a hype topic and not a tangible revolution. The previous three revolutions were built on concrete technologies (mechanization, electrification, computerization), whereas Industry 4.0 is built on the somewhat more intangible concept of digitalization. Some proponents argue that this is only because we are in the middle of this new era and therefore cannot see it clearly.

Industry 4.0 has gained much traction through government initiatives in many countries, sometimes referred to with alternative names such as smart industry or smart manufacturing. Companies, who embrace change, invest in research, and new technologies fare better in an uncertain world with changed prerequisites . This speaks for the paradigm shift that is Industry 4.0.



In each industrial revolution, new disruptive technologies appeared and paved the way for a new wave of innovations. When the effect of the innovations was large enough, it revolutionized the norm of how things were seen and done.

and draws its information from the basic control layer. Planning solutions are concerned with a large time scale and determine in what order customer order are fulfilled.

Standards are required to facilitate the information exchange efficiently and the main standard here is ISA95, which describes the integration of the enterprise system and the control system[7].

When manufacturing and processing companies speak about vertical and horizontal integration, they usually refer to the exchange of information between the different automation levels and across the entire supply chain[6]. Since Industry 4.0 facilitates the exchange of data and information, it enables horizontal and vertical integration.

Although there are many different aspects of integration depending on the industry and setup of the production, steelmaking is tied in with electricity management because it is an energy-intensive process—particularly in the melt shop, casting, and hot rolling mill processes where heating is required. The electricity grid may pose constraints on production or may make production more profitable if carried out at specific times. This will influence the schedule. As a result, it is necessary to share information between the different levels of automation. So, the vertical integration of scheduling is one aspect of steelmaking where Industry 4.0 shines.

Standards are required to facilitate the information exchange efficiently and the main standard here is ISA95, which describes the integration of the enterprise system and the control system[7]. At ABB, it was demonstrated how the ISA95 standard can be used to provide the production schedule data so that it can be shared with the energy grid[8].

Another option to improve overall process efficiency is to connect the scheduling and the control layer using key performance indicators[9] (KPIs). Metals solution provider Hitachi demonstrated how to integrate planning and scheduling, and the control systems, thus improving the production yield as well as production[10]. This is one example of IT and OT integration.

When data can be exchanged between process steps and between different planning and scheduling solutions, energy can be used more efficiently. Energy can also be used at times when electricity is more affordable, and production quality can be more consistent.

Implications and challenges

What implication does Industry 4.0 have for control engineers and how will control engineering impact Industry 4.0? Here are some emerging research directions, implementation considerations and potential challenges.

Distributed control and network control. What the authors see in many different areas—such as in the energy or telecommunication industries—is the desire for distributed and network modeling and associated control strategies. Distributed systems and network theory provide modeling and control strategies; however, these have not yet found their way into process manufacturing on a widespread basis.

The authors are only aware of academic works in this area but are expecting to see success stories soon. A hindrance is the lack of accurate dynamic models for many production processes. Even if it would be possible to derive such models in a concerted effort, there is a need to update them continuously.

Control assessment. Before taking the next leap and developing, for example, a plant-wide control strategy[11], it is important to assess the performance of existing technology. The assessment forms the foundation to motivate further investment in new technologies: Is it worth investing in a new scheduling solution or a new integrated controller technology? The business case and assessment should never be ignored.

Currently, it is possible to assess the performance of a plant to point toward problems with individual PID loops, but this is by no means standard technology, implemented everywhere[12]. When it comes to the assessment of the performance and maintenance of MPC controllers, the task is even more complicated. There are some reports in the literature[13], but it is not typically done in industry in a systematic way.

Lack of standards for information exchange. Vertical and horizontal integration requires that information and data be easily exchanged between different systems. It is one thing to draw a line between two boxes representing solutions, but it is another to transfer data from one to the other practically. There are some standards such as OPC that address this problem, but it is still a challenge to configure adapters that can interpret the data correctly.

In particular, it is necessary to build an asset structure as has been proposed in other standards such as ISA95, Namur Open Architecture (NOA), AutomationML, and others. Arguably, control engineers should participate more in the standardization bodies to keep the control perspective in mind.

If you are a control engineer in a production related field, you will have a large exposure to Industry 4.0. In addition, new skill sets are required.

Cross-discipline knowledge required. Control engineering has always been a multidisciplinary subject. Control engineers have their homes in electrical, mechanical, chemical, industrial, process, and aeronautical engineering departments, sometimes even in mathematics. As a result, control engineers may not combine forces as much as may be necessary. If you are a control engineer in a production related field, you will have a large exposure to Industry 4.0. In addition, new skill sets are required. Besides the knowledge of control theory as well as of the application, software skills are increasingly important in the era of Industry 4.0.

Engineering education changes. The difficulty is knowing what students should learn in their syllabus. Should control engineers be able to program a PLC or a DCS? Should they learn about software required to exchange information with, for example, a scheduling solution system? We need new degrees to deal with challenges in automation. An understanding of Industry 4.0 and control engineering is required if we really want to reap the benefit of this new revolution, understanding all aspects of production systems and software implementation.

Final Thoughts

How do control engineering and Industry 4.0 relate? In this article we have demonstrated that control engineering is an underlying technology of Industry 4.0. However, it is not cited as an underlying pillar in presentations on Industry 4.0, unlike, for example, simulation or robotics.

One could argue that control is such a fundamental engineering science that it contributes to all the different technologies of Industry 4.0. But the real reason could simply be the poor understanding of control among policy makers. Control engineering bodies should try harder to push the topic into the general public. One approach would be to participate more in industrial forums and standardization bodies to work against the alarming trend of increasing disconnect between control engineering and industry[14].

At the same time, control engineers are sought after by industry, especially as they venture into different domains. Control engineers have a versatile, applicable, and comprehensive skill set. Their skills include analysis, simulation, optimization, and data analytics. These are sought-after in the context of Industry 4.0.

It often happens that control engineers—academics included—start in one control area and then move outside of what is traditionally understood as "control." Industry 4.0 relies on control engineering knowledge and skill sets, while control remains a foundation of many of its driving technologies. With the advent of Industry 4.0, the inclusion of control in the syllabus of various engineering disciplines is more important than ever before.

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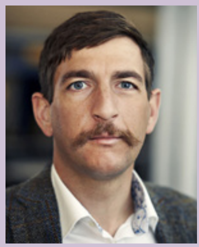

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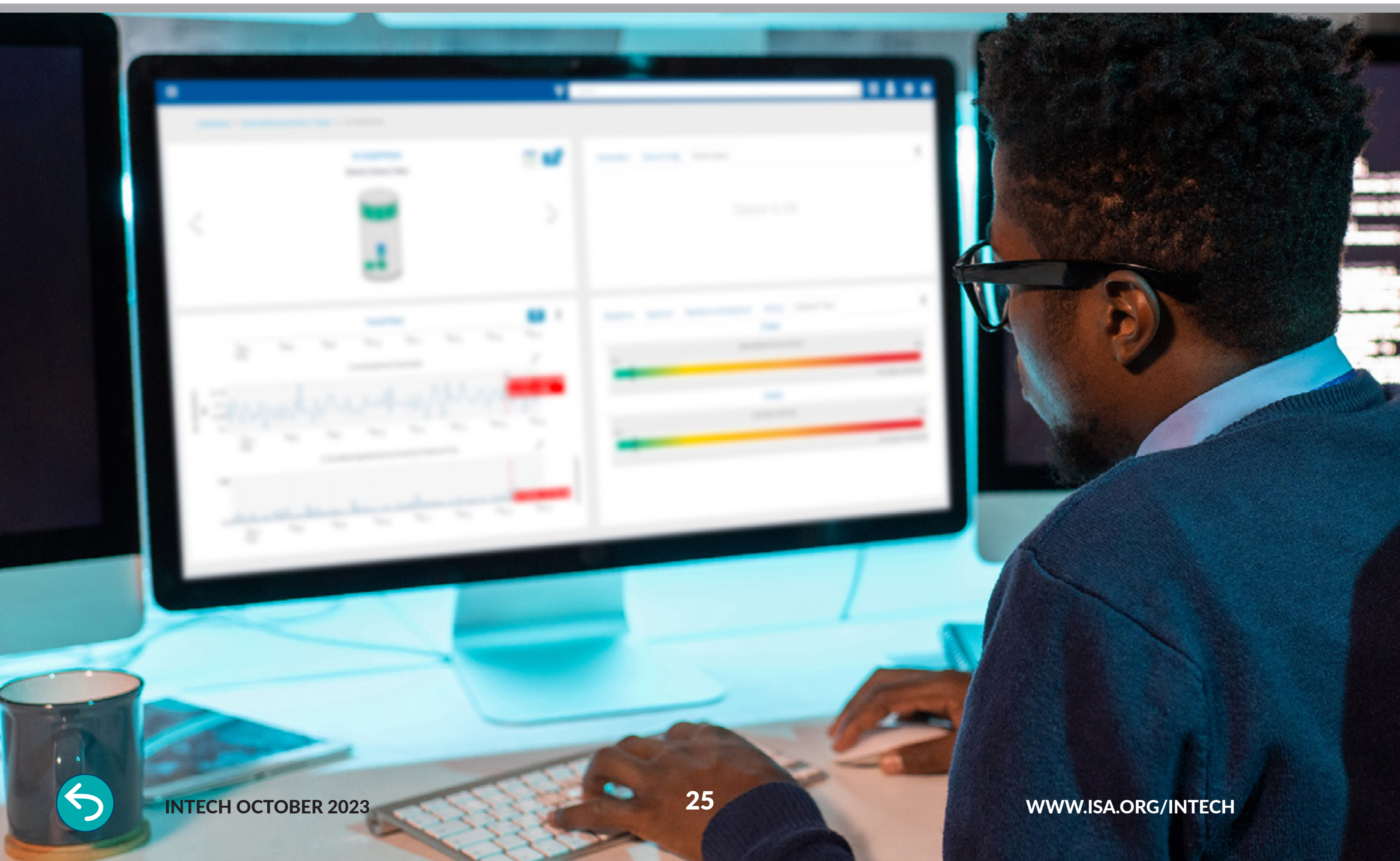
Remote Monitoring for Asset Reliability

Once field devices gather the data, consider these four strategies for remote analytics.

By Brian Dubaskas and Navin Rajashekar

At the end of the COVID-19 pandemic, many process manufacturers learned an unexpected lesson: under the right conditions, targeted remote work can be significantly more efficient than anticipated. As plants implemented remote systems, they saw that they were able to consolidate resources, empowering a smaller group of people to monitor and maintain assets, processes, and software over a wider global area, all without increasing costs due to travel.



Perhaps even more importantly, as the pandemic waned and fewer people than expected returned to the process manufacturing sector due to retirements and personnel shortages, organizations learned that in many cases, remote work freed their limited staff to focus on high value tasks.

A result of this change has been a shift in the way many organizations handle machine reliability analysis. More than ever before, plants are turning to remote analysis programs to supplement or replace onsite machinery health monitoring. For some plants, remote analysis is a more cost-effective way to continue the machinery health monitoring they have long relied upon. For others, it is a doorway to improved operation that would be otherwise out of reach.

In either case, understanding the value of remote analysis and following four key strategies to implementation are critical to getting the most out of any remote analysis program.

The value of remote analysis

Historically, major assets in a plant—those most essential to operation or those with the potential to create safety hazards upon failure—would be equipped with an online monitoring system. And plants that had enough equipment to warrant multiple systems often employed a few analysts on their reliability team.

However, balance of plant assets—those that are important to efficient operation but not critical—still require monitoring. Highly efficient reliability teams recognize that just because an asset is less critical, it does not mean it can be allowed to run to failure. The earlier technicians detect problems with an asset, the lower the maintenance cost to fix it. For example, if a team sees a motor bearing beginning to fail and doesn't act—or worse, is not aware of the flaw in the first place—they risk the entire motor failing, a coupling breaking, or a fire.

To avoid these types of problems, balance of plant assets were typically monitored through manual rounds—a time-consuming process where an individual would visit each asset with a handheld device and record vibration readings, then return to the office and analyze the data. Teams would set alarms to notify them of problems detected in the data collected from rounds. However, this system was not efficient. In many cases, by the time a handheld device detected a problem severe enough to trigger an alarm, significant damage was already done. The solution was reactive, not predictive.

Organizations expect their plant staff to collect data from balance of plant assets, analyze it quickly, and solve problems before they interrupt production, all with fewer people.

To complicate things further, today's plants operate in a highly competitive environment where peak efficiency is critical to profitability, safety, and sustainability. As a result, organizations expect their plant staff to collect data from balance of plant assets, analyze it quickly, and solve problems before they interrupt production, all with fewer people.

Fortunately, wireless technology enables reliability teams to cost effectively implement as many vibration measuring points as they need, without expensive hard wiring, and empowers them to collect the data continuously without the need to commit valuable personnel to walkarounds. Due to this paradigm shift in reliability monitoring, today, more data is collected in plants than ever before.

But this new normal creates its own set of problems. Massive amounts of data provide little value if they cannot be turned into actionable information. Reliability teams have significantly more data to analyze, but they have fewer analysts to accomplish that work. Analysts have an increasingly niche, specialized, and expensive skillset, making them hard to find, and even harder to retain. Consequently, many plants have a massive investment in data collection infrastructure, without an efficient way to turn this data into actionable information.

Remote analysis is the solution to this problem. Teams implementing a remote analysis solution send their data to analytics experts. If these experts are internal, they can provide analysis for multiple sites. If they are external, they typically provide analysis for a wide variety of organizations.

A team can choose to do this with all their data, or even use such a solution to augment the analysis they are already performing onsite. As reliability teams evaluate remote analytics solutions, they can significantly improve their chances of success by following four key strategies.

1

Collect the right data

Remote data analytics does not require extensive wireless monitoring solutions. It is possible to collect data for a remote analytics program using scheduled manual rounds with a handheld analyzer. Teams collecting data via manual rounds must ensure they collect consistent data. For example, if a technician is collecting data on "motor outboard horizontal," the data must be collected from the same spot each time, a task that can be particularly difficult to accomplish if several different technicians alternate on the route.

One strategy to ensure consistent collection of data is to mark the location for collection on each asset to remove guesswork. However, an even better strategy is to create comprehensive training to ensure every technician knows exactly how to collect data—without significant variation—on every asset in the plant. Such a training plan should be well documented so new technicians can be brought up to speed as quickly as possible.

For teams using wireless condition monitoring, collecting data is significantly easier. With wireless triaxial sensors, as long as the device is installed at the right location—typically as close to the bearing as possible—teams will know they are getting the right reading each time. In addition, wireless sensors ensure that readings are taken where they are needed without fail and ensure consistency of testing schedule. Regardless of how busy the staff is on a given day or who is out of the plant, the right data will come in at the right time.

One other key step in collecting the right data is performing a criticality assessment to ensure the team is receiving the correct data. Safety-critical assets and those that interrupt production will be the most important and will likely be covered by more complex systems. But for balance of plant assets, identifying which systems have spares, which have the most impact on production, which are the costliest to repair, and more can help teams determine data collection frequency for each machine to ensure they are not overloaded with data or taxing the wireless network.

2

Have the right team perform analysis

Assuming remote analysis cannot be performed in house due to a lack of qualified personnel, the next step is choosing a provider for remote analysis, and it is critical to have experienced people review the plant's data. The best vibration analysts carry category 3 or 4 certification from the International Organization for Standardization (ISO). ISO category 3 or 4 analysts will have years of experience and will be more likely to have seen a wide variety of issues, better preparing them to identify root cause of the most complex problems.

80% or more of the day-to-day asset problems in a typical process plant will likely be the most common ones: balance, misalignment, under-lubrication, etc. 20% of problems, due to their complexity, typically will be far more time-consuming to analyze.

In a typical process manufacturing plant, 80% or more of the day-to-day asset problems likely will be the most common ones: balance, misalignment, under-lubrication, etc. These problems will be easy for nearly any analyst to identify and isolate, and then help plant personnel with resolution. However, the other 20% of problems, due to their complexity, typically will be far more time-consuming to analyze, and will require deep expertise for resolution. A reliability team using remote analysis to drive efficiency needs someone who can solve such problems quickly.

Highly experienced personnel who have worked in multiple industries with multiple global customers will have seen many more unusual problems than other analysts. They will diagnose problems more quickly, and they will be far more qualified to help teams identify the severity of a problem and whether it needs to be fixed today, or can wait a month, or even a year, for a scheduled outage.

Moreover, highly experienced, certified analysts will be better prepared to perform the complex multivariate analysis necessary to uncover the most complex problems. Analysts primarily use vibration to identify issues, but the best providers will also be able to work with the plant's reliability team to check other process variables to help discover root cause when necessary. If something in the process changes, it can have a significant impact on asset reliability. An ISO category 3 or 4 analyst will have a much easier time using the available data to identify those changes.

3

Insist on meaningful reports

The most meaningful reports from a remote analytics group will identify problems and do so in a way that fits the needs of a wide variety of stakeholders. Teams need different reports for each role. For example:

- A report that an onsite analyst can examine and evaluate.
- A report that a technician can look at to guide his or her actions.
- A report that a manager can explore to track and trend reliability and performance.

First and foremost, analytics reports should quickly and easily identify problems and draw focus to what needs to be done first. The best reports provide a simple "green, yellow, red" view of asset status to quickly show teams of any experience level how to prioritize their action.

Assets in green are healthy and require no action. Yellow assets have developing problems that should be addressed when teams have availability. Red assets are experiencing critical failures and should be addressed immediately.

A high-quality analytics report also offers a single page overview of the plant as a whole, showing teams how many assets they have, how many are in each state, and how many are in other stages. Provided with such a view, any reliability team, regardless of size or experience level, can easily maintain a holistic view of plant health.

Teams also need access to deeper analytic details, such as spectrum, waveform, impacting, or other variables necessary to identify problems. While not every team will want or need such deep data, plants with onsite analysts will require access to the information they need to make key decisions about their assets.

Perhaps most importantly, reports should not just list asset health, but also provide actionable information to resolve problems, and the reasoning behind those decisions. Teams should be able to read a report and know exactly what to do to solve the problems that must be addressed.

Moreover, they should also have a way to provide feedback so they can report what they find when they perform repairs. Armed with that information, remote analysts can close the loop on problems, ensuring corrective actions resulted in expected outcomes.

4

Customize solutions to the plant's unique needs

No high-quality analytics solution is going to be one-size-fits-all. Every plant is unique and uses different equipment, technologies, and personnel to operate at its best. As a result, the best remote analytics solutions are the ones that can be adjusted to meet a plant's specific needs.

For example, every plant handles cybersecurity in its own way, and every plant will want to protect its data. Finding a remote analytics provider who can work with the plant's unique defense-in-depth strategy to make their solution work will lead to much more positive outcomes.

In addition, with the rising use of artificial intelligence (AI) in analytics, teams will want to identify a solution with the right mix of human analysis and AI solutions. Many organizations use AI to do some or most of their analysis. But while the pattern recognition strategies in AI are useful for fast results, they can also frequently misidentify faults. Reliability teams will get better results from providers who also use certified human experts to dive into results from AI analysis of raw or contextualized data.

For example, fault severity is very difficult for AI to distinguish. An AI solution can identify the same pattern on two different bearings, one that may last another month, and one that might last a year. In most cases, it takes an ISO certified analyst with years of experience to truly know the difference.

As reliability teams struggle to do more with less, many need outside help, either to supplement the analytics work they are already doing, or to close gaps created by personnel shortages. Such solutions can help teams drive higher efficiency across the plant to secure competitive advantage and be easily customized to meet their unique needs. Finding the right remote analytics solution is not difficult, it just requires knowing the benchmarks to look for and asking the right questions.

Figure courtesy of Emerson

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IN EXPLOSIVE ATMOSPHERE
KEEP TIGHT WHEN CIRCUIT ALIVE
34.57
inH20
Bluetooth Enabled
ROSEMOUNT
SHAKOPEE, MINNESOTA, USA
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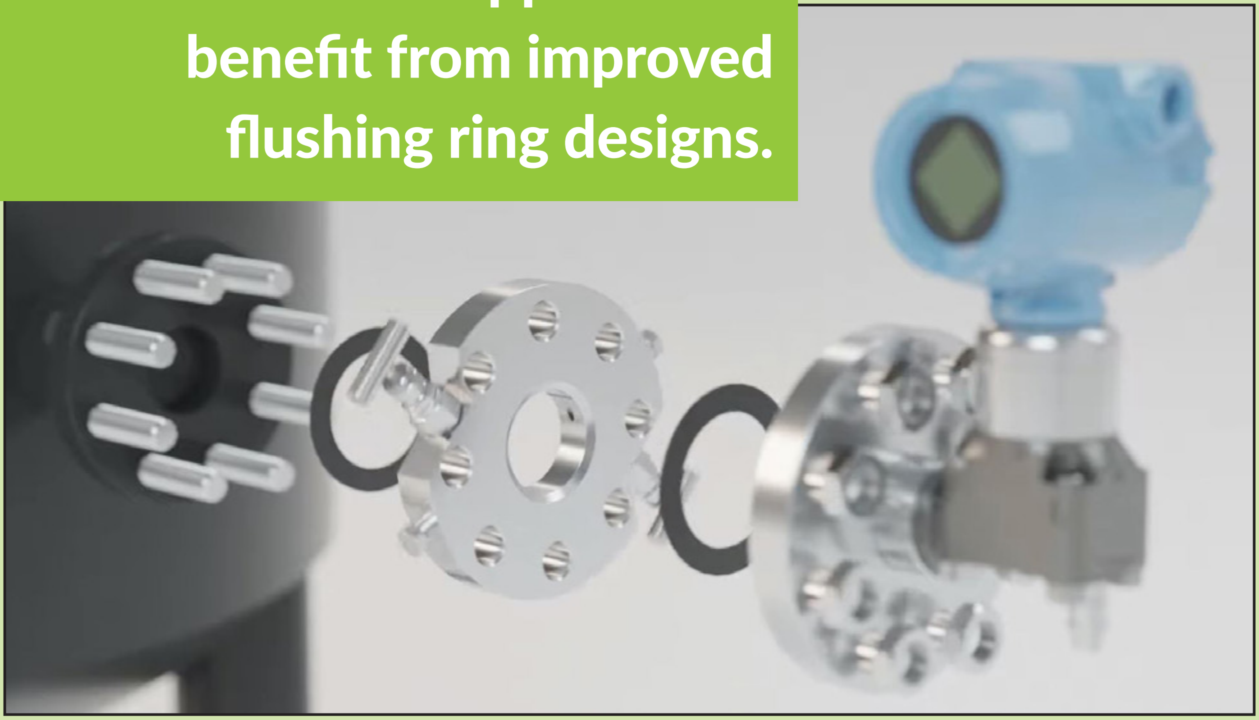
Pressure Transmitters: Improving Diaphragm Seal Maintenance

By Nicole Meidi

Level measurement systems and other applications benefit from improved flushing ring designs.



Diaphragm seal pressure transmitters are commonplace across industry. Whether they consist of an integral or remote seal configuration, they offer a reliable way to measure pressure and level in a wide variety of applications. While the specification of proper diaphragm seals and capillaries is well documented, flushing/calibration ring selection is often less understood.

This article discusses what flushing rings are, outlines the latest design improvements, and details benefits when they are used in level measurement systems, which is the most common application.

A flushing ring is positioned between the diaphragm seal and a tank connection, as shown at the top of this article. These rings can be made of a variety of materials and typically have one or more process connection ports, each serving a variety of functions.

If plugging and/or material build up is a problem in the tank nozzle, the ports on the flushing ring can be used to inject air, water, or solvent to clean the face of the diaphragm seal and clear any deposits that may be forming. This improves reliability and extends the time between tank maintenance outages. In particularly difficult applications, the flush ports can be connected to a solenoid, which activates intermittently to inject an appropriate fluid to keep the tank nozzle clear.

Flushing ring features

Different styles of flushing rings are available with varying price points and capabilities. The standard type shown at the top of the article has one or two threaded and plugged ports and is bolted between the diaphragm seal and the tank. Nipples and small isolation valves can be added to these ports to facilitate draining and venting.

While less expensive initially, standard types of flushing rings require the user to specify the correct piping and valve components, and ensure the materials, O-rings, and pressure and temperature ratings are appropriate for the application. They also require on-site assembly and have multiple potential leak points due to the number of required fittings.

An alternative is a prefabricated, bolt-through flushing ring with integral valves (Figure 1). These types of flushing rings are fire-safe and come in a wide variety of flange sizes, with many wetted material options. Needle, ball, and gate valve options with assorted connection types and materials of construction are available to suit most applications.

A common installation will have a vent and drain valve for calibration applications, or it may just have a single valve for flushing applications. This flushing ring assembly comes prefabricated and leak-tested, so installation is quick and easy. It also has fewer potential leak points than standard flushing rings, and it can be stocked as a single assembly for quick change out.

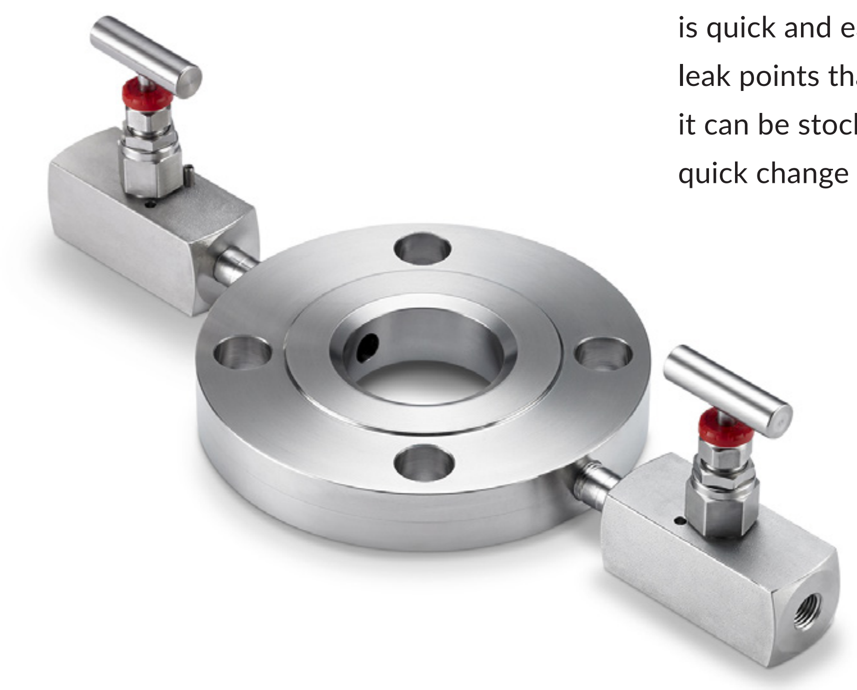


Figure 1. One alternative to a standard flushing ring comes pre-assembled and leak-tested, and offers a variety of process connections, materials of construction, O-rings, and valve types. This example is the Rosemount 319T.

Flushing ring alternatives

Recently, new compact flushing ring designs have been introduced (Figure 2). These have all the features and benefits of a standard ring assembly but add tangential injection of the process fluid into the ring.

Tangential fluid injection creates a vortex cleaning action that removes residue build-up up to five times faster than a standard design. It also can clean up to 30% more diaphragm seal surface area, providing a significant advantage in applications that are difficult to clean. (See the operation of a compact flushing ring compared to a standard design in this video.)

The compact, integral valve design of this new type of flushing ring lets it fit in much tighter spaces than a traditional flushing ring.

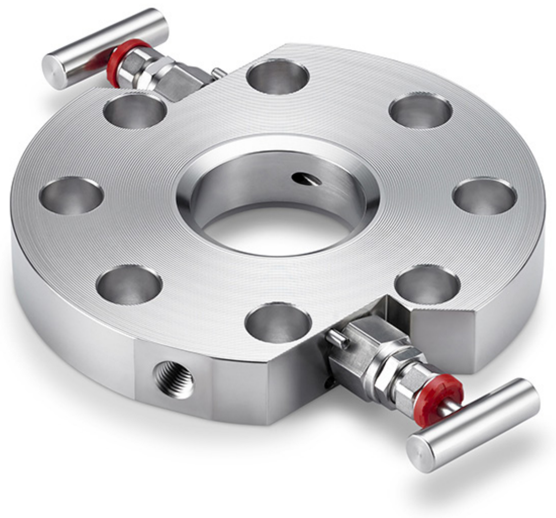


Figure 2. Compact flushing ring assemblies take up much less space than traditional flushing rings, and feature tangential fluid injection, providing superior cleaning. This example is the Rosemount 319C.

Flushing rings in action

One main differential pressure application is measuring the level of process media in a tank. If the tank is vented, the transmitter is typically installed at its base to detect head pressure. This pressure reading is converted to level based on the specific gravity of the tank contents using the following formula:

Tank Level (inches) =
Head Pressure (inches of water column)/
Specific Gravity of liquid

If the tank is closed and under variable pressure, a second diaphragm seal is added at the top of the tank to detect the tank vapor pressure. This second seal is connected to the low side of the differential pressure transmitter, allowing the device to measure the difference of the two readings to determine the resulting head pressure, which is converted to tank level using the same method discussed previously (Figure 3).

Flushing rings are sometimes referred to as calibration rings because they enable easy calibration of the level transmitter without taking the tank out of service. Calibration of a differential pressure transmitter requires the upper seal to be vented and removed from pressure, while the lower seal is subjected to a known calibration pressure to span and zero the transmitter.

If no flushing/calibration ring is installed, an in-service transmitter calibration requires removal of the entire assembly to clean the diaphragm seal. This procedure takes an extended amount of time, during which the process is offline. Diaphragm seals can be quite heavy, so between the mechanical effort involved, as well as the potential for hazardous material exposure during the flange breaks, calibrating a diaphragm level transmitter while the tank remains in service can be quite challenging, and potentially dangerous.

The installation of flushing and/or calibration rings with integrated vent/drain valves makes calibration much simpler. Flushing/calibration rings also make the flushing procedure significantly safer and faster, and it avoids potential diaphragm seal damage, which can easily occur when a seal is unbolted and bolted back into place.

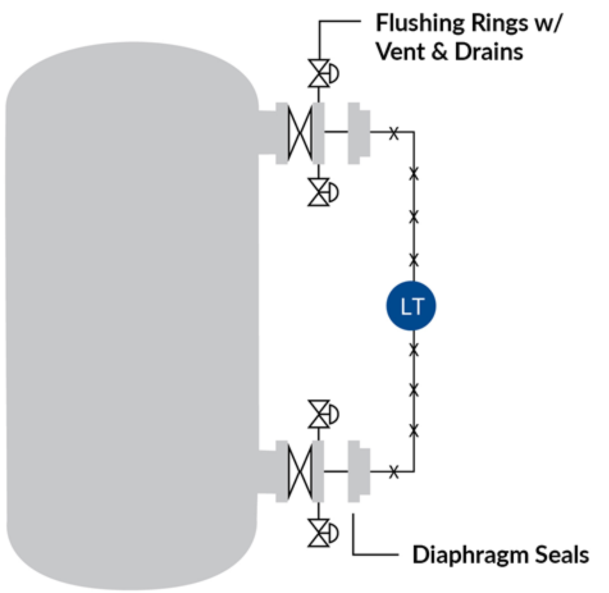


Figure 3. This diagram shows a typical dual-seal level transmitter installation with flushing rings and vent/drain valves. Calibrating the transmitter while keeping the tank in operation is much easier and safer if flushing rings are installed.

For these reasons, flushing/calibration rings and tank isolation valves are strongly recommended whenever a tank cannot easily be removed from service, and in other situations, such as when sludge or debris is present in the process media.

Conclusion

When caught up in the detailed specification of diaphragm seals and differential pressure instruments, it is easy to forget flushing rings. However, this component is often crucial to maintain reliable performance, enable easy and safe in-service maintenance of the seals and the instrument, and ease calibration.

If a flushing ring does make sense for the application, it is wise to evaluate the various options that are now available, particularly compact designs with faster and more thorough cleaning capabilities. Particularly in a large project with a wide variety of transmitters, prefabricated and factory-tested flushing rings will provide significant economic and performance advantages as compared to traditional designs.

As is often the case, the best designs require attention to detail at every stage and for each component, including flushing rings. The result will be many years of trouble-free service, with easier calibration and improved safety.

All figures courtesy of Emerson.

ABOUT THE AUTHOR

Nicole Meidl is a product manager for Emerson, specializing in Rosemount DP level and manifolds products. In her nine years with Emerson, she has also managed Rosemount pressure transmitters, MultiVariable transmitters, and Electronic Remote Sensor systems. Meidl holds a Bachelor of Science degree in mechanical engineering and an MBA, both from the University of St. Thomas in St. Paul, Minn.

Understanding Loop Diagrams & Process Loop Sheets

Detailed drawings conforming to the ANSI/ISA-5.1-2022, Instrumentation Symbols and Identification, standard show how all devices and equipment are wired to the control system.

By John Robert Davis and Graham Nasby

From an installation and maintenance electrician's point of view, two of the most useful types of drawings that can be included in a contract drawing set are loop diagrams and process loop sheets. These detail drawings show how each piece of equipment (e.g., instrument, motor starter, valve actuator, etc.) is to be wired to the control system. This article provides an overview of loop diagrams/process loop sheets and explains why creating and maintaining them is worth the effort.

From P&IDs to process loop sheets and diagrams

Piping and instrument diagrams (P&IDs) are developed at the beginning of a project to define the equipment, piping, and automation and control components needed to implement a process, including the control loops. P&ID drawings provide an overall summary of the process. Together with facility layout drawings, the P&ID drawings provide an overall view of a facility, what it does, and where the equipment is located. For large facilities, an additional set of drawings called process flow diagrams (PFDs) are sometimes created to summarize the P&IDs even further.

With the P&ID drawings in hand, the various design disciplines can create individual drawing sets to show how different aspects of the plant are to be built. These will include structural drawings, civil engineering drawings, architectural drawings, mechanical drawings, electrical drawings, and so on. From an electrical and instrumentation/contro perspective, these drawing sets will also include electrical power distribution (lighting panels, MCCs) drawings, control panel drawings (e.g., PLC panels), and loop diagrams and/or process loop sheets.

The instrumentation/control designer determines whether to use loop diagrams or process loop sheets. They both provide similar guidance for installation and maintenance electricians but, depending on the project type, one may be a better fit than the other.

A process loop sheet (PLS) provides the details for loops by illustrating all the devices and equipment in an instrumentation loop, how the various pieces interact, and how the process data is transmitted to the control room. It only provides summary information about the individual wiring details. Alternatively, this information can be arranged in a loop diagram (LD) format, where the same information is shown but in the form of more detailed wiring instructions on a wire-by-wire basis down to the terminal screw.

Loop diagrams and process flow sheets make it possible for many design issues to be seen and rectified during the design phase rather than during construction.

Depending on the contractor or maintenance team, either process loop sheets or loop diagrams may be more suitable. The chief takeaway is that it is better to work out the wiring details of instrumentation and control devices during design rather than during construction. It is much easier (and cheaper) to make design decisions than to have an electrician trying to sort out the design while the construction clock is ticking.

A water and wastewater example

For example, water and wastewater plants are typically designed to accommodate influent flow rates that are not consistent from one hour to the next. These flow rates are generally expressed as low flow rate, average daily flow rate, and maximum flow rate, and are indicated in the description blocks on the process loop sheet. In a typical water/wastewater plant, there are generally pump stations, screenings and grit removal, clarifier filters, odor control, various types of chemical injections, and storage tanks in the process loop, all of which may affect the flow rate. Flow, pressure, and temperature measuring devices transmit data to local PLC/DCS control panels that interface through software with operator workstations typically located in the central control room. The loop diagram shows the processes and equipment in the control loop, and the process loop sheet provides explanations and other essential information. Sometimes the loop diagram and process loop sheet are combined as a single drawing.

Use a standardized symbol and nomenclature structure so everyone involved can understand the components and the process. Best practice is to follow the ANSI/ISA-5.1-2022, Instrumentation Symbols and Identification, standard.

Throughout the life of the instrumentation system, including its construction, installation, commissioning, and operations, process loop sheets are accessed by personnel in multiple disciplines in the enterprise, as well as vendors and contractors. It is a resource used to document and explain how the control system and its instrumentation, motor starters, and valve actuators have been designed to operate and how they have been installed.

Due to the number of people using loop diagrams and process loop sheets, it is recommended to use a standardized symbol and nomenclature structure so everyone involved in the project can understand the components and the process. The best practice is to use the symbols and terminology developed by the International Society of Automation (ISA) and documented in ANSI/ISA-5.1-2022, Instrumentation Symbols and Identification. It is equally important to ensure that the information on the process loop sheets is complete. Also, as with any drawings, the sheet should be assigned a revision date and include the name of the designer who last updated and checked it.

Loop diagrams explained

Put succinctly, a loop diagram is a type of detail drawing that shows—on an instrument-by-instrument and device-by-device basis—how input/output (I/O) signals from equipment are to be wired to the control system. Loop diagrams show the specific wiring details down to the level of terminal screws, junction boxes, cable labels, and wire labels.

Most loop drawings (see Figure 1) are produced using a computer-aided design (CAD) package or auto-generated by an advanced plant design software package. A loop diagram is usually focused on a specific instrument or device but may include multiple sensors/actuators if they are related to each other process-wise. The use of "typicals" (a generic diagram that applies to multiple instruments/devices) is not recommended, as it defeats the purpose of the loop diagram containing instrument/device-specific I/O addresses and wiring details. Loop diagrams are generally the same size as other drawings in the drawing package for the plant. For example, the use of B-size (11” × 17”), D-size (22” × 34”), or E-size (34” × 44”) drawings sizes are relatively common in North America.

Loop diagrams are not a new concept. ISA standard ISA-5.4-1991, Instrument Loop Diagrams, covers a general version focused on instrumentation I/O wiring. Commonly known as ISA-5.4, the ISA loop diagram standard has been around since the 1950s and includes many good examples and best practices for creating effective loop diagrams.

Process loop sheets versus loop diagrams. Process loop sheets, developed later, are a type of summarized loop diagram that includes additional process information. They are intended to help the installation and maintenance electricians install and trouble-shoot equipment and provide additional context regarding its use. This context typically includes minimum and maximum temperatures, pressures, flows, and other process values, along with expected signal values during start-up, shutdown, steady-state and at-rest conditions. For example, a process

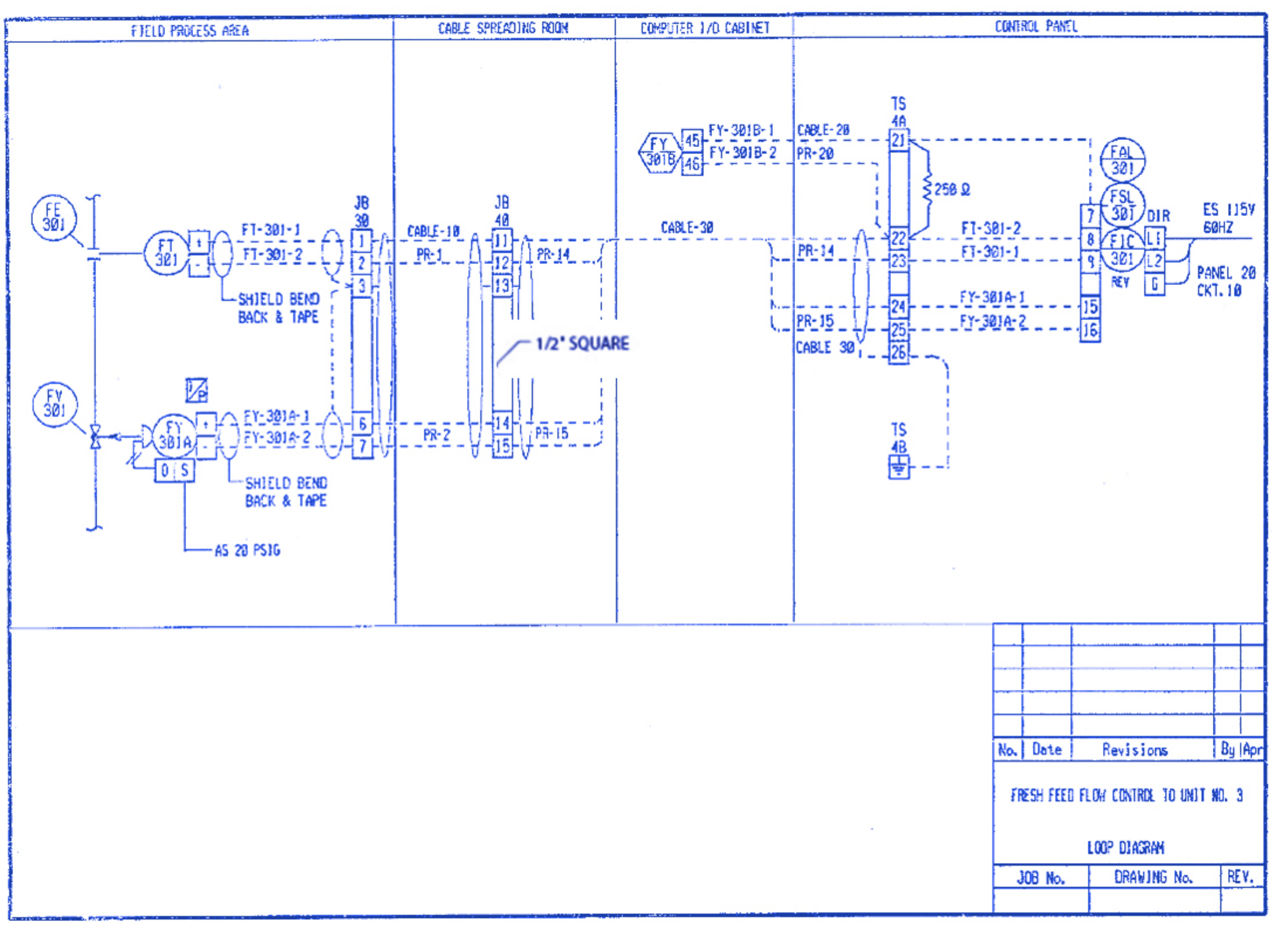


Figure 1. Example of a loop diagram. *Source: ISA-5.4-1991. Reproduced with permission.*

loop sheet for a magnetic flowmeter is shown in Figure 2. In the sample loop sheet, a flowmeter is reading the flow through a bar screen, totalizing it and then sending the reading to a PLC remote I/O panel. The reading is then used for various functions within the automation system.

Using loop diagrams and process loop sheets has been standard practice for many years in various industries, including oil refineries, chemical plants, power stations, and other types of manufacturing. Yet, using loop diagrams in the municipal water/wastewater sector is relatively new. The reasons for this are manyfold but usually can be traced to either individuals not knowing about them or perceiving that money can be saved by not creating them. This is changing as more water/wastewater utilities realize the initial and ongoing cost savings resulting from having proper sets of loop diagrams or process loop sheets for constructing and troubleshooting facilities.

Benefits of loop diagrams. There are many benefits from taking the time to create loop diagrams during the detailed design phase of a project. A major benefit is the ability to identify and fix problems during the design phase rather

ITEM	DESCRIPTION	TYPE	CRITERIA	TAG/SERVICE	QTY
FE	FLOW ELEMENT	MAGNETIC FLOW METER	METER: 16 IN LINE: 36 IN	PLANT INFLUENT FLOW	1
FITQ	FLOW INDICATE TRANSMITTER TOTALIZER	SIGNAL CONVERTER	RANGE: 0–15 MGD	PLANT INFLUENT FLOW	1
FIRQ A,B	FLOW INDICATE RECORDER TOTALIZER	INITIATED THRU SOFTWARE	RANGE: 0–15 MGD	PLANT INFLUENT FLOW	2

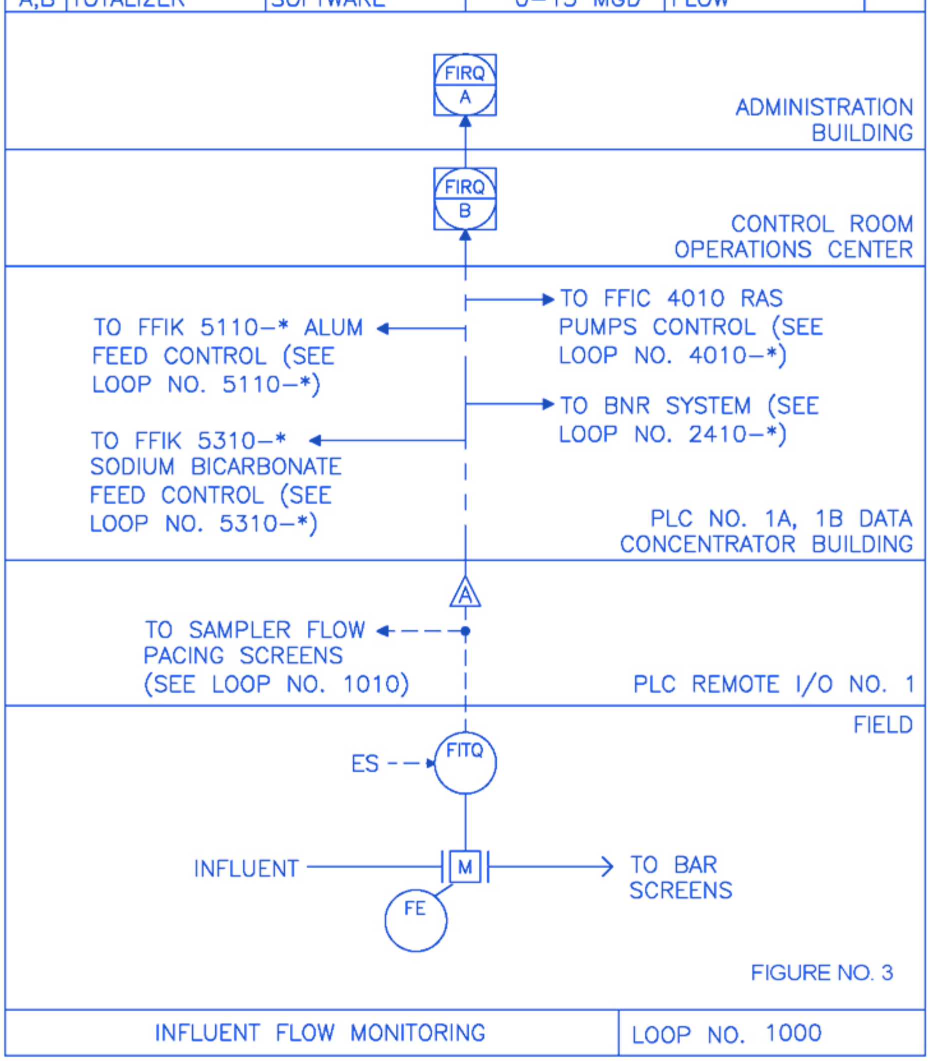


Figure 2. Example of a process loop sheet.

than during construction. It is significantly less expensive to sort out a design issue during the design phase (when it is easy to fix on paper) than during the construction of a facility.

Examples of potential design issues for process equipment include mismatched I/O signals, wrong power supply voltages, mis-ranged signal scaling, missing I/O signals, and missing installation details. These problems can cause delays and cost overruns when they must be fixed during a project's construction or commissioning phase.

In a typical capital project, it is not uncommon for an hour of work on-site during the construction phase to be up to 10 times more expensive than an hour of work during the paper-based design phase. Using a loop diagram during installation and maintenance can save thousands of dollars in terms of time savings and avoiding delays associated with investigation or troubleshooting.

For example, when installing a new motorized actuator with a loop diagram in hand, the electrical installation is as simple as hooking up the wires. The loop diagram provides a comprehensive guide for the installation electrician. The drawing will show what wires are needed, how to label them, and which I/O terminal screws to wire them to. The power connection details will also be shown. The loop diagram will also detail and summarize the voltages and scaling of all of the various signals.

If a loop diagram is not provided, the installation electrician will first have to search the PLC panel drawings to determine which I/O signals to wire to the actuator (if the descriptions in the PLC panel are clear). Next, they must review the motor control center (MCC) or lighting panel schedules to determine the intended power source for the device. Then the electrician will need to find the installation manual for the actuator (often not shipped with the actuator), to match the various terminals on the actuator with the requested I/O signals and power connections.

Without a loop diagram, a simple 10-minute troubleshooting task can turn into hours of difficult trial-and-error troubleshooting to find the issue.

Because the design engineer has likely not looked at these signals together (i.e., there was no corresponding loop diagram to be subjected to QA/QC), often there will be minor I/O errors in the design. The electrician will need to resolve the errors on-site or issue a request for information (RFI) to the design team to obtain the necessary data. All of this is very time-consuming during the construction phase, and the contractors are under tremendous pressure to get the plant built.

Likewise, suppose an installed valve actuator requires troubleshooting. In an ideal situation, an as-built loop diagram or process loop sheet for the actuator will include all the information the maintenance electrician will need to check the power and signals to/from the actuator. (When a construction project is completed, the design engineer will prepare an updated set of the contract drawings called "as-built" or "for record" that captures the details of what was actually built verses the initial plans.) However, suppose there is no loop diagram for the actuator. The electrician will have to search through PLC panel drawings, other drawings, and equipment manuals to determine how the actuator is wired and powered.

Often, if there are no loop diagrams, no drawing will exist that shows how the terminal screws of the valve actuator have been wired and what the terminals and configuration do. Thus, without a loop diagram, a simple 10-minute troubleshooting task can turn into hours of difficult trial-and-error troubleshooting to find the issue.

Process loop sheets explained

Process loop sheets can take many forms. One common practice is to size the sheet to fit on US letter size (8.5" × 11") paper. Multiple sheets can be grouped on a larger 24" × 36" contract drawing for larger projects. Another, used in other industries, is to make the process loop sheets the same size as other drawings used for the project, such as ANSI B or ISO A3.

Process loop sheets may be drawn by hand or produced in a drawing application such as AutoCAD (see Figure 3). On small projects, the sheets can easily be attached to the contract specification documents or placed

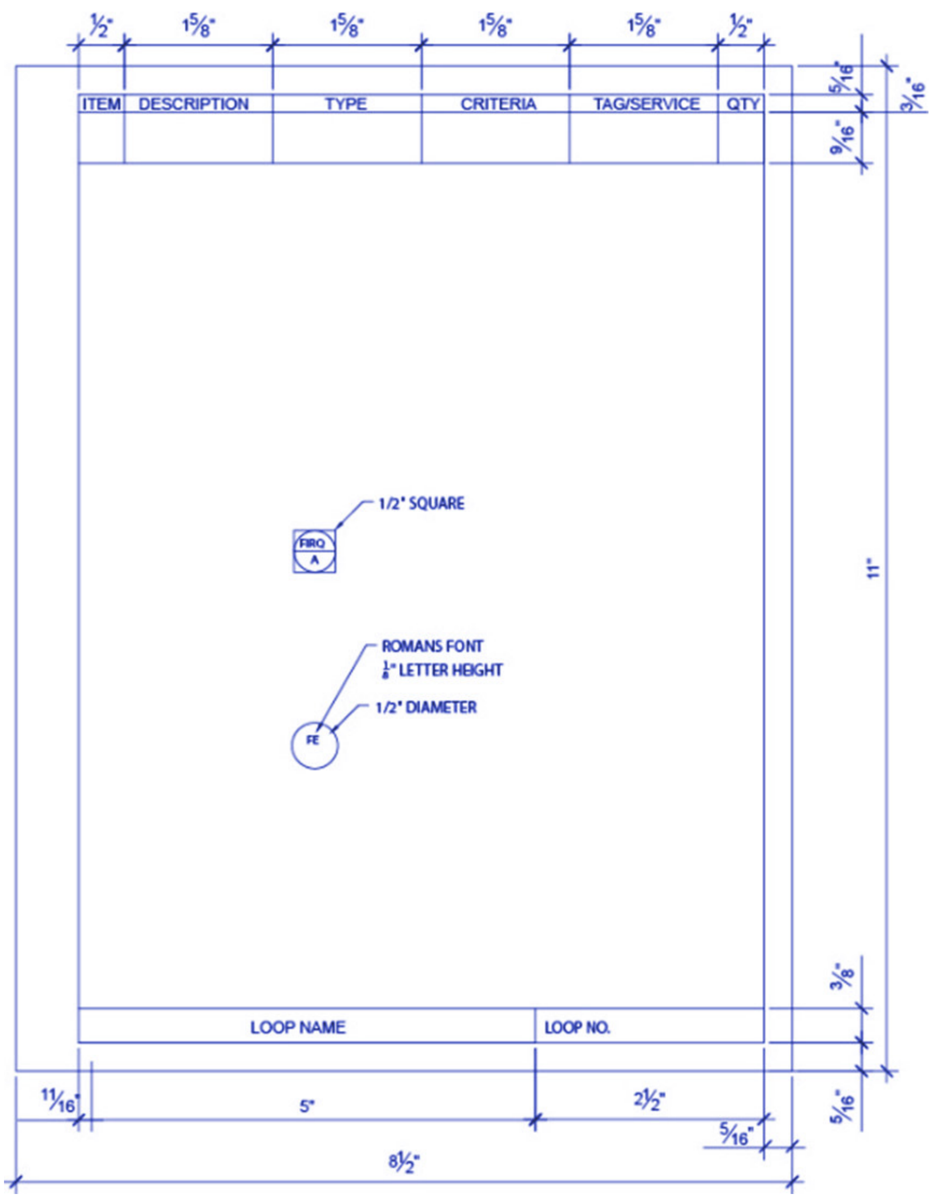


Figure 3. Example of a process loop sheet on 8.5" × 11" paper (portrait orientation).

with the engineering specifications to create an efficient and manageable document.

A process loop sheet is typically divided into as many horizontal layers—from the bottom of the drawing to the top—as required to show the entire loop diagram from the field device (at the bottom) to the control room (at the top). The following paragraphs provide an overview of the example Process Loop Sheet shown in Figure 4.

The top layer, just below the equipment description blocks, is the control room or administrative office at the end of the loop. The field device is always located in the bottom layer with intermediate layers denoting the path between the device and the control room, such as local control panels, remote I/O cabinets, PLC or DCS panels, or a fiber optic communication system. Each device and piece of equipment is assigned a unique ID to indicate that it is in a specific instrument loop. Best practice is to use the ISA-5.1 standards for assignment instrument IDs. However some SCADA systems may use different labeling systems, so these labels should also included if applicable.

The process loop sheet example in Figure 4 contains additional installation, commissioning, and troubleshooting information. The following paragraphs provide an explanation of the various pieces of information contained on this process loop sheet example.

Data fields. The process loop sheet contains fields where the designer can enter data. Each field contains a key piece of information about the device, instrument, or equipment connected to the control system. The loop name and number fields are located at the bottom of the sheet. The fields at the top of the form are referred to as description blocks. These blocks include detailed information about all the instruments and components in the loop diagram. A separate row is created for each instrument or device in the loop.

The list of fields typically used on a process loop diagram are as follows:

- **Loop name.** This is a brief description of the process being monitored or controlled.
- **Loop number.** This is a unique, four-digit number identifying the instrument loop.
- **Item.** This is a unique, four-digit alpha identifier for each piece of field equipment in the loop. These identifiers, called instrument codes, are defined in the ISA-5.1 standard for instrumentation. Identifiers for other devices will be

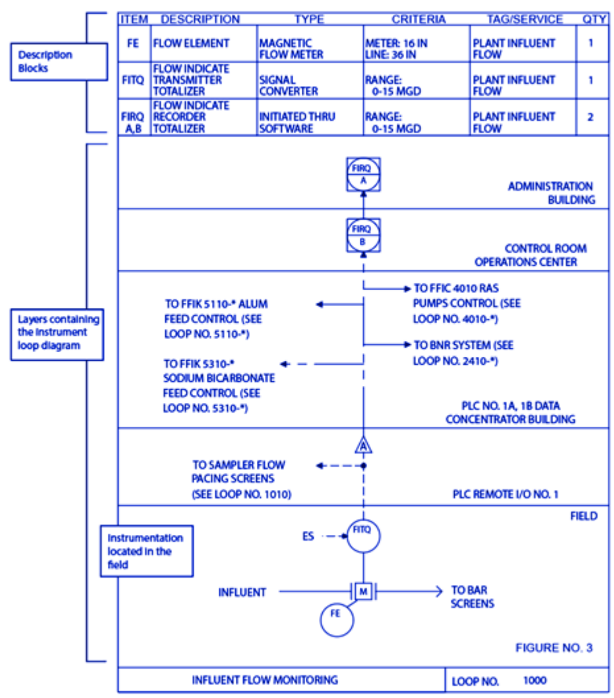


Figure 4. Process loop sheet with the parts of the sheet labeled.

typically defined in an end-user-specific standard. It is important to note that there are many of the same types of instruments. That is why each device and piece of equipment should be assigned a unique ID that is only used once at the plant. For example, ISA-5.1 provides a method of doing this using loop numbers, but each plant may have its own internal convention. The important takeaway is that the identifier must be unique.

- **Description.** This area explains the identifiers in the Item block. This block is valuable to anyone unfamiliar with ISA standard terminology and/or the plant's instrument/device tagging system.
- **Type.** This block provides details about each device. For example, it may identify a flow element (FE) as either a magnetic flow meter, a Venturi flow tube, or an ultrasonic flow meter.
- **Criteria.** This block contains requirements that are unique to the device or piece of equipment, such as the color of a pilot light lens, calibrated pressure, temperature, low-flow range requirements, elevations of level switches, and analysis analyzer ranges. This block or the Type block may also contain information indicating which contractor is responsible for providing the device or piece of equipment. If there are special installation or commissioning requirements that are unique to a particular instrument, these will sometimes be also included on the process loop sheet.
- **Tag/service.** This block is used to identify the item and what it does in the process. This is useful for an individual who does not understand the process or plant requirements, as well as someone assembling a control panel who must identify each piece of equipment on the panel by the process that is either being controlled or monitored.
- **Quantity.** This is the number of items.For example, if multiple items of the same type are needed a quantity is listed rather than having multiple row entries. Likewise if similar, but slightly different, items are needed it is best to list them separately in separate rows.

Some call loop diagrams and process flow sheets "the instrumentation engineer's gold mine" because they can result in considerable savings in the construction, installation, and commissioning phases of a project.

The example process loop sheet in Figure 4 shows that the influent flow meter sends a 4–20 mA signal via analog output to all devices throughout the diagram. In addition to providing a flow rate signal to the control system, the meter also records the average daily flow and keeps a 24-hour record, a process known as totalizing (denoted by the "Q" in the ISA-style identifier tag). The A and B labels on the FIRQ symbols indicate that the same information is transmitted to both devices, meaning that there are devices that show the totalized flow in both the control room and the administration center.

The line types used on a process loop sheet are the same as those used on the process part of a loop diagram. That is, dashed lines for electrical signals and solid lines for piping. Figure 5 provides an overview of the line types commonly used to process loop sheets. The intent of using process loop sheets is to provide enough detailed information so that an installation electrician can know how to wire a piece of equipment and how it is used.

Further examples

Both loop diagrams and process loop sheets can range from simple to complex depending on the equipment (instrumentation, devices, control elements, etc.) they describe. The example of a complex loop diagram in Figure 6 is from ISA-5.4. It shows an orifice-plate-based flow transmitter (which uses a differential pressure transmitter to read the flow based on the pressure drop across an orifice plate) and a flow control valve on a pumped fill line to a tank.

The field I/O wiring passes through a junction box in a cable spreading room; there is another set of junction terminals at the rear of a panel; then, there is a flow controller/PLC shown in a front-facing panel. Though showing older technology, the diagram in Figure 6 shows the amount of wiring/installation details that can be included on a loop diagram.

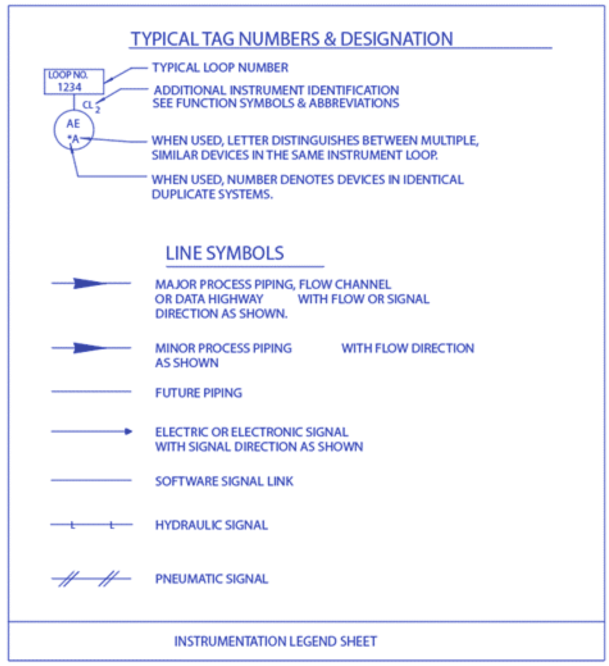


Figure 5. Commonly used line types on process loop sheets.

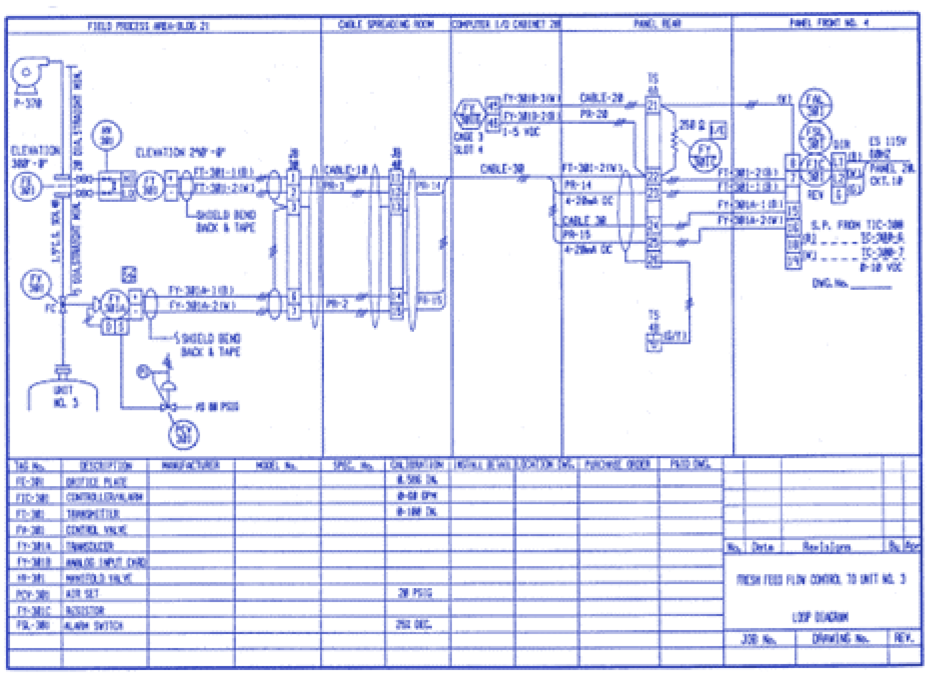


Figure 6. Example of a complex loop diagram.
Source: Figure 5 from ISA-5.4-1991. Reproduced with permission.

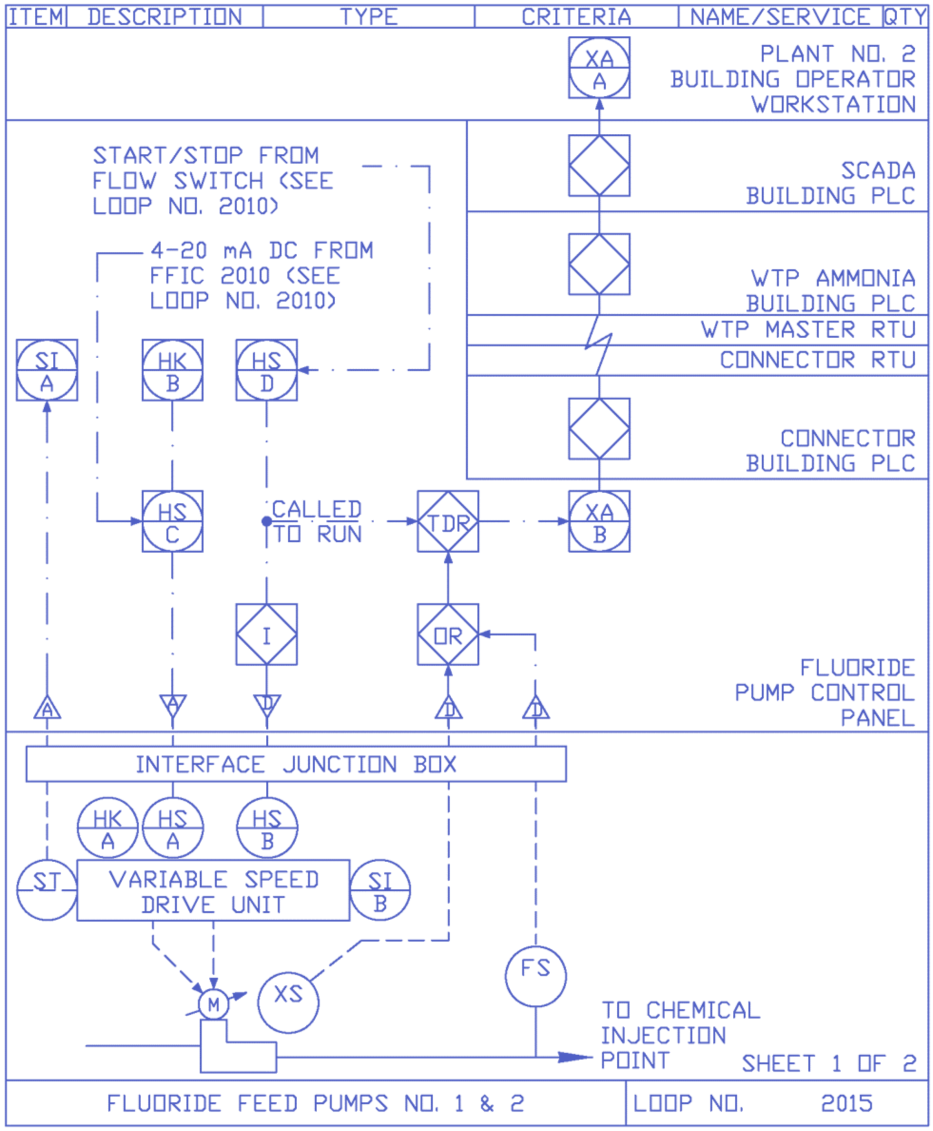


Figure 7. Example of a more complex process loop sheet.

Figure 7 shows a more complex process loop sheet. In this example, multiple I/O signals are wired to a chemical feed pump. The process loop sheet shows how the signals are wired from the pump to an interface junction box, to a fluoride system control panel, and then into a PLC system. Though it does not show the exact wire terminal details, it shows the flow of the signals so an installation or maintenance technician can easily see where the signals are being routed as part of the system.

Depending on the type and complexity of the project, it may be preferable to create a set of loop diagrams, a set of process loop sheets, or a combination of both. This will depend on the system designer and what they feel is necessary to provide clear instructions to the installation electrician for the system. Ideally, if both loop diagrams and process loop sheets are created, they can be used together to create an accurate account of how the system should be installed and how it has been installed once construction/commissioning is complete.

Summary

Loop diagrams and process loop sheets are two types of detail drawings that, though they take time to prepare, can result in considerable savings in the construction, installation, and commissioning phases of a project. These savings result from the installation electrician having clear instructions on how to wire and test the system instead of doing the detailed wiring design on-the-fly in the field as part of the construction process.

The production of loop diagrams and process flow sheets also makes it possible for many design issues to be seen and rectified during the design phase rather than during construction. Though there is a cost to prepare these drawings, the benefits of having them greatly outweigh the preparation cost. Hence, many instrumentation professionals refer to loop diagrams and process loop sheets as the "instrumentation engineer's goldmine"—they are worth their weight in gold when undertaking a project.

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DATA ANALYTICS

From Raw Data to Meaningful Insight

How cloud-based advanced data analytics empowers process engineers.

By Katie Pintar

The mass expansion of the industrial Internet of Things (IIoT) has brought with it a sudden and significant increase in the amount, complexity, and accessibility of operational and equipment data in process manufacturing facilities. Combined with the emergence of artificial intelligence (AI) and machine learning (ML), this is providing the potential to uncover more meaningful insights than ever before.

However, the journey from raw data to meaningful insight is still disjointed for many process manufacturers. The leading causes include limited data access and connectivity, a lack of time-series-specific analytical solutions, and collaboration difficulties, and addressing these issues is paramount to process optimization.

Spreadsheet-caused challenges

At most facilities, numerous data sources exist that each store their data in different databases. Historically, spreadsheet-based analytics tools were used to aggregate, cleanse, and align all this data so insights could be extracted. However, this manual procedure is cumbersome and time-intensive, and certainly not the most efficient use of an engineer's or process expert's skillset. On top of the manual inefficiencies, the lack of live data connectivity leaves subject matter experts (SMEs) with perpetually out-of-date analyses.

These challenges make it difficult for SMEs to wrangle data and prepare it for meaningful analysis. Furthermore, traditional solutions rendered sharing data and analyses across organizational teams and regions arduous or nearly impossible, limiting the ability for collaboration and knowledge transfer.

Traditional spreadsheet-based workflows are still active in many facilities today, but this severely cripples organizations because these tools are decoupled from real-time data visualizations. Fortunately, better solutions are now widely available.

Modern advanced analytics

To transition their analytics capabilities, increase operational efficiency, maximize profitability, and achieve ambitious corporate objectives—including digital transformation and sustainability metrics—process manufacturing organizations are rapidly implementing modern cloud-based advanced analytics solutions into their daily procedures. These software platforms are optimized to connect disparate data sources and immediately alleviate the challenges of live data connectivity.

Additionally, these solutions provide native tools for data cleansing, time stamp alignment, and contextualization, empowering SMEs to quickly derive reliable insights referencing all available data. With live data connectivity right in the software, SMEs can apply their analyses to near-real-time data, whether it is stored in the cloud or on-premises.

Because advanced analytics solutions are cloud-based, they are perfect for IIoT implementations, which gain direct access to the vast computing power and scalability of cloud software, advancing all types of Industry 4.0 projects, such as predictive maintenance programs and digital twins.

Advanced analytics solutions also strengthen the collaboration between process, maintenance, and reliability teams, with built-in tools for sharing analyses and insights in easily digestible dashboards and reports.

The lack of live data connectivity leaves subject SMEs with perpetually out-of-date analyses.

A root-cause analysis

One petrochemical and refining company experienced a slew of reactor shutdowns, caused by the failure of a critical feed gas compressor on a polyethylene line, with the inability for immediate restart. On this line, an unplanned reactor shutdown creates a minimum of 4 hours of downtime, costing the plant upwards of $200,000 USD with every occurrence. These compressors were previously maintained on a preventative maintenance (PM) schedule, but this did not prevent unplanned shutdowns entirely.

Following one compressor trip, the machinery, controls, and electrical engineers worked together to identify the source. However, tracing electrical diagrams around the pump motor was time-intensive, and it failed to yield a root cause.

Taking an alternative approach, a process engineer at the refinery opened a webpage in a modern advanced analytics application to quickly locate the five most recent shutdowns and subsequent restarts (planned

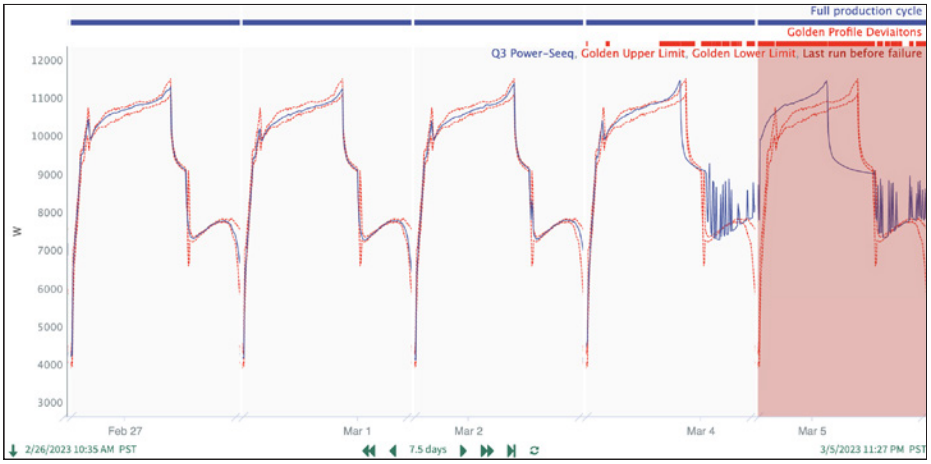


Figure 1. To troubleshoot a critical feed gas compressor failure, an advanced analytics application was used to quickly find the most recent shutdowns and subsequent restarts from decades of historical process data and then overlay the events to identify abnormalities.

and unplanned) from decades of historical process data (Figure 1).

In this example, Seeq's "Capsules" and "Chain View" tools let the engineer quickly find and focus on the shutdown and start-up time periods, then overlay the events. This led to identifying abnormalities in the discharge pressure profile of the two most recent start-ups. Investigating further, the engineer also noticed early warning signs on the motor amperage signal. Without a way to view the start-ups back-to-back, the motor degradation had gone unnoticed by operations.

As a result of this root-cause analysis, the process engineer implemented a monitoring solution to prevent future motor degradation from going unnoticed and causing similar unplanned shutdowns. When an out-of-tolerance value appears, the compressor motor is now immediately added to the maintenance work list for the next planned shutdown, a proactive maintenance approach that is expected to eliminate unplanned shutdowns due to this failure mode.

Cloud-based analytics applications empower process manufacturers to significantly reduce new software implementation time so they can deliver products to end users faster, while improving quality and reducing infrastructure and maintenance costs. Using point-and-click interfaces for descriptive, diagnostic, predictive, and prescriptive analytics, these platforms fulfill the needs of a range of SMEs to derive the insights needed to operate efficiently and optimize effectively.

Figure courtesy of Seeq

ABOUT THE AUTHOR

Katie Pintar is a Senior Analytics Engineer at Seeq Corporation, where she helps companies maximize value from their data. She has a process engineering background with a B.S. in chemical engineering from Montana State University. Katie has over five years of experience working for chemical manufacturers to optimize existing processes and develop processes for new materials. She has expertise in batch and continuous processing for a wide range of chemistries.

ISA Automation and Leadership Conference Brings Top Tech Experts to Colorado Springs

In early October, ISA held its annual Automation and Leadership Conference (ALC) in beautiful Colorado Springs, Colorado. Over the span of five days, ALC proudly brought together a global audience of 225 automation managers, engineers and technicians for professional development and interaction.

"ALC is the automation event of the year," said ISA President Marty Bince. "It combines leading technical presentations with society meetings, standards meetings, training, and career skills development opportunities alongside multiple fun networking events. There is really nothing else like ALC."

Vital technical sessions and an array of technical subject matter experts from the US, Canada, the Middle East, Brazil, Spain, and India were onsite, according to Morgan Foor, ISA director of communications and events. Brazil, India and the Middle East were very well represented by attendees as well, she said. Many of the ALC sessions were presented virtually as well as in person, widening access to the high-quality content. Local attendees and those who chose to travel to Colorado Springs were able to participate in face-to-face live sessions and talk with speakers, exhibitors and each other.

Each conference day began with a keynote address to standing-room-only crowds. Mark Weatherford, CSO and SVP of Regulated Industries at AlertEnterprise and chief strategy officer at the National Cybersecurity Center,

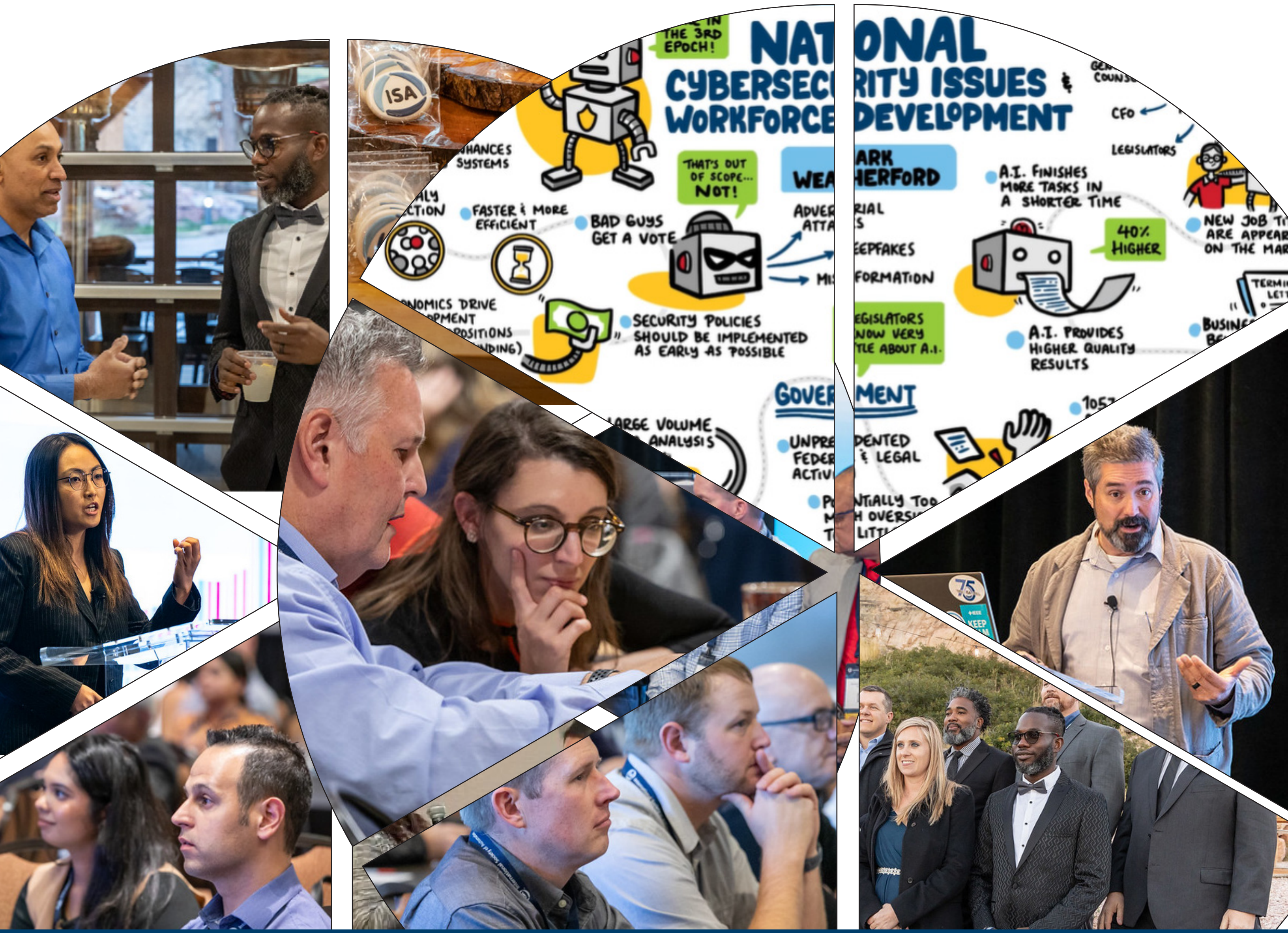
spoke on "National Cybersecurity Issues and Workforce Development." A key portion of his talk was on artificial intelligence (AI) and "why AI will save the world: Every engineer, every child, every artist, every business person, every doctor, every caregiver, every CEO, every government official, every athletic coach, every teacher will have an AI tutor this is infinitely patient, infinitely compassionate, infinitely knowledgeable, and infinitely helpful, and the magnification effects of better decisions is unfathomable in 2023," he said.

Ru Schaefferkoetter, president and CEO at Trido Solutions, spoke on "Unleashing the Potential of Carbon Credits: Strategy Monetization of Sustainability Initiatives, and How Automation Plays a Pivotal Role in Safeguarding the Integrity of the Carbon Credit Market."

Details on sessions and speakers are available on the event website.

Exhibit booths and technology demos

Attendees also had the option to visit more than a dozen sponsor exhibitor booths staffed by technology experts who shared their insights. Some exhibitor experts also hosted



technology-demo or panel-discussion sessions at the event. The Open Process Automation Pavilion, for example, brought representatives from 12 of its member companies onto a session stage to discuss the progress Exxon Mobil and The Open Group are making toward open architecture solutions. Those sponsors included CPLANE.ai, SCI, Intel, SMAR, Phoenix Contact, Stahl, Rockwell Automation, VMware and Wood.

Other booth sponsors included: Cyolo, G&D, ProcessVue, Verve, and ARMEXA. Fortinet and SDI were silver-level sponsors, and Control Station sponsored the breaks. ISA supporting organizations and media partners included ISA Global Cybersecurity Alliance, ISASecure, Automation.com and *InTech*.

Honeywell Process Solutions sponsored the Awards Gala, which was an exciting and uplifting evening of "Rodeo and Recognition." This annual celebration of excellence in the automation profession. The 2023 event was Held at the Flying W Ranch, this year's gala included inspiring remarks from honorees alongside Western-themed entertainment.

A complete list of 2023 honorees was published in last month's *InTech* issue, and more information on the awards program is at www.isa.org/awards.

Growing as a society

The annual ALC always includes details on the status and activities of ISA. During lunch on day one of the conference, ISA volunteer leadership and the Executive Director Claire Fallon gave the State of the Society address. These remarks included accomplishments, financial performance and highlights of the 2024 strategic plan. Retiring Automation.com Chief Editor Bill Lydon was honored, and ISA President-Elect Prabhu Soundarrajan accepted the gavel from Marty to signal the start of his 2024 term, beginning in January.

ALC 2023 included opportunities for Executive Board, Assembly and Committee

volunteers to meetup, as well as for self-identified young professionals and students to gather. A Section and Division Volunteer Workshop session was particularly popular: Over 90 current and future volunteers engaged in activities designed to co-create the most vibrant sections and divisions.

"The 2023 ALC was bigger and better than the 2022 one, with ISA's training, technical and career skills tracks, and volunteer workshops all happening along with an awesome rodeo-themed gala and a golf outing. There really was something to inspire us all to help create a better world through automation," said Steve Mustard, ISA treasurer and former president.

A sketch artist present during many of the sessions captured his interpretation of the important elements of the event in real-time. His sketches, photos and videos from the event are available in the ISA Flickr album.
—Ashley Ragan

2024 Automation & Leadership Conference: Charleston, SC, USA

Save the dates September 30 through October 3 for ALC 2024, being held in Charleston, South Carolina, USA. Once again, ISA will deliver "terrific technical content right alongside unforgettable and fun experiences," said ISA President Marty Bince. The historic city is filled with culture, charm, and delicious food, and speakers for the technical sessions are already signing up. A highlight is sure to be the 2024 ISA Honors and Awards Gala, which will be held on the flight deck of the World War II-era aircraft carrier the USS Yorktown.

The Evolving Language of Automation Engineering

By Jack Smith

The automation industry grew up using ladder logic to tell programmable logic controllers (PLCs) what to do and how to do it. But the era of classic computerized control has moved into the era of Industry 4.0, with its emphasis on industrial digitalization and software implementations of complex systems. To keep up with this shift, the industrial automation and control engineering disciplines are evolving as well, reflecting the convergence of operational technology (OT) and information technology (IT) systems.

When I spoke with Arlen Nipper, CTO for Cirrus Link Solutions and co-inventor of MQTT at a recent technical conference, we got to talking about this evolution. I asked him to rank the programming languages automation and control engineers are using today. He told me that Python, Java, and the C-family of languages (C, C++ and C#) are the top three. But he quickly clarified that their prevalence does not in any way exclude others.

Because of their similar syntax, Python and Java are considered part of the C-family of programming languages, which also includes Julia, Perl, and many other languages. What that family does not include, however, is ladder logic—long used to develop control applications for industrial hardware like PLCs and PACs—and IEC 61131-3, a newer open programming standard.

In an article in the June 2022 issue of *InTech* titled "Future-Proofing Controls Programming for the Edge," Emerson's Darrell Halterman wrote: Programmable automation controllers (PACs) "began to take on tasks we would associate with the edge today, although their dedicated real-time operating systems (RTOS) imposed some limitations. In many cases, users found it necessary to create complex algorithms, like machine learning strategies, using modern information technology (IT)–type languages like C++ and Python, running on PCs and industrial PCs (IPCs) working in conjunction with PACs."

In the same article, Halterman said users should seek product portfolios that embrace open programming, software, and communication standards when possible. He said that for edge controllers, this requires (among significant other criteria) that they be "programmable using C/C++, Python, and other modern languages suitable for applications like machine learning [ML] and artificial intelligence [AI]."

In an October 2022 *Robotics and Automation News* article titled "Most Popular Programming Languages for Automation," author Mark Allinson wrote: "According to surveys conducted last year, [Python] is the most preferred language for developing automated systems. Its open sources and freedom are the main pros."

Supporting Python's place in front, *IEEE Spectrum* recently released its 10th annual rankings of the top programming languages saying, "This year, Python doesn't just remain No. 1 in our general 'Spectrum' ranking...but it widens its lead. Python's increased dominance appears to be largely at the expense of smaller, more specialized, languages. It has become the jack-of-all-trades language."

What about IEC 61131-3?

Coming up through the OT ranks are open, interoperable programming standards seeking to replace the proprietary programming languages tied to specific pieces of industrial hardware. In a recent Automation.com article, "The Missing 'Industry 4.0/ Digitalization' Link—Open Programming Standard Conformance & Certification," Bill Lydon wrote: "The fundamentals of IEC 61131-3 have been adopted by a wide range of automation vendors throughout the world. IEC 61131-3 is supported by the PLCopen organization that extends the standard with special interest groups, standards, and certifications. These standards and certifications include motion control, safety, OPC UA, XML interchange, and reusability. Due to the task structure of a full IEC 61131 implementation, both event-driven and cyclical [programming] can be accomplished."

Lydon points out that, regardless of the programming methods, "manufacturers and process production companies must digitize, or they will be caught in a strategic gap putting them at a large competitive disadvantage. Achieving the benefits of digitalization requires organizations to leverage Industry 4.0 and IoT (Internet of Things) concepts, technology, and architecture with open standards. Vendor compliance and certification to open interoperable programming standards will accelerate the digitalization of manufacturing, production, and process industries."

Lydon seems concerned that, in the void left by the lack of strong conformance and certification to *industrial* automation programming standards like IEC 61131, "the industry may be preempted from the outside." Does that mean the alleged IT-centric languages like Python are "from the outside?"

Concerns that these "IT-esque" solutions would never work in industrial automation reminds me of the arguments that Ethernet could never be used for industrial networking. Maybe the convergence of IT and OT systems means there are no longer "sides." The evolution from ladder logic to Python and IEC 61131-3 and beyond speaks to where the industry has been and is headed. The PLC-oriented languages can all work together to promote digitalization.

ABOUT THE AUTHOR

Jack Smith is senior contributing editor for Automation.com and ISA's *InTech* magazine. He spent more than 20 years working in industry—from electrical power generation to instrumentation and control, to automation, and from electronic communications to computers—and has been a trade journalist for more than 25 years.