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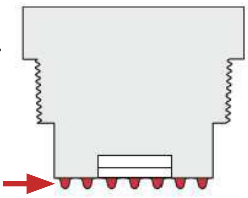

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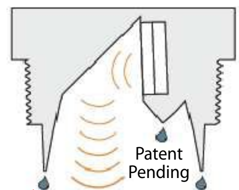

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ISSN 0192-303X

***InTech*, USPS # 0192-303X, is published bimonthly in Research Triangle Park, NC by the International Society of Automation (ISA), 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709. Vol. 66, Issue 5.**

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

Subscriptions: For ISA members, 8.65% of annual membership dues is the nondeductible portion allocated to the *InTech* subscription. Other subscribers: $175 in North America; $235 outside North America. Multi-year rates available on request. Single copy and back issues: $20 + shipping.

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

Printed in the U.S.A.

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

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Military veterans in industrial automation

By Renee Bassett, *InTech* Chief Editor

As Chief Editor of *InTech* magazine and also Automation.com, a subsidiary of ISA, I go to a lot of conferences. I get to meet ISA members and potential members, users of ISA standards, and other professionals active in the art, science, and challenge of industrial automation.

Whether it's an "I'll never retire!" systems integrator on his fourth or fifth industrial-adjacent career or a new graduate of a control engineering program looking to find his place, I love talking to people about how they got into automation. That's because industrial automation professionals are a rare breed—part architect or auto mechanic, part physics professor or lab rat, part electrician and computer scientist.

They often seem to have come out of nowhere and landed in a profession that fits. I always wonder how that happens, because it's not like kids are being taught at a young age how to close a control loop. Even with encouragement toward science, technology, engineering and math (STEM) careers, you don't see kids dressing up as instrumentation technicians for Halloween.

Many of the people I've talked to found their way to chemical plants or manufacturing facilities after childhood, and often after time in the military. It seems years of mastering the systems on a Navy ship can make PID loops and multivariate control charts seem like an easy next step. I was reminded of this recently by Chad Storlie, a retired U.S. Army Special Forces officer, author, and adjunct professor at the University of Minnesota – Carlson School of Management.

Storlie was talking to me about National Hire a Veteran Day (25 July) and about his website, CombatToCorporate.com. His message is that when organizations and individuals translate and apply military skills to businesses of any kind, they immediately produce results and are cost effective. Here are three of his 10 reasons why military veterans might find success in industrial automation:

1. The ability to work 24-7-365 in all weather with great results. The world of logistics, retail, food service, hospitality, manufacturing, and finance are now 24-7-365. Military veterans inherently understand the importance of working to high standards with a dual focus on quality and safety at any day and hour.
2. They understand they must work their way up. Every military veteran started his or her military career at the bottom. When military personnel transfer into a new military unit and duty station, they must relearn the ropes, learn the culture, and learn how the new team operates. Veterans understand they must come into a new organization, learn the ropes, and demonstrate their proficiency for a new position. This understanding, that starting at the bottom does not mean that you remain at the bottom, is what makes veterans great entry-level employees.
3. They will pick up the trash. One of the first things military organizations do in the day is walk their area of responsibility and pick up trash. Picking up trash gives everyone a level of pride in their organization. Also, as Navy carrier operations demonstrate, making everyone walk the carrier deck looking for objects that could damage aircraft creates a safer, more effective, and higher operational unit.

These and other reasons make military veterans excellent industrial automation employees. Are you one? I want to know more about your experience. Talk to me about being a military veteran in industrial automation, or working with one, or hiring one. You can reach me at rbassett@automation.com, rbassett@isa.org, or www.linkedIn.com/in/rrbassett. ■

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"Own" the control system

I wanted to drop you a note concerning your latest Final Say article [July/August 2019 *InTech*, www.isa.org/intech/201908final] and how you could not be more spot-on with your comments. As a veteran of workforce development advocacy for a number of years in government, education, and industry, it still remains today that automation is either considered someone else's problem within the decision-making ranks of the company unit, is a job killer from a Capitol Hill political standpoint, or is in need of support and a strong voice from industry in the halls of academia beyond local efforts.

Your point, enhanced by an Einstein quote regarding ability to change, is that "automation should be treated as a core business function that is critical for success . . . " in the industrial world. This would go a long way to solving a significant part of the skills gap, now 7 million and counting, according to our friends at NACFAM [National Council for Advanced Manufacturing], regarding unfilled skilled positions available in industry.

There are some heroes out there: Don Bossi and the folks at FIRST [For Inspiration and Recognition of Science and Technology] are showing young people how exciting a technical career can be, especially for those who didn't realize they had such an opportunity. Paul Galeski first really shined the light on how to address all the considerations, monetary and manpower costs, and future-think possibilities of replacing legacy DCS [distributed control systems] in partnership with ISA. Don Bartusiak is leading a global effort with new development and education in industrial data communications, and newly minted ISA Fellow Kelvin Erickson understands the needs of industry and is single-handedly designing and constructing a world-class and very successful industrial control system lab and coursework in industrial automation at a respected midwestern engineering university.

These are just a few of my heroes, but they all have in common a strong commitment and invested hard work in ISA as a technical society. There are many more, but ISA is structured as an individual member organization to benefit members who through association make their companies better. I'm certain there are many CTOs and/or CIOs in large process plants who choose not to "own" the control system, the one most important thing that could make their company more successful by being more competitive.

Your quote from Drucker, "If you want something new, you have to stop doing something old," not only applies to industry as you have stated regarding reactive investments. It maybe should apply to ISA or the profoundly weakened Automation Federation in the form of an industry alliance similar to the recent Cybersecurity Alliance, a strong voice united in a cause with a few heroes thrown in.

Stephen R. Huffman, ISA Fellow

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Capping off a decade of growth

By Cory Fogg

After five years of consistent growth, automation and control engineers in the U.S. reported sluggish growth for the year as the decade nears its end. The Automation.com/*InTech* 2019 Salary Survey showed 2% growth for automation and control engineers specifically, while the average salary of all U.S.-based respondents saw a fractional decrease. Similar drops in average salary were also reported in several global regions.

While it may be disappointing to see the momentum of a decade of salary growth stagnate, demand for engineers is expected to remain strong. For example, according to the U.S. Bureau of Labor Statistics, demand for industrial engineers is expected to grow 8% over the next 10 years, which is faster than the average (5%) for all occupations. Demand for chemical engineers will grow 6% by 2028.

Regarding salaries, the great news is that engineers in the U.S. today are finishing a decade in which salaries rose 16%. Technological advancements and increased connectivity have led to greater needs for industrial system designers, integrators, and cybersecurity specialists, boosting the value of professionals with expertise and experience in these areas. The less-great news is that the value boost did not seem to apply to 2019's 2% salary growth for U.S. automation and control engineers.

Still, in the U.S., 63.2% of respondents reported a salary of more than $100,000, with nearly 41% reporting a salary in the $100,000–$150,000 range. So, an engineering career clearly remains

Results from the 2019 engineering salary survey

a valuable proposition for many of our surveyed professionals. The 2019 salary survey data reveals rises and falls in several key areas:

- Some 83.3% of our respondents reported a salary increase in the past year, although 70.9 percent of those said that the raise was less than 4%.
- Entry-level average salaries dropped 11.2%, eliminating a boost reported in the 2018 survey.
- The East North Central region (including states like Ohio, Michigan, and Illinois) reported the lowest average salary of all U.S. regions in 2019—and 4.1% less than their 2018 average.
- The industries that saw the largest raises, proportionally, were oil and gas (4.9%) and utilities (4.1%).
- Respondents who reported having either an ISA professional certification or similar certification in 2019 (30.9%) averaged a 5.3% higher salary than those who did not.

Survey demographics

Our survey results reflect data collected from more than 1,600 responses sent in by automation professionals located around the world, with a special focus on the 995 responses received from the U.S. One of the biggest differentiators in terms of engineer salary is the region, so our analysis separates the U.S. responses. Note: All the results quoted in this article, other than average salary by region of the world, represent U.S. responses only.

As has been the case for several years, the primary respondent to our survey was a U.S.-based automation/control engineer (making up 26% of the survey pool). Although we had data come in from sources all over the world and from a variety of job functions and industries, U.S.-based personnel made up 66.7% of respondents, followed by Western Europe (5.8 percent) and Canada (5.7%).

Respondents were primarily "very experienced," as over half claimed more than 21 years of experience and almost 85% have more than 11 years of experience. Post-secondary degrees were also prevalent, with 69.3% of respondents having at least a bachelor's degree.

A varied world for automation professionals

Throughout the 15 years we have conducted this salary survey, we have identified five major factors that determine salary: geographic region, job function, level of education, industry segment, and years of experience.

Geography is a key differentiator in engineer salary. A U.S.-based engineer, for example, can expect a higher salary than his or her neighboring engineers in Canada, and far more than their colleagues to the south in Mexico. Mexican engineers reported the lowest average salary of any global region.

It is interesting that although respondents in most regions around the globe reported average salaries that were slightly lower than the previous year, there were significant salary gains in the South Pacific islands. Engineers in Australia and New Zealand, for instance, reported a 13% average rise in salary, while the Asia and South Pacific region reported a 5% rise—the only two global regions to report positive growth in their average salaries.

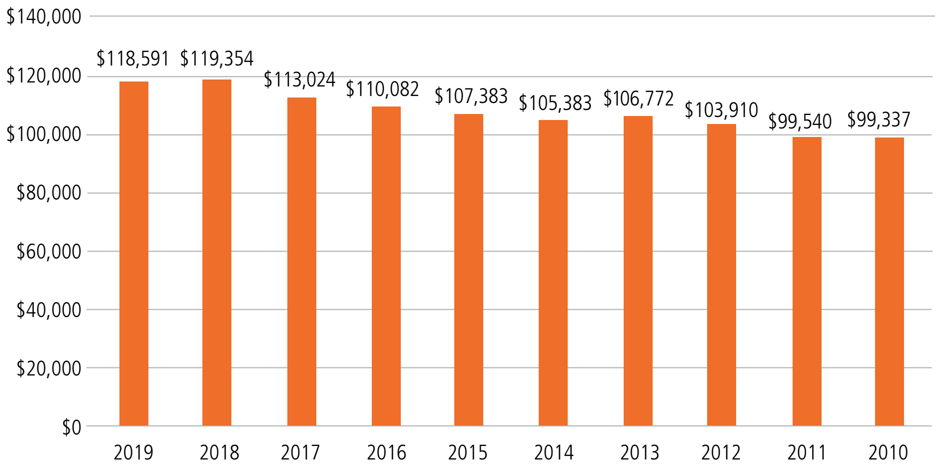
FAST FORWARD

- **After five years of consistent growth, automation and control engineers in the U.S. reported sluggish growth (2%) for the year as the decade nears its end.**
- **Entry-level average salaries dropped 11.2%, eliminating a boost reported in the 2018 survey.**
- **Respondents who reported having either an ISA professional certification or similar certification in 2019 (30.9%) averaged a 5.3% higher salary than those who did not.**

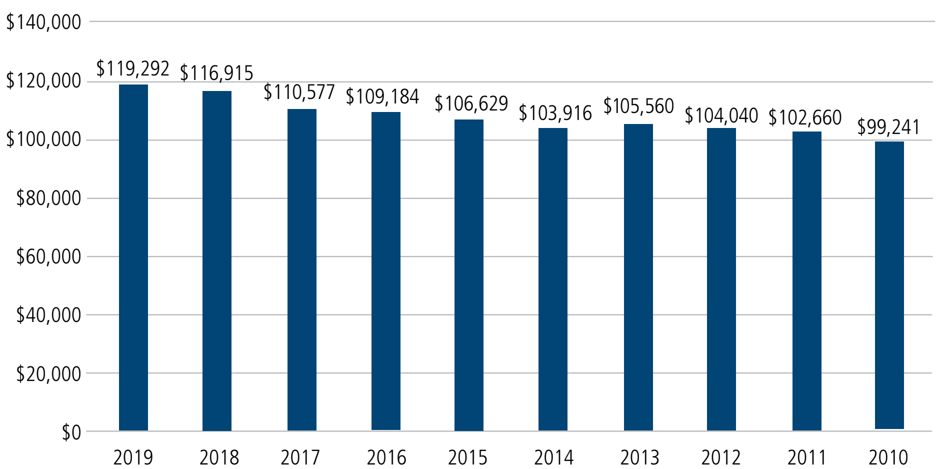
Average salary by region of the world

Region of world	Average salary	Percent respondents
United States	$118,591	66.7%
Canada	$103,794	5.7%
Mexico	$43,970	1.1%
Central America (including Caribbean)	$70,588	1.1%
South America	$50,625	4.6%
Europe (Western)	$81,511	5.8%
Europe (Eastern)	$45,113	1.5%
Africa	$45,337	2.5%
Middle East	$79,375	2.7%
Australia and New Zealand	$121,527	1.2%
Asia and South Pacific	$57,180	3.2%
South Asia	$49,333	4.0%

Average salary by year, all U.S. job functions



U.S. automation/control engineer average salary by year



The state of U.S. engineers

The salary for the U.S. engineer plateaued slightly in the past year, but this is the culmination of a decade in which average salaries rose by nearly $20,000. So, does this mean that the U.S. engineer should expect salaries to level off? Not necessarily. While the average salary did decrease by a fraction of a percent (.6%), the survey showed a similar infinitesimal regression in 2014 as well, which was sandwiched on each side by multiple years of significant salary growth.

Average salary by year, automation/control engineers

The data cannot tell us definitively how the automation and engineering skills gap and labor shortages may be affecting salaries; however, the data does show precedent that this single-year salary stagnation could well be an outlier in the middle of years of continued growth. We will continue to monitor this with great interest to see how salaries respond in the years to come.

Location within the U.S. matters as well. Just like a U.S. engineer might have a salary advantage over an engineer in a neighboring country, an engineer living in California or Texas has a salary advantage over an engineer living in Wisconsin or Montana. While we cannot say with certainty all the factors that create this disparity, we can definitely say that the demand for engineers in these higher-paid regions appears to be high.

The West South Central region, which includes Texas, reported the highest average salary in the U.S., while accounting for nearly 20% of all U.S. respondents. The Pacific region, where California contained more than 10 percent of U.S. respondents, was second in average pay. Still, as you will see from the numbers, demand might not be affecting salaries. The Rust Belt states in the East North Central region, for example, have high numbers of engineers, but significantly lower salaries than their Texan and Californian counterparts. Four of the nine U.S. regions reported average salary increases in 2019, with the largest percentage increases in the South Atlantic region (9.3% increase) and the West North Central region (4.3% increase and an 11.2% rise over the past two years). (*Regions are defined on Wikipedia.)

Average salary by U.S. region

Region of the U.S.*	Average salary	Percent respondents
New England (Northeast)	$122,928	3.4%
Mid-Atlantic (Northeast)	$114,650	10.0%
East North Central (Midwest)	$106,964	16.8%
West North Central (Midwest)	$115,668	8.5%
South Atlantic (South)	$115,728	15.2%
East South Central (South)	$117,083	4.2%
West South Central (South)	$130,536	19.1%
Mountain (West)	$110,657	7.5%
Pacific (West)	$127,814	14.4%

FYI 53.5% of global engineers report the ability to do their job remotely; 55% of U.S.-based engineers have remote capability.

A decade in review

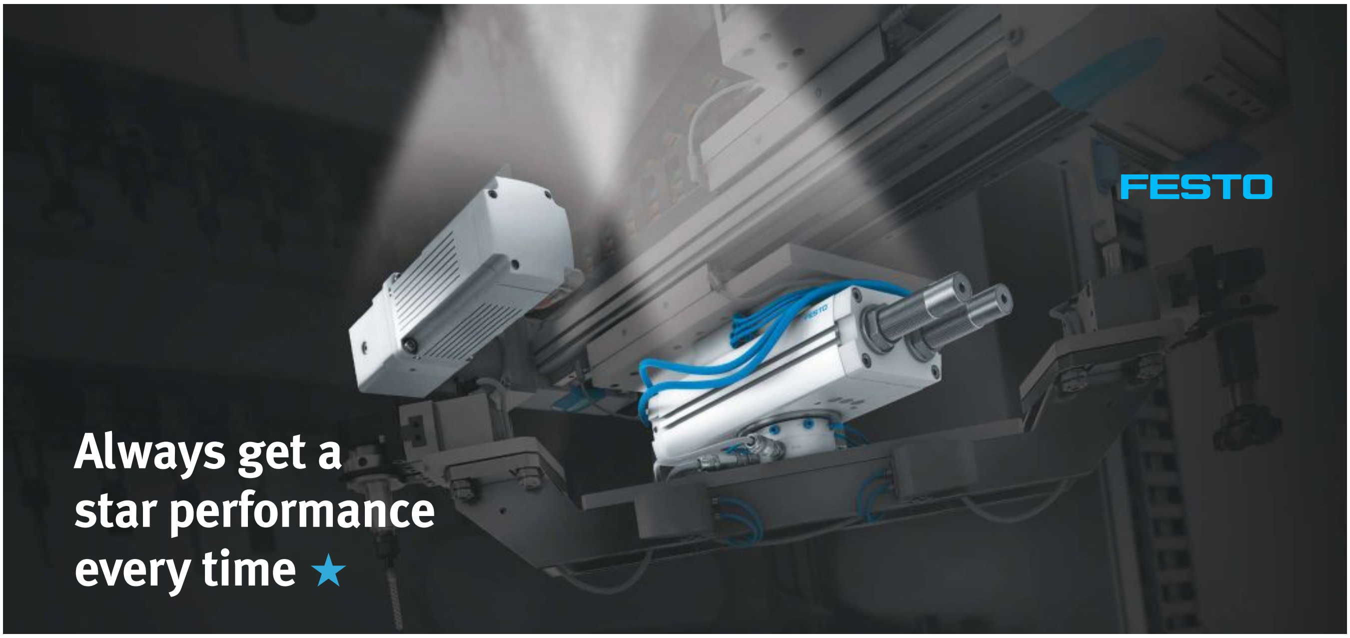
Although engineers as a whole reported an average salary hit in the past year, automation/control engineers had no such issue. Nearly 40% of U.S.-based respondents reported this as their job function, and it is clear that this is a prominent area for engineers to find some of the best value for their skills.

Automation/control engineers are also coming off a decade of significant growth, having seen average salaries rise by nearly 17 percent over that time, with 2% growth registered for last year. The 5% gain that automation/control engineers saw last year, we said, was likely not sustainable. However, given the number of aging and retiring engineers, along with many organizations still warning of a potential skills gap, we expect the demand for automation/control engineers, as well as their compensation, to remain relatively high.

While automation/control engineers made up the bulk of respondents, many other engineers of various job functions contributed to our survey, and we did not ignore them. In all, we collected data across 12 job functions to help depict the many options open for tomorrow's engineer, as shown in the chart.

Average salary by job function

Job function	Average salary	Percent respondents
Automation/control engineering	$119,292	39.4%
Consulting engineering	$139,423	3.9%
Design engineering	$112,053	5.6%
Engineering management	$150,457	8.2%
General or operations management	$130,540	3.7%
Operations and maintenance	$90,166	12.1%
Information technology	$119,722	1.8%
Process/plant/manufacturing engineering	$122,822	3.1%
Project management	$123,653	3.9%
Sales – business development	$132,142	6.3%
Teaching/instruction	$87,727	1.1%
Other	$107,289	10.8%



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FYI 69% of U.S. engineers report attending some form of training over the past year; 20.6% spent more than a week in training.

Unlike last year, however, most of these job functions reported decreases in average salary. Only automation/control engineers, process/plant/manufacturing engineers, engineering management, and sales professionals reported increases. A 6.3% salary rise for the process/plant/manufacturing engineers in 2019 set the pace, with this group seeing an average increase of $20,000 over the past two years.

Our survey collected a few responses from information technology engineers, and these professionals reported the largest drop in average salary (15.5%) compared to last year. However, given the growing need for professionals to be able to work with both information technology (IT) and operational technology (OT) systems, the overall value of these professionals remains high compared to many other functions.

Proven ROI for engineering degrees?

At a time when colleges may have to work to prove the value of many college degrees, the engineering field is one where the value is very clearly seen. The 48.6% of our respondents with college degrees reported a 13.5% higher salary than those who did not attend college. Advanced degrees paid off even further, with an 8.1 percent salary increase over those engineers with a bachelor's degree.

While college can cost a great deal for today's students, our survey suggests that engineering degrees, both undergraduate and advanced degrees, may boost salary opportunity by more than $10,000 annually. If this is indeed the case, the average engineer can find a decent return on investment (ROI) for his or her degree and an ability pay off student loans in just a few years.

Average salary by level of education

Level of education	Average salary	Percent respondents
High school graduate	$105,416	3.0%
Technical/trade school graduate	$99,477	15.4%
Attended some college	$109,385	12.3%
College graduate	$121,753	48.6%
Graduate school/advanced degree	$132,487	20.7%

The right industry can mean higher value

Education level is a big salary separator, but the industry an engineer works in also has a very significant impact. An engineer working in oil and gas, for instance, will likely have a larger salary than one working in food and beverage or water/wastewater.

The numbers in the chart show a wide spectrum of averages among industries. It is interesting to note that while utilities engineers (electrical, natural gas, nuclear, and water/wastewater) may not be paid as well as their oil and gas brethren, their average salaries have risen for a fourth consecutive year. Water/wastewater professionals in particular have reported a 17.5% ($17,622) rise in salary since our 2016 salary survey, so the utilities industry has been one of particular growth for engineers.

Average salary by industry

Industry	Average salary	Percent respondents
Chemicals	$126,574	8.1%
Education	$89,333	1.5%
Engineering consulting or systems integration	$128,643	20.3%
Food and beverage	$104,296	6.4%
Industrial machinery and equipment	$110,129	12.0%
Oil and gas	$140,942	11.5%
Pharmaceuticals	$121,071	3.5%
Utilities – electrical, natural gas, nuclear	$126,584	7.1%
Utilities – water/wastewater	$100,589	8.9%
Other	$109,463	20.6%

Experience rules

Although there are many differentiators that have measurable impacts on salary for today's engineer, none present as much variance as experience. It would seem to make sense that a 30-year industry veteran would make more than a fresh college graduate, and the numbers continue to back that up, as the chart shows.

By the time engineers hit 11 years in the industry, their earnings potential has already risen over 40 percent since they joined, according to our survey. Yet, if they continue accruing that experience, in another 20 years they can expect a 15% boost in earnings potential over that time.

Average salary by experience

Years of professional work experience	Average salary	Percent respondents
2 years or fewer	$64,722	1.8%
3–5 years	$82,647	5.1%
6–10 years	$98,631	9.5%
11–15 years	$110,675	11.2%
16–20 years	$121,698	11.8%
21–25 Years	$119,720	12.6%
26–30 Years	$126,015	16.6%
31 or more years	$130,632	32.6%

Recipe to maximize your engineering salary*

As we have conducted the Automation.com/*InTech* Salary Survey, we have built the following recipe for engineering and automation professionals to use to maximize their salaries. Like any great recipe, we tinker a bit, but the main ingredients have not changed much over the years.

- Get your bachelor of science degree (any kind of engineering will do). Then get your advanced degree. Bonus points if you can get your company to pay for it.
- Live in the U.S. or Western Europe. California and Texas are the best-paying states for today's engineers, but in every U.S. region, engineer salaries average six figures.
- Engineering/integration consulting is a lucrative area of great momentum. Chemical and oil and gas are also well-paying options. If money is your primary goal, do not teach engineering—go out and practice your trade. Previously, we recommended avoiding water/wastewater careers because of low salaries, but this appears to be changing.
- Show off your leadership attributes and get into management. Forty-five percent of survey respondents have at least one person reporting to them, and, in the U.S., their annual salary averaged $13,000 more than nonmanagerial engineers.
- Become indispensable to your managers and company. Take more training courses. Gain skills in integration, cybersecurity, and connectivity. Regularly research new technology and trends. There are more ways to enhance your company value than ever today.
- Stick with your profession and pay your dues. Engineering has a lucrative career ladder. There are not many industries with six figure earning potential within 10 years of entry, but engineering is one and demand is going to remain high.
- Advocate for yourself. At the end of the day, a profitable organization's priority has to be the bottom line. You are the only person that is guaranteed to look out for your interests. Other companies want your skills, and it is not rude to show your boss an offer sheet and remind him or her of your value.

*Results may vary depending on attitude.

We continue to hear companies worrying about a looming skills gap, with dozens of positions going unfilled due to a lack of qualified or experienced candidates. While our survey provides some evidence that paying one's dues and gaining experience does pay off, entry-level salaries have been taking a step backward. For rookie engineers in the U.S., salaries for entry-level employees (0–2 years of experience) fell 11.3% this past year.

There are variables that prevent us from coming to definitive conclusions, but it seems like closing the skills gap may require companies to boost the financial incentive to attract the younger employees needed. This could help alleviate any gaps that may result from the retirement of more experienced engineers.

FYI **20.9% of surveyed U.S. engineers reported a raise of 5% or higher in 2019.**

In general, job satisfaction among U.S. engineers appears to be holding steady. Just as we reported last year, slightly more than 54% of those surveyed in the U.S. say they are not looking for new opportunities. This group had an average salary of around $123,000.

As one might expect, money seems to be a factor in whether or not someone is looking for a new opportunity. Those who claimed they were "passively looking" for new opportunities made an average salary that was 6.2% less than those who were not looking at all. Those who described themselves as "actively looking" made an average 16.3% less than those not looking. So, again, organizations looking to facilitate higher job satisfaction among their employees might see some positive results with financial incentives. ■

ABOUT THE AUTHOR

Cory Fogg (cfogg@automation.com) is content editor for the Automation.com website, newsletters, and ebooks.

View the online version at www.isa.org/intech/20191001.

What has industry learned about model-based multivariable control?

And where do the lessons lead going forward?

By Allan Kern, PE

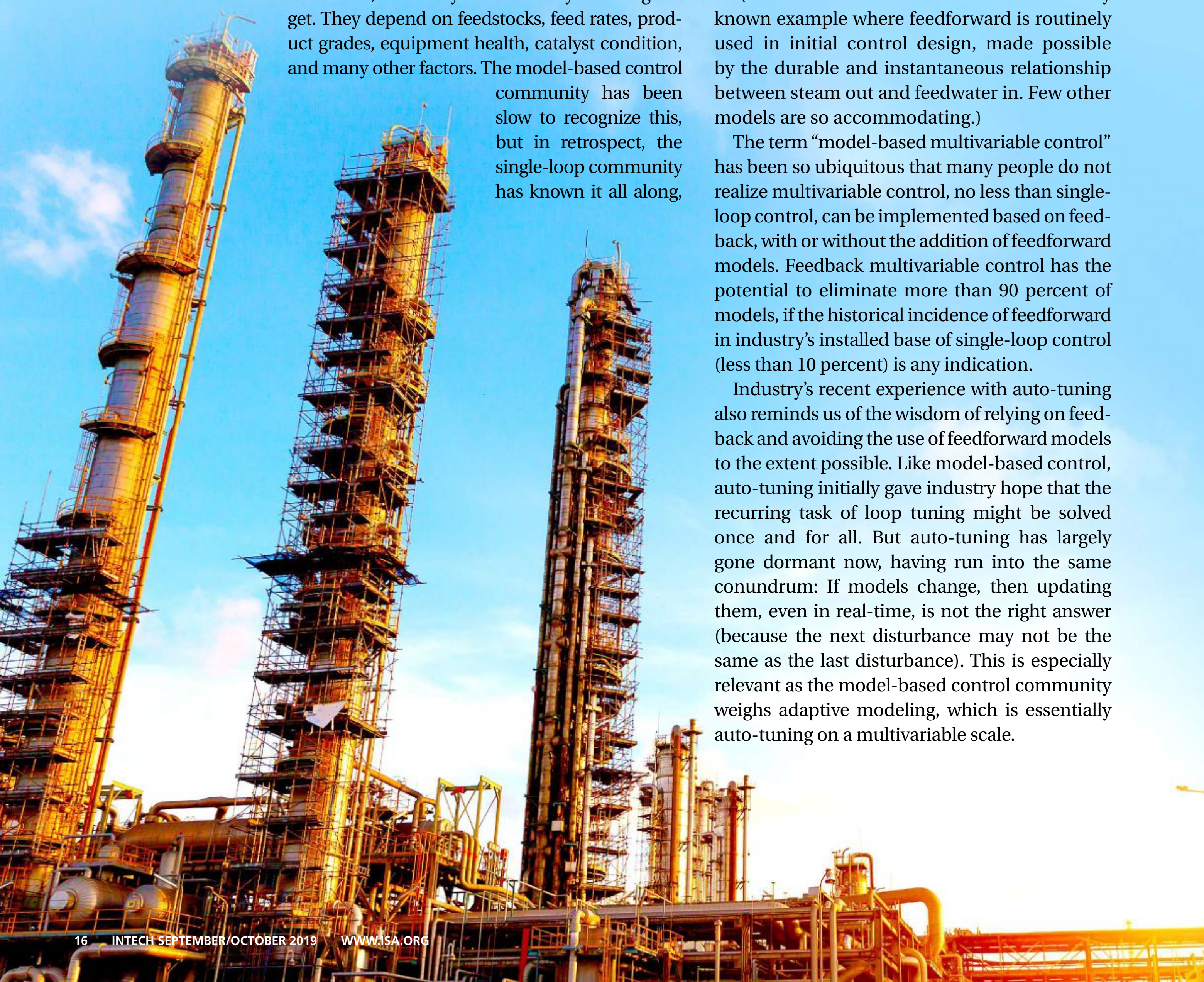
When model-based multivariable control made its debut in the 1980s, it was expected that process models, once acquired through a plant step test, would be durable and long lived. However, this assumption proved to be mistaken, revealed in the form of "clamped" manipulated variables and "degraded" performance. Multivariable control technology has struggled with this problem ever since.

Experience has shown that most models are short lived, and many are essentially a moving target. They depend on feedstocks, feed rates, product grades, equipment health, catalyst condition, and many other factors. The model-based control community has been slow to recognize this, but in retrospect, the single-loop community has known it all along, and industry attempts at auto-tuning have also recently refreshed this lesson.

In single-loop control, feedback is universally the first choice, due to its low cost, ease of implementation, and high rate of success and long-term reliability. Feedforward (which is the single-loop equivalent of model-based control) is only used sparingly, because of its greater difficulty of implementation and risk of unstable performance due to model error, sooner or later. (Boiler drum level control is almost the only known example where feedforward is routinely used in initial control design, made possible by the durable and instantaneous relationship between steam out and feedwater in. Few other models are so accommodating.)

The term "model-based multivariable control" has been so ubiquitous that many people do not realize multivariable control, no less than single-loop control, can be implemented based on feedback, with or without the addition of feedforward models. Feedback multivariable control has the potential to eliminate more than 90 percent of models, if the historical incidence of feedforward in industry's installed base of single-loop control (less than 10 percent) is any indication.

Industry's recent experience with auto-tuning also reminds us of the wisdom of relying on feedback and avoiding the use of feedforward models to the extent possible. Like model-based control, auto-tuning initially gave industry hope that the recurring task of loop tuning might be solved once and for all. But auto-tuning has largely gone dormant now, having run into the same conundrum: If models change, then updating them, even in real-time, is not the right answer (because the next disturbance may not be the same as the last disturbance). This is especially relevant as the model-based control community weighs adaptive modeling, which is essentially auto-tuning on a multivariable scale.



Optimization belongs in the business layer

After model maintenance, the embedded optimization programs that are integral to conventional multivariable control technology form a large part of application cost, maintenance, and complexity. Fortunately, experience and evolving technology make it possible to leverage optimization results from the business layer and eliminate optimization from the control layer, where it becomes largely redundant and is probably inappropriate.

The business layer has a much more complete and global optimization solution, because it has access to much more information. With today's technology, business-side optimization solutions (or parts thereof) can be updated at higher frequency if necessary. Any results that affect constraint limits or optimization targets in the control layer (which in practice are actually quite few) can easily be pushed down to the control layer, either via connectivity or simply via the operating chain of command. Both of these methods are common practice in industry today.

Moreover, optimization at the control network layer is probably inappropriate from a process control and automation principles point of view. End users expected multivariable control maintenance and support to decrease as the technology matured, but instead they have steadily increased with no sign of abating. As this has unfolded, many have lost sight of the fact that industrial automation applications should be robust and deterministic, and carry minimal support and maintenance requirements, in order to minimize unnecessary activity on the control network, for reliability and security purposes. Optimization by its nature does not meet these application criteria.

FAST FORWARD

- **Efficient model-based control depends on reliable models, but models have proven to be very fragile. This conundrum is unlikely to be solved, but it can be mitigated.**
- **Optimization is at home in the business layer, but it is out of place, unnecessary, and even inappropriate in the control layer.**
- **The conventional multivariable control paradigm has a large footprint that is increasingly seen as unsustainable. A smaller, more efficient paradigm is emerging.**

Table 1. Potential aspects of a new multivariable control paradigm
Multivariable control is no longer a complicated "black box" application, but a fundamental aspect of nearly all process operations and a basic piece of control and automation.
Multivariable control, like single loop, is predominantly feedback, with limited use of feedforward models.
Optimization is removed from the control layer, with relevant constraint limits and optimization targets leveraged from the business optimization and planning layer.
Multivariable controller scope, objectives, and benefits are identified in matrix diagrams and are as plain as closing any loop—*multivariable control closes the loop on the matrix.*
Multivariable control tools become simpler, more affordable, agile, easy to use, and operation friendly.
Model selection, matrix design, and optimization give way to the Pareto principle, rather than the conventional "large footprint" (more is better) paradigm.
Control engineers focus more on control and automation and less on models and optimization.
The approach captures many smaller but more numerous multivariable control applications, such as individual columns, that have remained below the radar or economic hurdle of the large matrix, model-based paradigm.
A more affordable and agile tool most closely reflects the modern flexible manufacturing paradigm.
Multivariable control becomes a core competency and falls with normal operating budgets, schedules, and support, rather than a specialization requiring off site support, dedicated budgets, and long schedules.

Emerging paradigm

If it is hard to imagine (at first) that the (often esteemed) task of multivariable control and optimization can be accomplished without large burdens in modeling, optimization, and maintenance, then it helps to realize that this, too—the essential role of multivariable control in industrial process operation—has also come into a more practical and realistic focus with the hindsight of experience.

Multivariable control, traditionally viewed as a complex, monolithic piece of automation with often difficult-to-discern objectives and benefits, can now be seen as a fundamental aspect of nearly every industrial process operation, and (therefore) as a fundamental part of process control and automation going forward. The functional specifications of multivariable control applications can be succinctly captured in matrix diagrams, with the objectives and benefits as plain as those of closing any loop—*multivariable control closes the loop on the matrix*. (See sidebar.)

In this emerging multivariable control paradigm:

- Multivariable control, like single-loop control, is predominantly feedback, with selective (not wholesale) use of feedforward models.
- Optimization is removed from the control layer and leveraged as necessary from the business layer.
- Applications can be succinctly defined using a matrix format, with scope, objectives, and benefits as plain as closing any loop.

With the elimination of 90 percent of modeling and optimization, multivariable control becomes much simpler, more agile and affordable, easier to use, and more operation friendly overall. Smaller, more numerous applications can be expected to proliferate, since optimization will no longer drive monolithic matrix designs. Table 1 lists additional potential aspects of an emerging multivariable control paradigm. ■

ABOUT THE AUTHOR

Allan Kern, PE, has 35 years of industrial process automation experience and has authored dozens of papers on more practical, reliable, and sustainable advanced process control solutions. Kern helps companies improve process efficiency, quality, and profits on site or with online consulting complementing in-house resources, helping bridge a skill shortage at many sites. He is the founder of APC Performance LLC and the inventor of patented Rate-Predictive Control (RPC®) and Model-less Multivariable Control (XMC®). For more information, visit APCperformance.com.

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Multivariable control: Closing the loop on the matrix

When console operators adjust controller set points and outputs in the course of a shift, they are doing manual multivariable control. When a piece of process automation is deployed that manipulates those set points and outputs automatically, that is automated (or closed-loop) multivariable control (also known as advanced process control [APC]).

Multivariable control simply means adjusting the available single-loop controllers to keep related process variables within limits, and to move toward more optimal operation to the extent possible. This is an inherent and natural aspect of nearly every industrial process operation, from a feed drum to a crude oil distillation column (figure 1).

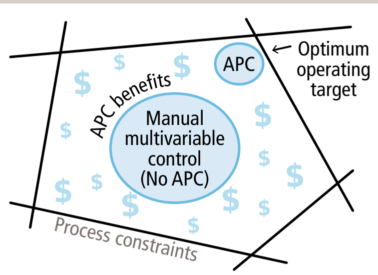

Figure 1. When an operator adjusts controller set points in the course of a shift, that is manual multivariable control. When this is automated, that is closed-loop multivariable control. Multivariable control is an inherent aspect of nearly every industrial process operation, from a feed drum to a crude oil distillation column. Automated multivariable control brings the same important benefits as closing any loop.

Perhaps the most important contribution to industry from the model-based multivariable control era will ultimately prove to be—not model-based control—but popularizing the concept of the matrix within the process control and operation communities. The matrix provides a concise method to diagram the multivariable nature of any process. A matrix consists of the available set points and outputs along one axis (also known as "handles" or manipulated variables [MVs]), the controlled variables (CVs) along the other axis, and models (or at least model *directions*) at various locations within the matrix, which indicate which MVs can be used to control which CVs.

A knowledgeable team, which comprises process engineers, control engineers, and experienced operations personnel, can develop a matrix diagram, including constraint limits, optimization targets, and other key parameters, for most processes in a single *meeting* (with no plant test). The matrix then becomes the heart of multivariable control, whether manual or automated. (Matrix diagrams have not migrated out of the multivariable control space to become common operation and training aids, but a good case can be made for availing matrix diagrams in this role.)

Automated multivariable control has obvious benefits over manual multivariable control, just like closing any loop. Benefits come in timeliness and consistency of action, reliability of constraint control, and maximizing optimized operation to the extent possible. Automated multivariable control also offloads this time-consuming task from operators and process engineers, who then have more time for other priorities.

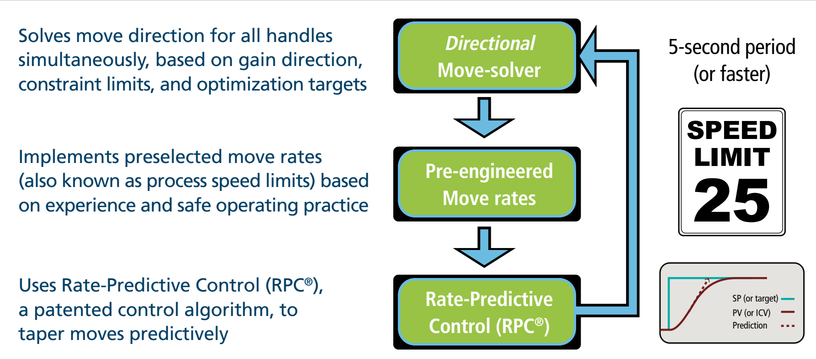

Figure 2. Model-less multivariable control (XMC) automates the way operating teams have always carried out multivariable constraint control and optimization manually. Notably, this method does not require detailed models or embedded optimizers. XMC uses rate-predictive control as its internal feedback control mechanism.

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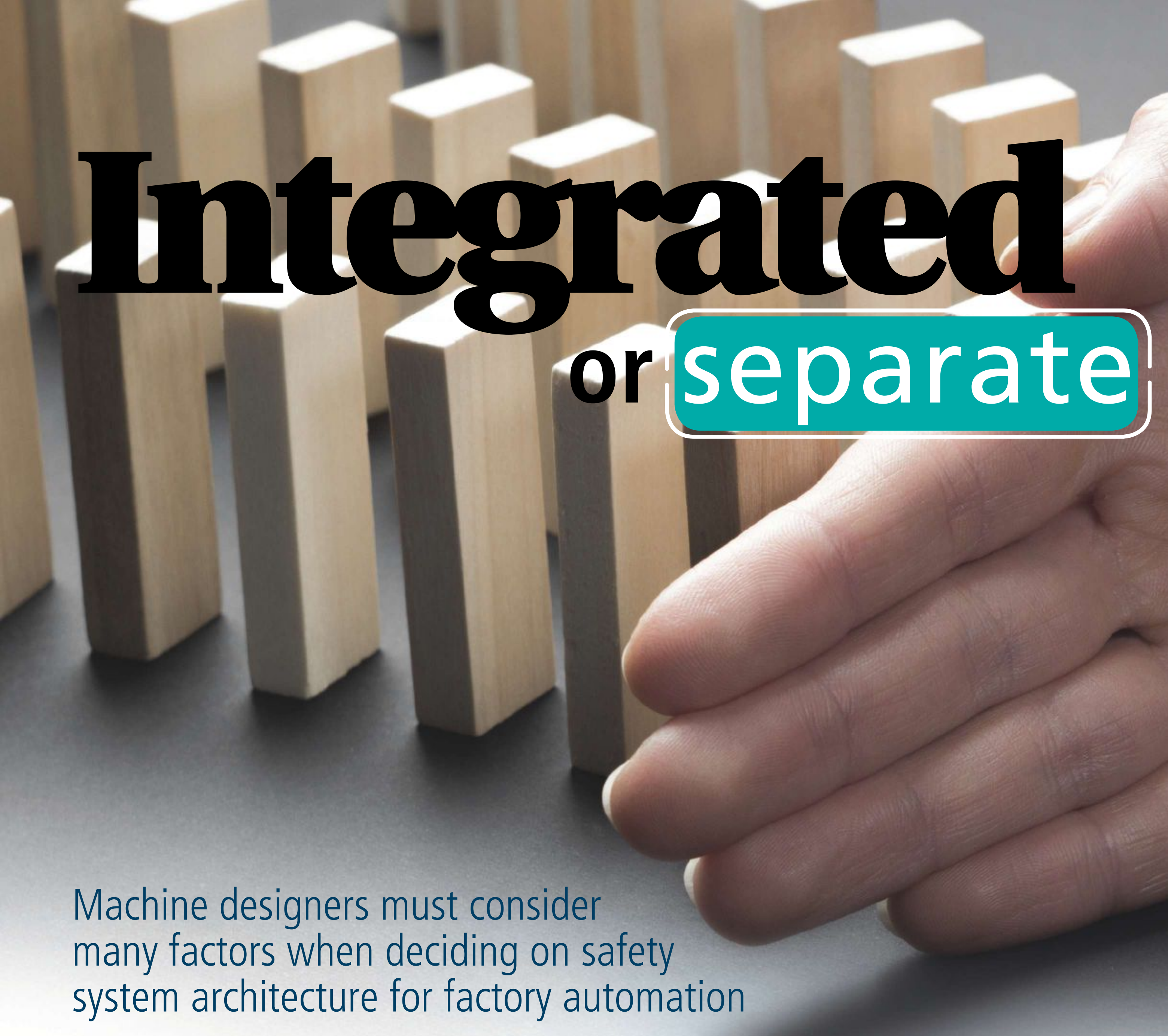

Integrated or separate

Machine designers must consider many factors when deciding on safety system architecture for factory automation

By Larry Reynolds

Factory equipment continues to become increasingly intelligent in large part due to the improved processing power and communication abilities found within underlying controllers, sensors, and components. This is true for basic machine operation and functionality, as well as for the safety systems. Therefore, just as designers must evaluate features when selecting an automation platform, they also need to consider safety system options.

Equipment automation can be deemed a critical application, yet it is clear that properly designing the safety aspects are even more crucial. This has typically meant applying safety components to the fundamental automated system, throughout the life cycle of the system. The purpose of a safety system is to bring a machine to a safe state as quickly as possible if a safety sensor is triggered by personnel or equipment conditions, or an emergency stop pushbutton.

The most basic safety systems are based on hardwired safety relays. More flexibility and other advanced capabilities are available with digital safety controllers and safety-rated smart relays, which can be used in conjunction with nonsafety automation controls. Taking this a step further, there are complete control platforms available for merging factory automation and safety functions into a single integrated digital system. This article discusses evaluations that designers and engineers should perform as they consider the right safety system fit for their machine automation application.

FAST FORWARD
- Always begin with a risk assessment.
- Three typical approaches are: using hardwired safety relays, configuring safety controllers, or integrating safety with equipment controls.
- Machine safety usually, but not always, means stopping everything as fast as possible.

safety systems

Risk assessment comes first

Regardless of the final safety system approach, the first step is for qualified personnel to perform a risk assessment to identify potential hazards. Team members with backgrounds in design/engineering, equipment function, operations, and maintenance apply their experience to identify risks, the frequency and duration of worker exposure, and how risks can be removed or mitigated. Equipment manufacturers generally follow methods outlined in various standards, such as ANSI B11.0, ANSI B11:19, ANSI/RIA R15.06, or ISO 12100 to name a few.

In very general terms, if an unsafe condition can be sensed, then the equipment should be deenergized and stopped, or in some instances, the equipment should just hold its position or return to a safe position. Unsafe conditions can include a variety of situations, such as an out-of-place guard, a pressure mat sensing a worker entering a hazardous area, a pushed emergency stop button, or even a failure within the safety system itself. Field devices may be simple like an emergency stop pull-cable, or more complex like a configurable light curtain.

Safety systems must be designed, installed, wired, and configured to act based on condition monitoring to make the equipment as safe as possible. A risk assessment is fundamental to understand the hazards, and how the equipment can be brought to a safe state when an unsafe condition is detected.

Driving to a safe state

Understanding the concept of a safe state is important to any safety discussion. Most often, a safe state is achieved by removing sources of energy, such as electricity, compressed air, or hydraulics. Some high-inertia equipment can be commanded to actively brake to a faster stop using regenerative variable frequency drives or other mechanical means. There may be mechanisms requiring activation to lock the equipment in position.

In some situations, there may be a requirement to maintain power to hold equipment in the safest state. Some energized equipment may hold product or tooling in an elevated position because deenergizing it would cause the material or equipment to drop in a way more unsafe than just a holding position. From the standpoint of IEC 60204-1 or NFPA 70, there are three stop categories that designers may consider in their effort to drive equipment to a safe state:

- Category 0: An uncontrolled stop by immediately removing power to the machine actuators.
- Category 1: A controlled stop keeping machine actuator power available to achieve the stop, and then removing power once the stop is achieved.
- Category 2: A controlled stop with power left available to the machine actuators.

A risk assessment will not only define the risk, but also identify how best to remove it. This in turn points to what devices can be applied for best safety.

Paths to proper safety

Having defined the risks and how the equipment can be driven to a safe state, the design process turns to specific means and methods for implementing a safety system. Here the team will find three main paths:

- basic safety relays
- individual safety controllers or safety-rated smart relays, sometimes used in conjunction with nonsafety automation controls
- fully integrated equipment/safety control systems where machine control and safety monitoring are performed on the same platform, such as a safety programmable logic controller (PLC)

Many safety solutions could be implemented in any of these three ways with acceptable performance. Therefore, designers will need to consider some other criteria outside of basic safety, such as:

- hardware costs
- installation costs
- design effort required
- programming/configuration effort required
- maintainability for troubleshooting
- operator friendliness
- long-term support
- ease of future updates or modifications

More advanced safety components, especially for the fully integrated approach, can cost much more from a hardware and configuration standpoint than basic safety devices do. Sometimes this cost is somewhat offset by that fact that basic safety components often require a higher installation cost. Also, if long-term maintenance and operations are considered, there are many benefits to safety controllers and fully integrated systems.

The following sections explore the advantages and downsides of each approach.

Figure 1. A basic machine like this tape wrapper can be designed to provide the necessary safety using safety relays and light curtain relays.

Basic safety relays

Hardwired safety control wiring was the original method of providing machine safety, because much of machine automation uses electrical signals that can be interrupted to stop operation. Even pneumatics, hydraulics, and other types of nonelectrical stored energy can incorporate solenoids or other electromechanical means for deactivation.

Designers can improve wired safety for handling more complex situations by designing it with safety-sensing devices and relays that are energized when conditions are safe and deenergized when they are not to provide a fail-safe function. These devices incorporate features like redundant signal sensing to satisfy control reliability and circuitry to analyze the inputs.

Some safety relays are similar to standard relays with added safety features, such as monitored auxiliary contacts, while others may have additional characteristics making them specifically adapted to functions like emergency stop button circuits or light curtains for a basic machine (figure 1). Sometimes a more advanced safety relay may be used in conjunction with a standard safety relay, such as to increase the number of controlled outputs. When specific hardwired safety components are used, often in a redundant fashion, a high-reliability safety circuit is the result.

Modern safety relays are specifically standardized components, with features like electrically isolated and mechanically force-guided operational contacts and monitoring contacts, to best ensure that the relay functions as intended and provides notification if there is a malfunction (figure 2).

Figure 2. Safety relays, like these examples from AutomationDirect, range from fundamental and reliable hardwired electromechanical force-guided relays to more advanced versions with additional features optimized for functions like emergency stop buttons or light curtains.

Basic safety relay designs also provide good familiarity for design and operations personnel, and the components themselves are economical. Safety relays are often used in conjunction with more advanced and expensive components to multiply safety outputs and interlock multiple electrical devices. Another feature to consider is that safety relay circuits are a separate system from any automated controls. The controls may monitor the safety circuit or even trip it, but they otherwise operate independently in parallel, an advantageous approach in many cases.

There are some considerations with the tried-and-true basic safety relay approach, however. These devices are less suitable for more complex safety designs. Furthermore, their hardwired nature means they are more difficult to modify in the future if there are technical product advancements or a need to improve the safety architecture. Another important consequence concerns the significant amount of field wiring that may be required to achieve the performance level required by the risk assessment. Recognition of these issues and the availability of high-value and high-performance electronics led to the creation of individual safety controllers.

Individual safety controllers

With the introduction of robust digital industrial automation electronics, the progression from basic safety relays to individual safety controllers was natural. Many safety controller components look much like smart relays, and their outputs may operate similarly (figure 3).

However, safety controllers offer many expanded features. They can be all-in-one devices with inputs and outputs (I/O), or they may be modular with connectable components for the controller, inputs, outputs, and communications. This expandability enables safety controllers to easily connect with many more field devices.

A flexible configuration environment is another key attraction. Inputs and outputs are managed through software configuration. This means that zones can be assigned and even overlapped as necessary and changed in the future via an easy configuration change, instead of requiring a field wiring change, as with basic safety relays. All field devices are simply home-run to the safety controller, and more complex hardwired interconnection schemes are avoided.

Finally, because safety controllers usually have digital communications options, it is possible for the associated nonsafety automation control system to easily monitor the status of all safety system signals, while keeping the two systems independent.

The downsides revolve around cost-per-point for the components and the engineering cost to learn the programming software. For very small I/O counts, a safety controller will likely be more expensive than a few basic safety relays due to the step cost of the controller.

However, for larger I/O counts, a safety controller solution will become comparable to or less expensive than hardwired safety controls, when all hardware and installation is considered. And once the designers have learned the software, they can apply their design efforts to software configuration if any changes are needed, as opposed to inflexible hardwired circuit designs inherent to systems employing basic safety relays.

Full integration of equipment control with safety control

Machines and other factory equipment are often automated using programmable logic controllers, a very mature technology that can and often does work in conjunction, although in parallel, with basic safety relays or safety controllers. There are also specialized safety-rated PLCs that combine the equipment control abilities of standard PLCs with the safety functionality of safety controllers.

Safety PLCs are generally used for more complex systems with many I/O. They are very flexible and offer as many safety functions as safety controllers. Because equipment control and safety functionality are both handled within a single controller, there are no communication issues, and all configuration is handled within a consistent programming environment. More advanced diagnostics are available to help engineers and end users. However, keep in mind that equipment programming and safety programming are two separate activities.

The complexity of fully integrated safety PLCs comes at a price, which is higher for the hardware platform itself.

Figure 3. Safety controllers, such as these MOSAIC examples, are far more advanced than basic relays, with additional protective features, configurability, expandable I/O options, and even communication capabilities.

Figure 4. Advanced safety relays or safety controllers are more suitable for more complicated moving equipment installed within a guarded cell.

It also demands a greater skill level to perform the programming. Their more specialized nature may also make them more challenging for end users to support as compared with standard PLCs and simpler safety systems.

Typical applications for this type of solution are found when a large proportion of the I/O points are safety related. When only a relatively small number of I/O points are safety related, this approach will be much more expensive than separate control and safety systems.

Making a safe choice

Each safety design situation and equipment application requires consideration of the equipment, risk, and safety provisions. Designers may find the following guidelines applicable.

For the most basic systems with few safety I/O and simple needs, basic safety relays are economical, easy to design, and readily maintained. If the I/O count is more than a few points or any more advanced features are needed, especially communications to a PLC, then safety controllers are an excellent fit and may result in an installed cost comparable to that of an equivalent relay system.

Fully integrated safety-rated PLCs allow equipment manufacturers and original equipment manufacturers (OEMs) to consolidate their control hardware bill of material and provide a tightly integrated automation and safety package. Once an OEM is geared up to use these more complex controllers, it may realize ongoing savings and performance benefits from this approach, although initial costs will be quite high.

However, if end users will be supporting this fully integrated control/safety equipment, they need to consider personnel training costs. If costs are prohibitive, end users may be better off specifying a consistent application of safety relays or controllers.

Equipment protection

A final thought regards equipment protection in conjunction with personnel safety. These are related but not to be confused. Of course, personnel safety is absolutely the highest concern, and safety design must always be accomplished in accordance with industry standards.

However, designers can also apply many of the same safety concepts and components to provide automation that attempts to protect equipment and processes from improper operation, especially in the case of a failure or error. By preventing machinery from experiencing collisions or otherwise destroying itself, the safety risk is also reduced for personnel. Consider a grinding wheel where a speed control relay can be employed to limit the maximum speed, so the wheel will not fail, which could injure workers.

Another example is a robot system or similar moving equipment installed within a caged area known as a cell (figure 4). Safety systems can be configured such that if the gate is forcibly opened, the robot will undergo a rapid shutdown to protect personnel, even at the expense of product loss or equipment damage. However, other stop conditions might allow a more controlled robot stop while keeping the gates locked, and only unlock the gates when all energy is removed. This sort of good engineering practice keeps systems in operating order and helps prevent downtime while maintaining work safety.

For safety designs, there are three main approaches that are progressively more complex, capable, and costly. When designers complete a risk assessment and look at the cost versus performance options, they can determine the appropriate solution. ■

ABOUT THE AUTHOR

Larry Reynolds (lreynolds@automationdirect.com) is a product engineer for safety components at AutomationDirect. He started his career over 30 years ago and has served in many industry roles, such as technical specialist, radiation safety officer, plant safety officer, project manager, control designer, and system integrator. He has also specialized in safety applications for automation systems. Reynolds has a BE degree from Cleveland Institute of Technology, is a certified Project Management Professional, and has a Functional Safety Engineer certificate from TÜV.

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Steam control valves in food

By Jason Carpenter

Best practices, such as choosing options with a wide flow range and tight temperature control, ensure reliable service

Food and beverage applications must meet a variety of process temperature and pressure control requirements to maintain the tight temperatures that ensure product quality and safety. Selecting the right steam control system, and using best practices for piping and installation, can have a huge effect on production, downtime, and the health and safety of end users.

Steam control systems, which include control valves, steam traps, and condensate recovery equipment, are critical in many food and beverage applications. Key applications include clean-in-place (CIP) processes and high-temperature/short-time (HTST) pasteurization used in dairy, cheese, milk, and ice cream manufacturing. Other widely used steam processes include retort sterilization in canning operations, bottle washers, tempered hot water systems, condensate of

FAST FORWARD

- Food and beverage applications must maintain tight temperature control to help ensure product quality and safety.
- Selecting the right steam control system and using best practices for piping and installation can have a huge effect.
- Consider a rotary globe valve with a 100:1 turndown to simplify the process and allow tight performance control.

and beverage applications

whey (COW) water, poultry scalders, flash steam peelers and blanchers, evaporators, direct steam injection processes, and hot air dryer systems.

These applications all use a temperature controller with a valve to maintain a separate temperature. The valve is critical, because operators must maintain very tight temperature control to avoid issues that would otherwise occur, like bacteria growth or loss of product.

The challenge faced by many food and beverage applications is that they often do not have a set flow range. This variation of flow ranges is especially true for plants that run different products at different times. For example, at many plants the HTST pasteurization flow can range from 10,000 pounds per hour to 2,000 pounds per hour. To maintain proper temperature control in the face of changes in flow, operators must use a control valve with varying rangeability and excellent shutoff characteristics.

Unfortunately, operators too often use a cookie-cutter approach for steam isolation on modulating process steam equipment. For example, many systems incorporate a pneumatically activated, quarter-turn ball valve to assist in shutting off the steam to the heat exchanger. Users typically select the ball valve because the standard globe valve applications in the market have leaked. Using an actuated ball valve for isolation on the steam train to the process can lead to water hammer, pressure spikes, loss of product, or bacteria growth.

In contrast, a rotary valve has exceptional shutoff and can meet FCI ANSI Class V shutoff on steam for these process applications. This eliminates the need for actuated ball valves for isolation on the steam train to the process. Rotary valves also can enable precise control over a wide range of flows and provide a long service life.

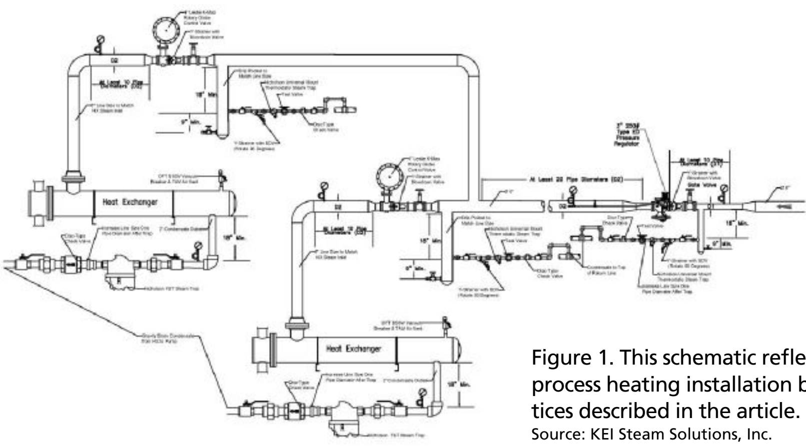

Figure 1. This schematic reflects the process heating installation best practices described in the article.
Source: KEI Steam Solutions, Inc.

An example is the K-Max rotary globe valve. Its rangeability is 100:1, allowing control over a wide range of flows, so a plant can use the same control valve for all the facility's steam and fluid-control applications. There can be quite an advantage to using one valve style for many applications, because a plant can standardize and minimize stocking requirements.

Best practices for clean in place

An example of a best-practice installation for a CIP process that performs at high level (figure 1) was developed by Kevin Rasmussen, president of KEI Steam Solutions, Inc. The Green Bay, Wis., industrial machinery and equipment company provides end-to-end solutions to the food and beverage processing industry.

"The setups used today typically require a lot more service and maintenance because they are not laid out or selected correctly and lack best-practice piping, which can cause equipment to fail," said Rasmussen.

Use of best practices increases productivity, reduces downtime, and increases equipment reliability on the systems. "In addition to using best-practice implementation methods, plant operators should always conduct an annual evaluation of steam and condensate equipment to make sure the equipment is running at optimal levels," Rasmussen added.

CIP systems for the food and beverage industry use steam to heat water in the process through the noncontact heating of a heat exchanger, or through direct injection of the steam into the CIP tanks. The rotary globe control valve can be used for heat exchanger temperature control. The turndown allows for maximum temperature and pressure control across a wide range of flow variations. This is critical in CIP heating, where load variations are constant and the application requires consistent temperature control. The application requires very tight shutoff when the system is not in operation, so there is no steam and condensate losses and degradation of the heat exchanger.

Another issue in food and beverage applications is the steam trap and condensate return system, which should remove condensate quickly to allow heat transfer to occur and eliminate the stall point. The best-practice solution includes condensate elimination for the CIP heat exchanger.

Using a Nicholson NFT free-float steam trap allows facilities to continuously remove condensate from the heat transfer surface, allowing for proper heat transfer to the product. Unlike standard float and thermostatic traps, this free-floating steam trap does not have any mechanical linkage. It has a variable orifice that will modulate with the continuous condensate load for fast, efficient condensate removal and process temperature control.

In addition, the best-practices setup also eliminates condensate from stalling or stacking into heat transfer surfaces by using a steam motor or a steam pump and trap combination. When using a modulating control valve, all condensate lines must be drained by gravity or pumped back to the boiler room.

For example, facilities can use a Nicholson condensate steam/air motive pump to recover and pump the condensate back. This eliminates the need for electric pumps, control panels, and wash-down-rated controllers. The ASME-rated pump operates on motive steam or plant air to push the condensate back to the boiler room for energy and utility recovery. Figure 2 shows the standard setup on the top, and the pump and trap combination below. The ideal setup includes a main pressure-reducing valve for reducing the steam pressure to the CIP system from main plant pressure. Examples include a Spence ED or Leslie GPKP.

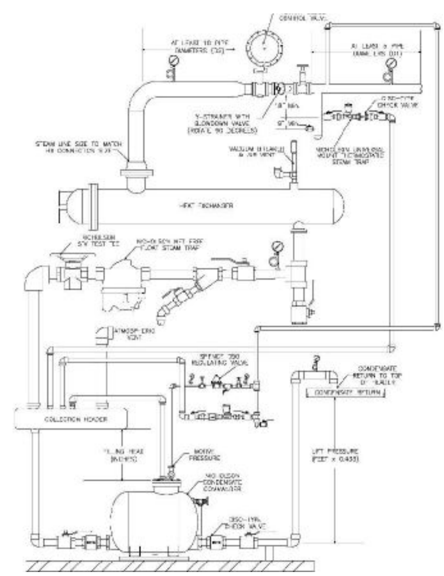

Figure 2. Condensate recovery using the standard pump option is shown in the top schematic. A pump-and-trap option is shown below.
Source: KEI Steam Solutions, Inc.

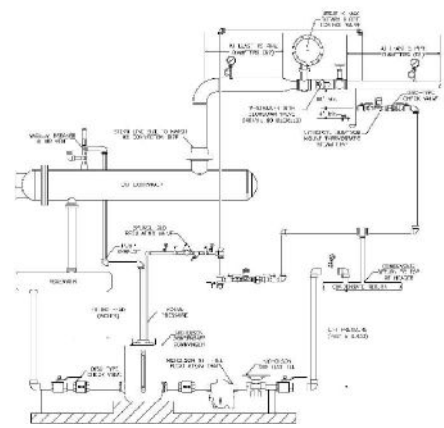

Figure 3. A Midwestern cheese manufacturing plant "before," using an automated ball valve and a range of improper practices.
Source: KEI Steam Solutions, Inc.

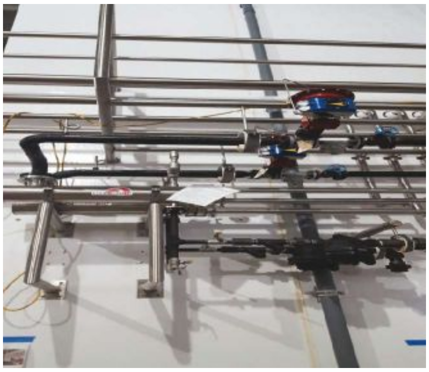

Figure 4. The cheese manufacturing plant after implementing a rotary control valve and other best practices.
Source: KEI Steam Solutions, Inc.

It should be noted that a best-practice implementation also positions plants to take advantage of energy savings from recovering condensate, which can be like liquid gold to a process. This type of setup helps a plant meet the required balance between energy recovery and food product performance. It also helps answer the question, "How can I maintain my control without having to install costly extra bells and whistles?"

Improper practices

To illustrate the benefits of a steam control system designed in accordance with best practices, consider the example of a large cheese manufacturing facility that recently overhauled its setup from an automated ball valve to the rotary valve setup. Figure 3 shows the "before" state, with a variety of improper practices. These include:

- No drip steam trap was installed for condensate removal before the control valve to prevent valve seat wire drawing.
- The installation has an automated ball valve for isolation directly before the control valve, which offers only on/off service. This will likely cause premature failure of the control valve and heat exchanger tube bundle. It will also cause instability in the process control.
- The control valve is piped too close to the heat exchanger inlet, which does not allow for the velocities to expand out on the pressure reduction through the control valve. The minimum should be 10 pipe diameters of straight pipe run after the control valve of the heat exchanger inlet connection size.
- The heat exchanger should use a continuous-type steam trap or variable orifice steam trap, which continuously discharges condensate to remove condensate from the heat transfer surface and allow for full latent energy utilization.
- The condensate must be gravity-drained to a condensate pump for full condensate removal. This can be done with a steam/air motive pump or electric condensate pump.
- The setup has no thermostatic air vent for the removal of air on startup of the heat exchanger. Without proper air removal, the heat exchanger may experience lagging startup times, improper heat transfer, and air binding of the equipment.
- There is no Y strainer protection before the control valve to allow draining of the piping and removal of scale and debris.

Best practices in action

Figure 4 shows the same cheese factory once a new solution was installed following best practices. The seven best practices shown include:

1. A rotary control valve provides tight process temperature control and isolation in one valve. There is no need for a ball valve isolation, because the rotary globe valve allows for 100:1 turndown for process control rangeability, Class V shutoff, and larger CV.
2. Proper piping layout before and after the control valve to the heat exchanger ensures performance will be optimal.
3. The new setup features the correct use of a thermostatic air vent with vacuum breaker on the heat exchanger.
4. Correct discharge piping utilizing a variable orifice free-float steam trap provides continuous condensate evacuation on the heat transfer surfaces.
5. Proper drip pockets and Y strainer protect the control valve from wire drawing of the valve seat.
6. Gravity draining the steam traps to the steam/air motive condensate pump or electric condensate pump provides proper condensate removal from the heat exchanger.
7. Expanding the piping after the steam trap, the setup includes one pipe diameter for a flash allowance from the trap discharge.

Implementation of best-practice equipment selection, piping, and procedures will result in reliable long-lasting service and control of equipment and processes. Because many food and beverage plant operators do not have the technical expertise to ensure the equipment setup is properly implemented, they may be relying on vendors and process equipment providers for this service. That is why promoting best practices is critical to making the process work correctly. ■

ABOUT THE AUTHOR

Jason Carpenter, business program manager for CIRCOR International, has almost two decades of experience. He manages the company's portfolio of control valves, regulators, steam-fired heaters, and steam straps for applications in the food and beverage, pharmaceutical, chemical, and pulp and paper industries in the Americas.

View the online version at www.isa.org/intech/20191004.

Taming your process automation data

The challenge—what to do with all this data

By Brian E. Bolton

Technological advances in automation and control have grown to a point where trying to keep up with them is increasingly difficult. The amount of data being produced has far exceeded "big data." Thus, the need to capture and store data has risen. Fortunately, the cost of data storage has dropped. The real challenge is figuring out what to do with all this data. We must unlock the data, analyze it, and decide what data is business critical and what data will make us more productive. We only need one set of data based on real facts. We can then use the information to improve business efficiency and processes.

For a long time when we heard the term *process automation data,* we immediately thought of manufacturing data (e.g., a valve being open or closed, the level in a tank, the temperature in a vessel, or a motor being off or on). As instruments and equipment became more advanced, process automation data followed suit. We could analyze the data to determine when a valve was opened, how long it took to open it, how

long it remained open, when it was closed, and how long it took to close it.

For instance, a valve could control cooling water being applied to a vessel to ensure a product was cooled to its specified shipping temperature. With the data from the valve, we could then determine the daily effectiveness of the cooling system. As simplistic as this information seems today, at one point in time, this type of data was considered advanced process automation data. Understanding where the process automation data comes from and how to consume and analyze it provides decision makers with the information needed to successfully run the business.

System data

Data acquisition (DAQ) is the process of measuring an electrical or physical condition, such as voltage, current, temperature, pressure, or sound, with a computer. A data acquisition system consists of sensors, data acquisition measurement hardware, and a computer with programmable software. Sensors, a type of transducer, are devices that convert physical properties into a corresponding electrical signal. Signal conditioning is required to convert sensor signals into a form that can be converted into digital values. Analog-to-digital converters convert conditioned sensor signals to digital values.

Programmable logic controllers (PLCs), distributed control systems (DCSs), and supervisory control and data acquisition (SCADA) control systems are designed to interface with local control modules from different manufacturers. SCADA, DCS, and PLC systems utilize an instrument tag database. The database contains elements called *tags* or *points*. The tags or points are related to specific instrumentation or actuators within the process system.

Mission-critical process data is extracted from these systems and stored in a process data historian. Using a variety of available tools, manufacturing personnel can then capture, collect, visualize, and analyze the data.

FAST FORWARD

- The amount of data being produced has far exceeded "big data."
- We must unlock the data, analyze it, and decide what data is business critical and what data will make us more productive.
- Selecting the right data historians and the architecture used to gather, collect, store, and protect business critical information/data is key to success.

On the leading edge of technology

Early adopters in certain industries (e.g., pulp and paper, oil and gas, and power generation) were the first to grasp the value of unlocking process automation data and to understand the importance of capturing and collecting it to improve production processes. As these industries were also the least regulated, it was less expensive to generate process automation data using data acquisition systems. In some respects, these early adopters paved the way for more regulatory-compliant manufacturers, who had to make significant upfront financial investments to automate and install large enough data acquisition systems to capture the available process automation data.

In particular, the life sciences industry (mostly pharmaceutical) recognizes the value of process data but is much slower at adopting data acquisition systems. The challenge is finding data acquisition systems that will reduce risk in compliance and address inefficiencies, all while accessing data that is useful. Many of these manufacturers are currently in the process of identifying systems and best practices that will take them to the next level in all areas of their businesses, while also maintaining the integrity of their strict regulatory compliance requirements.

Meanwhile, for manufacturers moving right along the technology curve, process automation data is no longer limited to manufacturing equipment. Smart devices and edge devices are providing data for full end-to-end analytics. Every level of the organization can now make data-driven decisions.

Many software companies have worked diligently to create products that not only will unlock process automation data but will also make it available for other applications. Businesses can now combine metadata, enterprise resource planning/manufacturing execution system (ERP/MES) data, and maintenance management data with process automation data to perform various detailed analyses. Scheduling takes on a whole new meaning when manufacturers can capture a variety of data to help understand the entire life cycle of their products. From the time an order is taken to the accepted delivery to the customer—and everything in between—actionable data is captured.

The data path forward

Selecting the right data historians and the architecture used to gather, collect, store, and protect business critical information/data is key to success. Once that decision is made and implemented, the what, how, when, and who questions will determine the next steps.

- What data is needed to make informed decisions?
- How do you want the data presented?
- When or how often do you need access to the data?
- Who are the right decision makers that need access to the data?

To be successful, a business will understand early on that the answers to these questions can and probably should change as the analysis of the process automation data matures. Using continuous improvement models will certainly drive early success. These models also generate critical-thinking skills from the data-driven decision makers. With each success comes a new challenge and helps generate a new enthusiasm for all employees, especially when the improvements are tied to monetary gains.

Developing best practices along the way will ensure process knowledge, recognizable quality improvements, and financial gains are realized across the entire enterprise. Things like the development of naming conventions for assets, instrument tags, and data historian tags, will make the end users' jobs much easier. Using a structured data or framework will allow data related to a single asset or multiple assets to be consumed more efficiently.

Implementing condition-based maintenance will greatly improve the efficiency of the maintenance process and should save money by properly identifying the exact time to perform routine maintenance tasks. Notifications can help identify when things are going well or badly and are also key in alerting the right people to stay on top of processes.

Data, for example, can drive tasks like greasing a motor. Let's say the motor manufacturer recommends greasing its motor after every 150 hours of running. Without capturing run-time data, greasing that motor may be scheduled each week. Maybe the motor does not run 150 hours in an entire month. With the run-time data captured and notifications developed, the proper people can be notified when the pump has run 140 hours, so maintenance can be scheduled for the proper greasing intervals.

Although this is a very simplistic example, we can see how using process automation data effectively will help us approach even the most complex tasks with more thought and insight. With the right amount of process knowledge, notifications can be written and implemented for any measurable activity. As with process alarms, it is very important that notifications be used in such a way that they are not a nuisance. It is also important that escalations be used when setting up notifications. Escalations will assure notifications are addressed within a specified time. Using the run time of a motor to determine when it needs to be greased as an example, the notification would be sent to the appropriate maintenance scheduler. The escalation period may be set for a 24-hour acknowledgment. If the person notified does not take action, an escalation notification would be sent to the next person responsible. Some notifications may be of high enough importance to even have additional escalations.

Future data keys

Unlocking process automation data has found its way to other areas of business. Business process automation (BPA) looks at repeatable processes within a company's day-to-day activities and applies automation. This includes things like transferring files, generating reports, and extracting data from unstructured sources and automating them from one central location or computer. A great example would be when hiring a new employee. A simple email with the right information in a consistent format can be sent to BPA software, where the data is extracted to automatically create a user account and passwords for the employees' access to the business servers and applications.

Robotic process automation (RPA) is an automation technology where software robots are used to manipulate and communicate with business systems and applications. This streamlines processes to reduce the burden on human employees. RPA is automation at the graphical user-interface level, or GUI automation. RPA is commonly used in call centers for customer relationship management systems. Having the software robots track down things like order history from an ERP while the customer is being helped makes the process timelier and allows the customer service agent to focus on the needs of the customer.

Intelligent process automation (IPA) is the latest set of technologies used to combine the redesign of fundamental processes with robotic process automation and machine learning. Business process improvements and next-generation tools assist knowledgeable workers by removing repetitive, replicable, and routine tasks.

For those who struggle with the fast-paced technology world, a very significant trend to prepare for is the coming of 5G technology. 5G will have a larger impact on the way we do business and the speed at which we do business than any other technology thus far. What was once just future planning will be available very soon. 5G's speed and efficiency will take industry from off-site monitoring to real-time off-site controlling. It will allow engineering personnel from corporate headquarters to run and monitor equipment in a remote facility. Currently, we can monitor off site with some lag in the information, but when 5G is fully implemented, the network speeds will be fast enough to react to the processes from remote locations. This capability will greatly change the landscape of manufacturing facilities, as it minimizes the number of people required to operate manufacturing processes on site. It will only be possible if businesses are unlocking, processing, and analyzing the right process automation data and preparing their networks for 5G and all it has to offer.

The amount of available data will continue to grow. At the end of the day, the most successful businesses will be the ones that are able to determine what data is critical to their business and how to capitalize on what their data tells them. ■

ABOUT THE AUTHOR

Brian E. Bolton (brian.bolton@mavtech-global.com) is a consultant for MAVERICK Technologies. He has more than 35 years of experience in chemical manufacturing, including more than 20 years involved with the OSIsoft PI suite of applications, quality assurance, continuous improvement, and data analysis.

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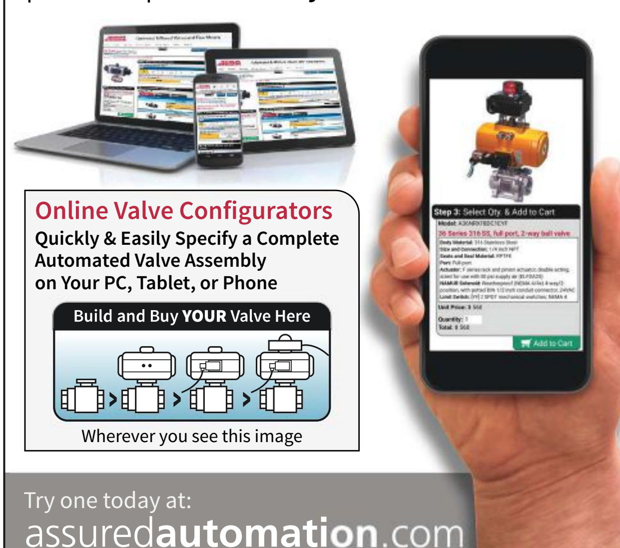

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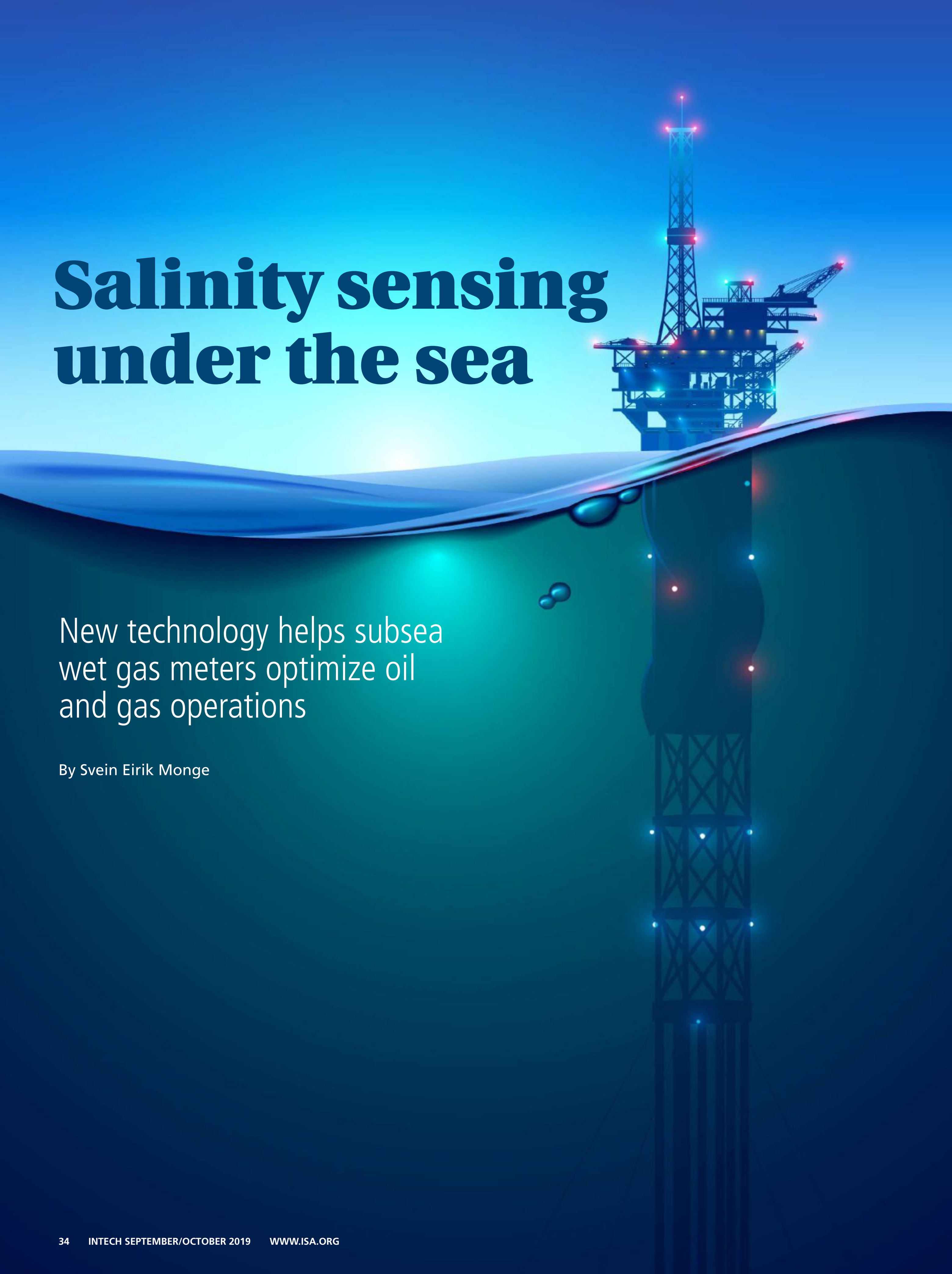


Salinity sensing under the sea

New technology helps subsea wet gas meters optimize oil and gas operations

By Svein Eirik Monge

The growth in offshore brownfield projects and operators looking to develop new fields in remote areas means it is more important than ever to adopt cost-effective, flexible, and innovative technologies that can both negate production threats and optimize subsea oil and gas production.

To this end, operators are looking for sophisticated technologies that provide real-time information on flow performance, protect well integrity, ensure more effective production operations, and preempt production threats. New salinity sensor technologies exist today that can meet these subsea oil and gas exploration challenges.

Subsea oil and gas operators face a variety of challenges when it comes to identifying fluid composition and securing flow assurance. These include a wide range of operating conditions, particularly with the growth of wet gas fields. In wet gas fields, the dangers of water breakthrough and condensate increase, bringing with them greater chances of saline formation water entering the flow.

Challenges

Formation water and salinity lead to scaling and the formation of hydrates, corrosion, and overall threats to the integrity and availability of subsea wells and infrastructure. In worst-case scenarios, formation water and water coning—a problem in which bottom water infiltrates the perforation zone in the near-wellbore area and reduces gas production—in the reservoir can jeopardize hydrocarbon production and lead to well shutdowns.

Another challenge is subsea tiebacks. This is one of the more economical means of developing deep water fields, as it connects new discoveries to existing facilities in order to extend the life of the production infrastructure. Industry analyst Douglas-Westwood predicts expenditures on subsea tiebacks will be around $94.3 billion from 2016 through 2020.

In a tieback setup, however, it can take hours or even days before any onset of formation water is detected by the topside or onshore measurement system. The delay adds risk to the accompanying potential dangers. It is in this context that detecting changing fluid composition and water salinity in real time is vital.

Salinity measurement, for example, tells the reservoir engineer if formation water is entering the flow and helps the process engineer adjust the rates of scale and corrosion inhibitors. Once measured, fluctuating operating conditions can be accommodated, risk reduced, and remedial action taken against hydrates, scaling, and corrosion.

FAST FORWARD

- **Salinity measurement tells the reservoir engineer if formation water is entering the flow and helps the process engineer adjust the rates of scale and corrosion inhibitors.**
- **Although traditional detection was based on a fluctuating value, new technologies provide quantitative measurements in many types of field conditions.**
- **A salinity sensor based on microwave resonance technology gives an immediate response to salinity changes and measures water conductivity with a high level of accuracy.**

Other remedial action might include adjusting the choke setting or instigating zonal isolation.

Any one of these measurements must operate quickly and in real time. Given the right conditions, hydrate formation can accelerate at an alarming pace, with a critical time window of as little as 20 minutes needed for preventative action.

Lastly, it should be noted that other key drivers in subsea operations are safety, flexibility, and the ability for subsea measurement instruments to fit seamlessly within existing infrastructure. The latter is an especially crucial criteria for engineering, procurement, and construction companies. The size, weight, and compactness of instruments are essential, as manifolds are often already crowded with instrumentation and have little room to spare.

Traditional vs. new techniques

Traditionally, operators have used several techniques to address these challenges. Chief among them are laboratory analysis of a water sample and conductivity measurement.

Laboratory analysis of a water sample is used to determine the salinity of the water. However, this is a time consuming and costly process that does not capture rapid variations in the water salinity. Formation water detection has historically been based on an indication value that remains stable if there is no salinity but increases when more saline water enters the flow. The downside of this form of measurement is that it is only a qualitative indication, not a quantitative measurement essential to flow assurance and salinity detection in today's operations.

There is a perception that subsea multiphase and wet gas meters are unwieldy and expensive, with operators put off by the perceived scale and potential expense of such deployments. However, there are alternatives on the market now. One is a cost-effective and compact design including salinity measurement.

Although traditional formation water detection was based on an indication value that increased as more saline water entered the flow, new technolo-

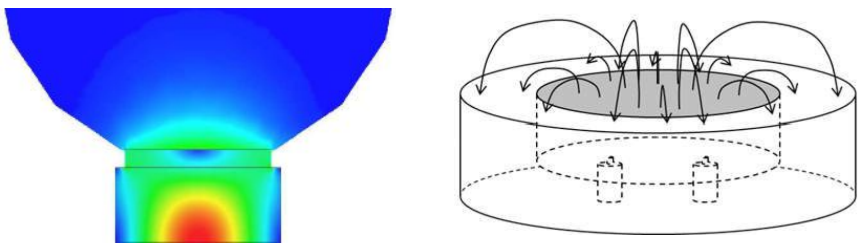


Figure 1. Conceptual drawings of the ceramic salinity sensor based on microwave resonance technology

gies provide quantitative measurements in many types of field conditions. One of these technologies (created by Emerson's Roxar unit) consists of a salinity sensor mounted flush against the wall of a subsea wet gas meter, which provides individual flow rates of gas, condensate, or oil and water. This salinity sensor design is ceramic and based on microwave (MW) resonance technology (figure 1).

Electromagnetic resonance field lines go out of the ceramic sensor into the metal surrounding it, including the two small antennas below the ceramic cylinder. From a microwave sensor perspective, the sensor is categorized as a waveguide cavity resonator, shortened on one end and open on the other, the side that is facing the flow. As part of the MW measurements, electromagnetic waves bounce off reflective surfaces, such as the metallic surface used in the ceramic sensor. A resonance typically occurs when a reflection bounces back and forth in such a way that a constructive interference between the incident and reflected wave occurs. This is similar to how a pressure wave creates resonances at certain frequencies in a flute or a brass horn.

Within this system, the higher the Q-factor—a dimensionless parameter that describes the resonator's bandwidth relative to its center frequency—the "stronger" the resonance.

That means the energy dissipated per cycle is small, with the Q-factor decreasing if more energy is dissipated per cycle. Higher water conductivity from increased salinity causes the resonator to leak more of its energy to the surroundings, which again results in a decreasing Q-factor. The Q-factor shift versus the frequency shift determines the conductivity of the water on the probe.

The result is an immediate response to salinity changes, and the ability to measure water conductivity with a high level of accuracy. Small pockets of formation water leaking into the flow can be detected instantaneously—something that no other technology has achieved to date.

Performance testing

Extensive testing of the salinity sensor took place at the Colorado Experiment Engineering Station (CEESI) based on a qualification process prescribed by a leading operator. Three separate flow tests took place at CEESI with close to 700 individual test points in total. Testing was conducted along the full range of the subsea wet gas meter from 85 percent to 100 percent gas volume fraction (GVF), 0–100 water liquid ratio, and a wide range of conductivities. The sweet spot of the salinity measurement technology (figure 2) is conductivity of < 2 Siemens per meter and high GVF. In the sweet spot, the probe shows better performance than ±0.5 S/m and uncertainty is kept at up to 99.98 percent GVF at low conductivities.

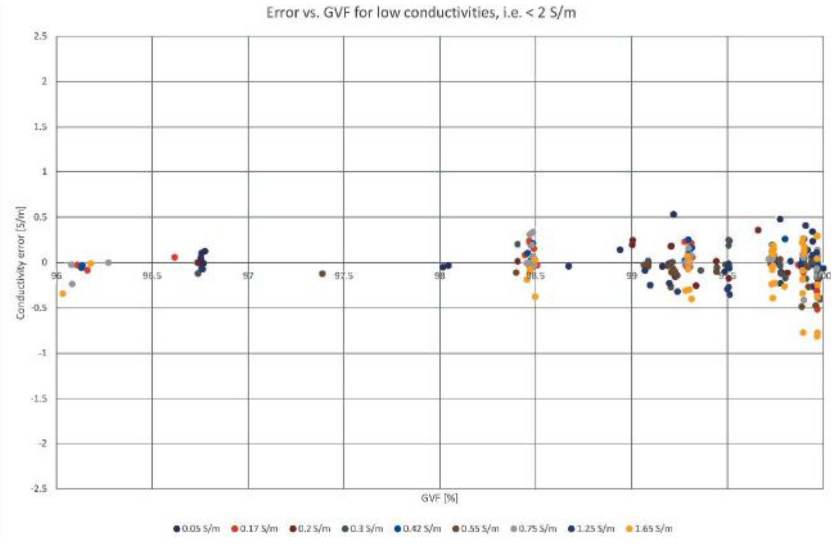


Figure 2. Overview of performance test points in high gas volume fraction (GVF)

The testing results demonstrated that the new salinity probe can perform effectively in a wide range of conductivities, detecting changes in water conductivity as low as ±0.004 S/m.

With oil and gas wells being produced over a broader range of process conditions, and water salinity and conductivity being a key operational parameter for reservoir management and flow assurance, new salinity and subsea multiphase measurement devices are enabling oil and gas companies to expand their operations into areas that were not previously feasible.

The new measurement tool described in this article helps to meet the need for decision support based on accurate process information, which is crucial for operators in identifying production, safety, and environmental threats. Being able to respond quickly and judiciously to these situations goes a long way toward minimizing downtime, reducing risk, and increasing operational efficiency, which in turn translates into greater profitability. ■

ABOUT THE AUTHOR

Svein Eirik Monge is product manager, subsea flow measurement, for Emerson Automation Solutions. The Roxar brand Salinity Measurement System is part of the Roxar Subsea Wetgas Meter (www.emerson.com/en-us/automation/roxar).

View the online version at www.isa.org/intech/20191006.

How to measure liquid level in vessels

Readings can be taken from the top down or bottom up. Examine the application to determine the right instrument and technique

By Lydia Miller

Radar level instruments can be used in hazardous applications such as fuel vessels. (Shown is Emerson's Rosemount 5900S Radar Level Gauge.)

In most applications, level measurements need to be quantified and sent electronically to an automation system, which requires some type of instrument. Sorting through the instrument selection process begins by determining what data is needed for the application and how it can be obtained as simply as possible. Level measurements are generally concerned with these points:

- Level of liquid—How close is the vessel to being full or empty?
- Volume of liquid—How many liters or gallons is in the vessel?
- Level has reached a high limit—Will the vessel overflow?
- Level has reached a low limit—Will the vessel run dry?

The first two points require a continuous measurement, which tracks the liquid level in real time as it moves throughout the tank. The third and fourth points may only be of concern when the level has crossed a specific point, but in many situations knowing when the level is both too high and too low will be necessary.

Frequently, all these readings may be used with the continuous measurements provided to control room operators, while the high- and low-limit measurements are tied to alarms to avoid either extreme. Both continuous and point measurements can be used in safety-instrumented functions to prevent overfill, typically tied into a separate control system specifically for safety.

Point versus continuous level

If the objective is to determine if liquid has moved to or beyond a given point, a point-level measuring device, also known as a level switch, can be inserted through a vessel wall or inserted from above. Older switch designs used floats. Newer designs might use a vibrating fork (figure 1) that vibrates at a different frequency when immersed in liquid than when exposed to air.

Because the vibrating forks are not mechanical devices, they are more suitable when a switch is needed for a safety application. As the name implies, a level switch can only indicate if liquid is present or not. If it is immersed, there is no way to tell if it is just below the surface or under many feet of liquid.

If continuous measurement is necessary, as it is when an application requires knowing where the liquid is inside the tank at all times, there are many instrumentation options, but the majority fall into two categories: measuring from the top or bottom.

Figure 1. A vibrating-fork level switch can identify the presence of a liquid, which is sufficient for many level measurement applications. (Shown is Emerson's Rosemount 2140 Level Detector.)

The bottom approach uses one technology for all practical purposes: static pressure. A pressure instrument reads through a penetration in the vessel wall and registers pressure created by the weight of the liquid. If the vessel contains water and is vented to atmosphere, a pressure reading of 4.34 pounds per square inch indicates there is 10 feet of water above the instrument.

This concept is straightforward in theory but can be complex in practice for three reasons:

1. The position of the pressure instrument relative to the vessel penetration will change the reading. That means it is critical to know where the actual sensing point is if the instrument is mounted.
2. Liquid density affects the reading, so the density characteristics of the process fluid must be understood to determine its effect on the measurement.
3. A single pressure reading works only if the vessel is vented to atmosphere. If the system is closed and above or below atmospheric pressure, a differential pressure (DP) reading is necessary. The high side of the reading is the weight of the liquid, and the low side is connected to a second penetration at the top of the vessel to sense the head space pressure.

Newer differential pressure level options—including tuned-system assemblies or electronic remote sensor systems—significantly improve the performance of DP level systems and make specification less complex. Using DP for level is an excellent approach, because it is unaffected by equipment or structures inside the vessel, or by turbulence and foam, with minimal effects related to liquid characteristics outside of density.

Take it from the top

When the level instrument is mounted on top of the vessel, there are multiple technology choices. Older approaches are more mechanical in nature, for example, a float connected to a tape.

Over the past decade or so, many more nonmechanical methods have emerged. Radar level measurement options in particular have increased, because of improvements in cost and their ability to measure easily in many conditions.

For all radar options, the common denominator is bouncing a microwave radar signal off the liquid surface and measuring the time necessary for it to go down and come back to a sensor. This can be accomplished by measuring time of flight for a microwave pulse, or the degree of frequency shift with a frequency-modulated continuous wave (FMCW) signal. In any case, top-down techniques determine the distance from the instrument to the liquid surface.

Radar can measure the distance very accurately regardless of the liquid characteristics, with no compensation necessary for changes in density, dielectric constant, or conductivity.

The two main types of radar instruments are guided-wave radar (GWR) and noncontact radar (NCR). With GWR instruments (figure 2), a metal probe extends down through the air or vapor space and into the process medium. This helps concentrate the pulse, so the reflection is less affected by reflections from vessel walls, internal structures, or agitators. On the other hand, if there are moving agitators, the probe could get wrapped around them, so a noncontacting method might be better.

NCR level transmitters provide continuous level measurements, but without touching the process medium. Some models use a microwave pulse, while others send an FMCW signal to perform the measurement. With pulse radar, the same time-of-flight technique used by GWR determines distance.

With FMCW instruments, the transmitter sends microwaves in a continuous signal sweep (figure 3) with a constantly changing frequency. The frequency of

Figure 2. A guided wave radar (GWR) instrument uses a metallic probe to guide the pulse to the surface and back. (Shown is a Rosemount 5300 Level Transmitter.)

the reflected signal is compared with the frequency of the signal transmitted at that moment, and the difference between these frequencies is proportional to the distance from the radar to the surface, providing the data required to determine level.

Level versus volume

When a volume measurement is needed, accuracy is typically important, because inventory value or product custody transfer could be at stake. Level instruments do not measure volume. If a volume value is necessary, it has to be calculated based on the vessel dimensions, which must be fully understood. A radar instrument often has an accuracy of ±0.12 inch (3 millimeters). But if the vessel diameter measurement is off by several inches, the calculated volume will not be accurate. Higher-accuracy applications may call for radar instruments with ±0.02-inch (0.5 millimeter) accuracy, but additional methods are needed to get an accurate volume calculation.

For example, situations where the volume measurement must be very precise require "strapping" where the tank diameter is measured critically at multiple points, with the values incorporated into a look-up table so a change at any level will reflect the correct volume change. This is particularly important with distorted or odd-shaped vessels, such as spherical, conical, and horizontal cylinders.

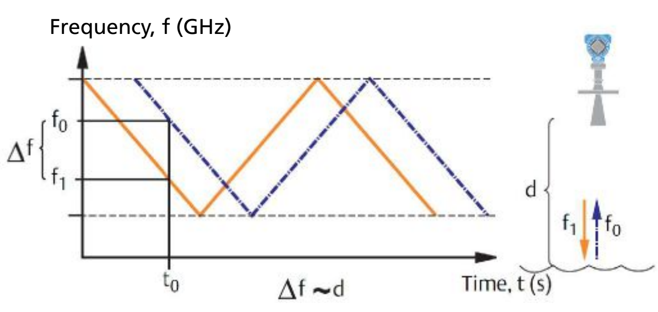
A change of 10 inches near the top of the vessel may represent a much different volume than the same change near the bottom. Additionally, temperature and pressure measurements may also be required to get a full picture of the actual volume inside a very large vessel. Such situations are rare outside of custody transfer applications where money changes hands based on product volume measurements.

In many real-world applications, repeatability alone is sufficient, and the level measurement by DP or radar level instruments can certainly deliver. A company will have to examine the needs of each application to determine which type of measurement and instrument is appropriate for its needs. Fortunately, there is no shortage of options. ■

ABOUT THE AUTHOR

Lydia Miller is a product manager with Emerson's Automation Solutions business who works with Rosemount level products, focusing on radar and ultrasonic instruments and level switches. She joined the company in 2011 and has additional work experience with air-to-air energy recovery for process industries and heating, ventilating, and air conditioning applications. Miller has a bachelor's degree in mechanical engineering and English from the University of Minnesota.

Figure 3. A frequency-modulated continuous wave (FMCW) instrument delivers more powerful reflections to provide a higher degree of accuracy than most pulse-based radar transmitters. (Shown is a Rosemount 5408 Level Transmitter.)



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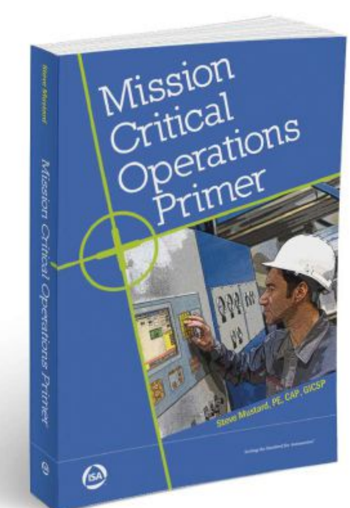

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Setting the Standard for Automation™

Paying attention to IIoT solution providers

By Renee Bassett

ABOUT THE AUTHOR

Renee Bassett (rbassett@isa.org) is chief editor for *InTech* magazine and Automation.com, as well as contributing editor for ISA Publications. She has a bachelor's degree in journalism and has been writing for technical, engineering, and management-level audiences about industrial automation for almost 20 years.

When you hear the terms "Industrial Internet of Things (IIoT)" and "industrial digitalization," what comes to mind? "We're hearing from customers that they're confused," says Alan Griffiths, principal analyst at Cambashi, a global market research and consulting firm based in Cambridge, U.K. "They're being bombarded with platforms and technologies at the bottom end, and from the top end they're being told to transform their businesses. There's a general perception that IIoT might be hype, while at the same time there's a tendency to go to a technical solution before they know what business drivers can make the Industrial Internet of Things a success."

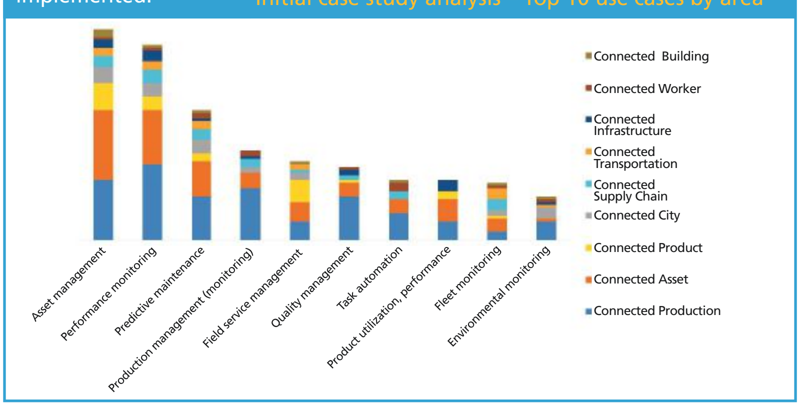
From the supplier perspective, 2018 was "quite a signification year" for IIoT, says Griffiths, with lots of reorganization within supplier companies, and a lot of change. The standards are developing separately as well. "There is a clear distinction between IT/enterprise and OT/industrial providers," he says, "and we are observing the formation of new relationships and ecosystems. We expect further significant changes and consolidation in the next few years."

That is why analysis of IIoT solution providers can be so useful right now to engineers, operational strategists, and decision makers in companies large and small. The past couple years have seen many in process plants or manufacturing facilities assigned to their company's "transformation initiative" or "digitalization committee." Others are being told, "We need an IIoT pilot project. Find out what that is and get me one!" Some do not know where to start.

This summer, Cambashi announced new research results on "the IIoT and Connected Applications." The research focused on 18 top vendors of IIoT solutions and brings in background from 200 additional vendors. Called the Cambashi IIoT Software Observatory, this "global market-sizing project" estimates provider revenue to size the market and analyzes IIoT case studies published by suppliers to produce insights about what kind of IIoT applications are being implemented—an indicator of where success can be found in the future.

The Cambashi IIoT Software Observatory analyzes IIoT case studies published by suppliers to produce insights about the kinds of IIoT applications being implemented.

Initial case study analysis – Top 10 use cases by area



The results are illuminating, in part because they show that the IIoT is not just hype. Initial analysis of hundreds of case studies shows the most popular IIoT use cases to be asset management, performance monitoring, and predictive maintenance. All use cases can be grouped into nine areas of connected application: connected production, connected asset, connected supply chain, connected city, connected product, connected infrastructure, connected transportation, connected worker, and connected building.

"The asset management and performance monitoring use cases have the most published case studies," says Griffiths, "while the top 10 use cases all strongly feature in the connected production and connected asset market areas." Such a sort can be a boon to users wondering where to start transforming their businesses, or where to implement IIoT applications. It also points to who is available to help.

Griffiths says some of the major players in connected applications software include Microsoft, Siemens, ABB, Amazon Web Services, and IBM. Microsoft, IBM, and Amazon come at IIoT from an information technology (IT) perspective, while others like Siemens and ABB have an OT legacy.

The IIoT as a whole "is gradually coming of age as useful applications are developed and deployed by leading providers, supported by technology that is now advanced and robust," says Griffiths. "Some of the major IT applications, such as cloud computing and analytics are playing off of OT applications like industrial automation, PLCs, and semiconductor. It will be interesting to see how these two groups of providers—IT and OT—compete and/or work together to deliver solutions to industry."

Some of the major players are already working together—SAP with Honeywell, Oracle with Mitsubishi, IBM and Bosch—and this helps the IIoT and connected industry overall. Griffiths says his data also points to success using packaged software rather than build-it-yourself pilot projects and other initiatives. "Where IIoT got traction was when there was a solid product to download, rather than a toolkit you have to learn," he says.

Griffiths had another bit emerge from his research: "OT people don't like the terms 'IoT' and 'Internet'. Their focus is on 'robust' and 'proprietary,' while IT people talk about 'clouds' and 'transformation.'"

That won't come as a surprise to anyone reading *InTech*. ■

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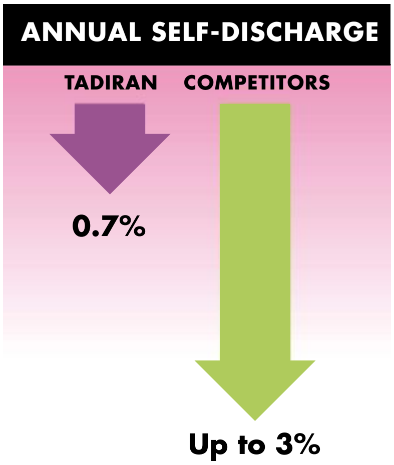

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ISA celebrates excellence, announces 2019 honors, awards, and fellows

ISA's Annual Leadership Conference, 25–28 October in San Diego, will bring together ISA leaders from around the world to engage, share best practices, and network while enhancing the professional competence of Society members. The educational event also provides an opportunity to celebrate the best of the best at the Honors and Awards Gala.

Individual accomplishment and commitment are driving forces behind ISA's mission to meet the needs of automation professionals and advance the automation profession. ISA's honors and awards programs let the Society formally showcase and celebrate the achievements of its members, partners, and other automation professionals. And the honors go to . . . .

2019 ISA Fellows. ISA members are organized into grades: Honorary, Fellow, Senior Member, Member, and Student Member. Elevation to the distinguished grade of ISA Fellow is granted to ISA Senior Members in recognition of outstanding achievements in scientific or engineering fields as recognized by ISA peers. ISA named two Fellows this year.


Kelvin Erickson, PhD


Edward J. Farmer

Kelvin Erickson, PhD, of Missouri University of Science and Technology in Rolla, Mo., was honored for furthering the creation of an industrial automation program for engineers. *Edward J. Farmer* of EFA Technologies, Inc., in Sacramento, Calif., was honored for furthering revolutionary developments in the pipeline leak detection methods and systems.

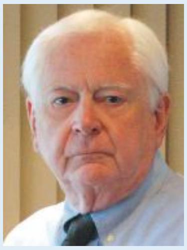
Excellence in Leadership. This award recognizes an individual who has made significant contributions to the industry and/or profession to advance automation. *Thomas Burke* of OPC Foundation in Scottsdale, Ariz., won the award for his leadership and initiative in driving the OPC UA communication standard's development, application, and global awareness, and through it, making a powerful impact on interoperability of automation systems.

Excellence in Technical Innovation. This award, endowed by Honeywell UOP, recognizes an individual who has played a critical role in the conception, design, and/or implementation of an innovative product, process, and/or service. *Jayesh Barve* of the GE Global Research Center, Bangalore, Karnataka, India, was honored in recognition of his conception and contribution to research and development projects related to next-generation technology.

Excellence in Technical Presentation. This award recognizes the author(s) of the most outstanding paper, article, presentation, or document published and/or presented on behalf of ISA that introduces a new technology or explains an existing automation process. *Brian Mast* of Copper Bell Consulting LLC, in Seattle, Wash., was awarded for his outstanding presentation on "Summary of the King County, Washington, West Point WWTP Flood of 2017."

Excellence in Education. The honor recognizes an individual who has devel-

In memoriam



Our industry lost a great man and pioneer on 6 September 2019. **Leonard W. Moore (Len), PE,** who was founder and owner of Moore Industries-International, Inc. (www.miinet.com), passed away at the age of 85. Moore was a pioneer of the automation industry who was inducted into ISA's revered group of Honorary Members in 2009. That distinction recognizes individuals who profoundly support and/or contribute to the advancement of the arts and sciences of instrumentation, systems, and automation.

At the time, Moore said, "When I learned about this honor, and this might sound corny, the first thing that came to mind was all of the talented people that have come through our door to earn an honest living, and that we have supported them with a great place to work . . . . While I have been involved with many exciting product and business development pursuits during our 40-year history, I think what I am most proud of is the culture we have created at Moore Industries."

Starting with one signal isolating/converting instrument, the SCT Signal Converter and Isolator, Moore and his "troops" went on to design, build, and support more than 225 different products that isolate, protect, convert, alarm, monitor, control, and interface with any industrial or automation control and monitoring system.

After graduating from Iowa State University with a BS in electrical engineering, Moore entered the Army in 1953 as a weapons guidance specialist and spent time at Fort Sill, Okla., and Fort Bliss, Texas. He then served in Japan training and teaching soldiers how to operate, calibrate, and repair various guidance and artillery weapon systems. It was here where Moore realized he had a passion for instruments and control circuits. After his tour in Japan, he left the Army and returned home to Iowa.

In 1958, newly married to wife Martha Moore and eager to start his career, he took a job with Hughes Aircraft in El Segundo, Calif. In 1968, he founded Moore Industries-International, Inc. in North Hills, Calif. With one employee and a very small budget, he set out to design rugged industrial instrument solutions that he knew the industry needed. He used to say that at Moore Industries "we are an engineering company that solves customer's problems by manufacturing bulletproof solutions."

Moore was an accomplished race car driver, competing on the Trans Am Race Circuit. Flying was always a hobby, and he got his pilot's license in 2005 at the age of 73. ■

oped and/or enhanced established educational programs to advance the automation profession in educational institutions. *Ravindra Thamma, PhD*, of Central Connecticut State University in New Britain, Conn., was honored for establishing a robust Robotics Mechatronics and Engineering Technology ABET-accredited program at Central Connecticut State University.

Mentoring Excellence. This award recognizes a member who, in the previous year, has excelled in mentoring students and/or young professionals in automation or student sections in advancing the mission of the Society. *Mary Cannon* of Pentair Valves & Controls, Sugar Land, Texas, received this honor for active involvement mentoring students in ISA for many years in the Houston area.

Excellence in Enduring Service. This honor recognizes dedicated volunteer service to the Society at the grassroots level. It may be presented to up to five honorees. This year's honoree is *Luay Awami* of Saudi Aramco, Qatif, Eastern, Saudi Arabia, for years of dedicated service and leadership to the Society and the ISA Saudi Arabia Section.

Excellence in Society Service. This honor recognizes distinguished and dedicated volunteer service to the Society. This year *Jerry Clemons* of ABB Process Analytics, Lewisburg, W.Va., received the honor for his dedicated service and long-term support, activity, and accomplishments across every aspect of the Society.

Standards Excellence. This award recognizes an ISA standards committee member for exceptional efforts in organization, development, and/or administration to further the development of ISA standards and for services to advance the mission of the Society. *Ted Trost* of Cargill, Hopkins, Minn., received the award for strong contributions and understanding of the topics covered by ISA99 WG6.

Volunteer Leader of the Year. This award went to *Don Dickinson* of Phoenix Contact, Cary, N.C., for outstanding service to lead the move of the ISA Water/Wastewater and Automatic Controls Symposium to the Washington, D.C. area in 2018.

To find out who won the awards for excellence and leadership at the division and section levels, visit www.isa.org/isa-annual-leadership-conference. ■

ISA Certified Automation Professional (CAP) program

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

CAP question

Which of the following practices will *not* necessarily enhance login security for process control system software?

A. Use a firewall as a gatekeeper between the network system and the Internet and set up a system to automatically install software upgrades.
B. Use alphanumeric passwords with at least one capital letter if the protection system is case-sensitive.
C. Change passwords regularly.
D. Assign a user access level commensurate with job function.

CAP answer

The correct answer is *A,* "Use a firewall as a gatekeeper between the network system and the Internet and set up a system to automatically install software upgrades." Answers B, C, and D all describe ways to enhance login security for process control system software through application of best practices: password complexity, user access level management, and aging of passwords.

Allowing automatic software updates through a firewall between the control network and the Internet is not a good security practice. Software updates should be initiated from within the control system network after being fully tested and vetted in a nonproduction environment that is representative of the control network. This prevents critical automation systems from being shut down or halted erroneously.

Reference: Sands, Nicholas P. & Verhappen, Ian, *A Guide to the Automation Body of Knowledge, Third Edition,* ISA Press, 2018.

ISA Certified Control Systems Technician (CCST) program

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

CCST question

What must be done to reverse the direction of a three-phase motor?

A. Turn off one phase
B. Put DC to the stator
C. Reverse any two input leads
D. Switch all three phases

CCST answer

The correct answer is *C,* "Reverse any two input leads." In a three-phase induction motor, reversing any two of the three wires will change the rotation direction.

The windings in a three-phase motor, when activated by a three-phase supply, produce a rotating magnetic field in the rotor of the motor. Swapping phase A with phase B reorders the fluxes so that the flux rotates in the opposite direction. Swapping B with C does exactly the same thing, so does swapping A with C.

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

Six easy steps that will make you rethink your business model

By Lisa Richter

As director of the Control System Integrators Association (CSIA), a not-for-profit, global trade association that seeks to advance the industry of control system integration, a major goal is to help members grow business. It is important to periodically review your business model.

When was the last time you really thought about your business model? What? You haven't? Or it was so long ago you think you might have been sporting an epic 70s 'stache or rocking a groovy pair of bell bottoms? With Q4 comfortably settling in—strategizing and budgeting season—there has never been a better time to grab a beverage, go dark, and really take some time to dig into what makes your business tick and how you are going to position it for success in 2020. Let's get started.

1. Gather your leadership team: It is time for The Talk. Set aside some time to unflinchingly go through a set of questions about your customers and company. Some examples of questions about your customers:

- How well do you understand your customers' needs?
- Can you formulate the key unmet needs of your customers?
- What is the monetary implication of not meeting these needs?
- What would resolve those unmet needs?
- Are there solutions available today that could solve your customers' problems? Why haven't they been implemented yet?

Some examples of questions about your company:

- What are your key areas of deep expertise? What are key areas where additional expertise or mastery is needed?
- What are areas of weaknesses?
- Who are considered competitors? Only other system integrators (SIs)? How do you differente from competitors?
- How is the market segmented?

Pro tip: Consider breaking this list up and tackling it in separate sessions to ensure your team stays fresh.

2. Play matchmaker. Next, have your team match the unmet needs of your customers with your capabilities and areas of deep expertise. Avoid the temptation to design the solution to the ultimate detail. Assume that technology is available to solve problems, and focus on identifying your customers' issues. Pare the list down to three-to-five options to flesh out further. Some things to consider:

- Are there solutions to key customer problems that leverage your capabilities/areas of expertise?
- What part of the solution do you consider to be critical to master?
- What part of these solutions can you provide?
- Which parts can you develop?
- If you can't, who can you partner with?
- Are there other industry verticals that could use them?
- What is the addressable market?

3. Write it down. Take the time to document the ideas that came out of the brainstorming sessions and start to do some due diligence. Some things to think about: Have these ideas already been commercialized? If so, are your solutions better mousetraps and are they adding real value?

4. Bump against other businesses. Now it is time to analyze your best solutions from the perspective of their associated business models. Do not forget, the innovation may come from delivering an exisiting solution through a different business model.

Pro tip: You might find this book useful: *Business Model Generation: A Handbook for Visionaries, Game Changers and Challengers* by Alexander Osterwalder and Yves Pigneur.

5. Innoculate against analysis paralysis. Continue to refine your concept, but be mindful of reaching the point of diminishing returns. At some point, research and analysis will start cutting into time to market—or worse, open a window for a competitor to climb through. (Speaking of which, now would be a good time to look into patenting your work.) Remember, perfection is the enemy of done. Some things to consider at this stage:

- Are you comfortable with rapid prototyping and failing fast? Can you and your organization quickly move past a failure to learn and regroup for a new launch?
- How much of your time and resources do you plan to dedicate to this venture and not risk your current operation?
- How far out will you plan in pursuit of the new business?
- Serial venture capitalists consider having one out of four investments pan out as quite normal. This failure rate is unacceptable from the perspective of a traditional SI. Can you and your organization cope with this?

6. Create a business plan. Finally, you need to put together a solid business plan to share with investors, including how you will sell your plan. This sounds daunting, but there are plenty of resources available to help, including CSIA's *A Business Model Analysis Guide for System Integrators*. (This is normally a member-only resource, but is now available for download.) It is not easy—or particularly fun—to scrutinize your business and contemplate a pivot. But you owe it to your business to buckle down and do it. Right on, man. ■

ABOUT THE AUTHOR

Lisa Richter, industry director for CSIA, helps members grow their business, share industry expertise, and advance the industry of control system integration. She is also host of the Talking Industrial Automation podcast. Founded in 1994, the CSIA (www.controlsys.org) has more than 500-member companies in 40 countries. Send questions and comments to LeAnne Munoz, lmunoz@staff.controlsys.org

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AutomationDirect, www.automationdirect.com

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Phoenix Contact, www.phoenixcontact.com

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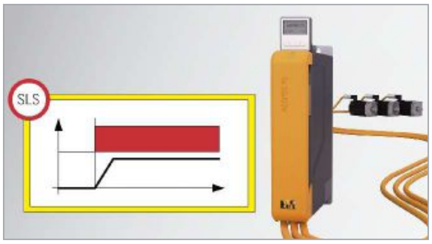
Larson Electronics, www.larsonelectronics.com

Safety I/O modules

These safety I/O modules can meet the needs of producers in process and heavy industries that require fixed field-wiring terminations or both vertical and horizontal I/O mounting in their distributed safety applications. They have safety reaction times as fast as 4.5 milliseconds to help designers create smaller smart machines and equipment. They also have diagnostics to help users identify faults based on real-time data. The modules are TÜV certified for use in fail-safe applications up to SIL 3 and PLe, Category 4. They can be directly connected to copper and fiber networks.

Rockwell Automation, www.rockwellautomation.com

Virtual sensor for servo drives



The company has developed a virtual sensor for its ACOPOS P3 servo drive, the Safe Speed Observer. It determines speed in accordance with SIL 2/PL d/CAT 3 requirements, eliminating the need for a safe encoder. From the electrical variables of a permanent magnet synchronous motor, the device calculates two redundant models of the motor, achieving a safety level for the calculated speed. The virtual sensor can be used for both linear and rotary synchronous motors. The observer is configured in the Automation Studio engineering environment via the respective encoder interface. The user can implement the safety functions available for the safe axis from the safety library.

B&R, www.br-automation.com

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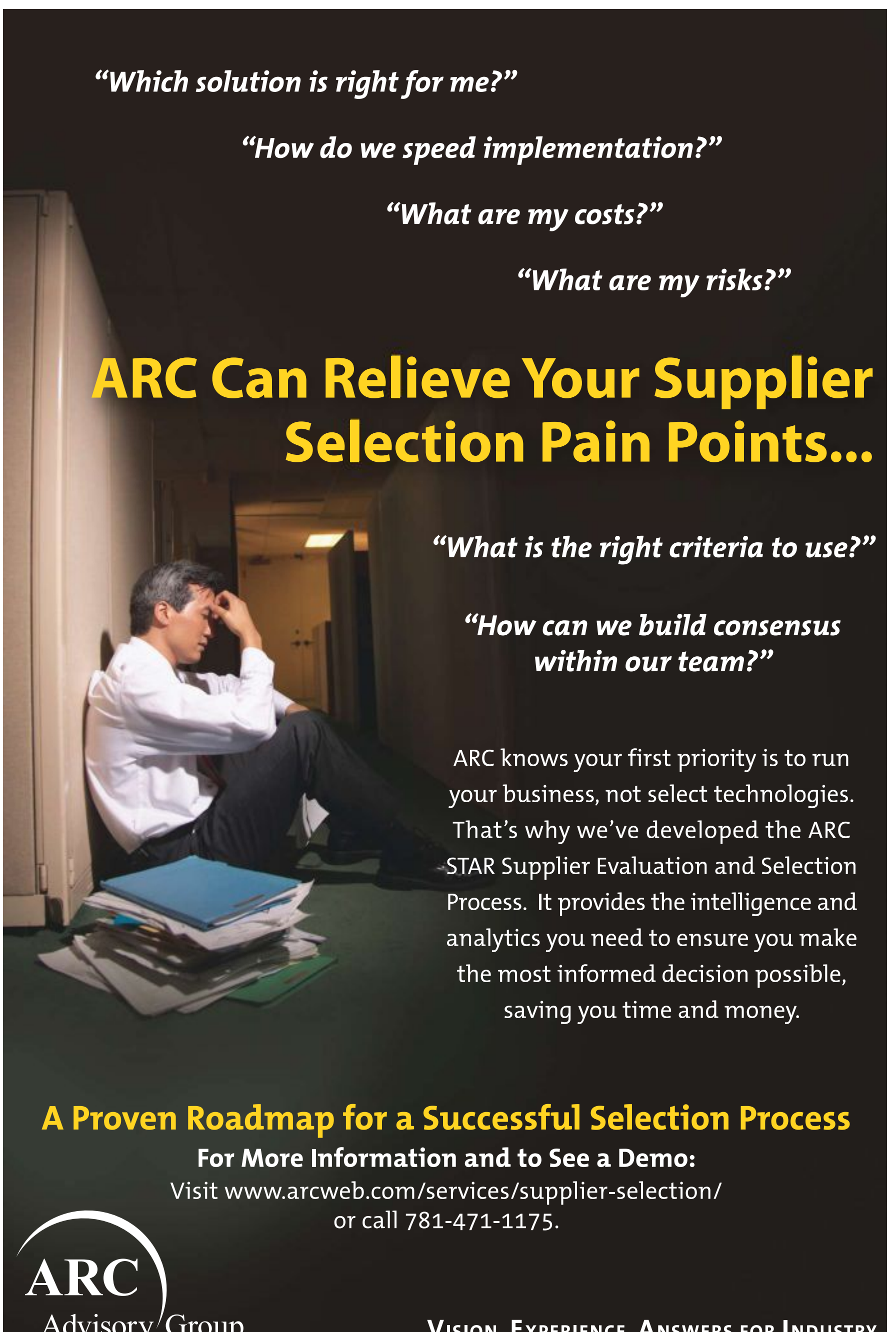

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Senior systems engineer

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SCADA operations graduate engineer

City of Austin: This is an essential position in Austin, Texas, requiring on-call availability on a rotating basis and mandatory service in certain situations, which include nights, weekends, and holidays. Minimum qualifications vary by engineer grade but include graduation from an accredited four-year college or university with major coursework in engineering or a field related to the job. Texas Engineer-in-Training certification and a State of Texas Professional Engineer license are also desired . . . see more at Jobs.isa.org.

Mechanical designer

Engineering System Solutions: The successful candidate for this Las Vegas position will perform all levels of engineering, including providing competent and appropriate correspondence with all involved disciplines, designing appropriate mechanical and plumbing systems in accordance with current code requirements and sound engineering principles, assisting with the development of complete sets of construction drawings, and contributing to the amicable working environment. The position requires a BS in mechanical engineering and three to five years of experience. REVIT experience is beneficial . . . see more at Jobs.isa.org.

Electrical engineer intern

General Motors: This engineer in Toledo, Ohio, is responsible for controls engineering and electrical support for engine programs. He or she will manage electrical projects, including new, replacement, operations improvements, and periodic repair and replacement. The engineer with participate in functional area plant meetings to represent engineering and to assist in reaching the plant's performance goals. The successful candidate will be pursuing a BS in electrical engineering or electrical engineering technology from an accredited college or university and have a minimum 3.0 cumulative GPA . . . see more at Jobs.isa.org.

Principal engineer antenna design

Raytheon Missile Systems: The successful candidate for this Tucson, Ariz., position will lead and shape antenna, radome, and antenna measurement system technology. He or she will lead a diverse team, provide technical oversight, delegate tasks, and work with the engineering organization to enable modernization, and contribute to general innovation. A minimum of eight years of applicable experience, the ability to obtain an active DoD secret clearance, and a BS in math, engineering, science, or a related technical field is required. . . see more at Jobs.isa.org.

Is your automation asset management out of sync?

By Bill Lydon

ABOUT THE AUTHOR

Bill Lydon (blydon@isa.org) is an *InTech* contributing editor with more than 25 years of industry experience. He travels globally to attend automation events and regularly provides news reports, observations, and insights here and on Automation.com.

Automation asset management should be part of the business strategy for a manufacturing company to remain competitive, and automation professionals need to help their organization properly plan investments.

The accounting and financial systems in many manufacturing organizations treat the useful life of equipment and automation systems as the same. Production equipment typically has a significantly longer useful and productive life than automation and control systems. Defining the same useful and productive life for automation and control systems really doesn't make sense with the rapid changes in technology. An unfortunate example of this is the number of older PCs running in plant operations with old operating systems, such as Windows 3.x versions that have known cybersecurity risks and are not capable of running newer, more secure software. This hardware remains in place, since it has not reached the end of its financial depreciation time. In this case, financial considerations take precedence over secure operations.

As another example, the president of a machine builder that designs and builds a range of machines gave me a tour of his operations. He demonstrated a highly flexible machine for a manufacturing customer that featured impressive controls and automation. In contrast, as we toured the facility, he showed me some very large older machines that had been shipped to them from a major manufacturer to be renewed with new bearings drives and other fundamental maintenance items. I asked why that manufacturer did not purchase the new, more flexible and efficient machines? He told me they had advised the manufacturer to do just that, but the accounting department would not allow it, because the machine had not been fully written off on the financial books. He further emphasized that the new machines would provide much greater efficiency and flexibility in manufacturing. This is another example of how not focusing on the overall goal of the organization can be a counterproductive.

Accounting systems use depreciation based on the useful life of an asset for financial write-offs. Once these depreciation schedules are defined for an asset, it is difficult if not impossible to change, since there are tax and investment implications. It is critical to define the useful life of automation systems up front.

Thinking of asset life-cycle management (ALM) separately for production equipment and automation and control systems is a better way for manufacturers to manage. The classical definition of ALM is the process of optimizing the profit generated by your assets throughout their life cycle. Separating the useful and productive life of automation and control systems, so they can be changed throughout the life cycle of the production equipment to make manufacturing more efficient, will keep your company competitive.

In addition to replacing automation and control systems, significant upgrades need to be estimated in advance and built into ALM investment plans.

Rather than complaining that management doesn't understand the need for improved automation and control, automation professionals need to frame the discussion around the need for the company to invest to remain competitive. Automation and control systems orchestrate manufacturing assets to gain the greatest flexibility, productivity, quality, and efficiency to keep manufacturers competitive. Considering this from another perspective, keeping older automation and control systems in place can make manufacturing noncompetitive, leading to lost profits.

ALM is particularly important with the move to manufacturing digitalization that requires investment in a wide range of new technology, including smart sensors, edge computing devices, and high-speed communications to create a more responsive and competitive holistic manufacturing system. The benefits of these investments include more responsive operations, higher quality, lower maintenance costs, and greater productivity. These investments bring the opportunity for providing data for full end-to-end analytics and benchmarking operations against virtual digital twins. Smart sensors and edge computing devices may require separate depreciation schedules.

Automation professionals need to serve multiple stakeholders throughout the manufacturing organization in this new environment, providing decision makers with the information needed to successfully run the business. This requires investment in automation and control systems to support these efforts. Stakeholders should be reminded that technology is a competitive weapon to be used to gain an advantage relative to other manufacturing competitors in your industry. ■

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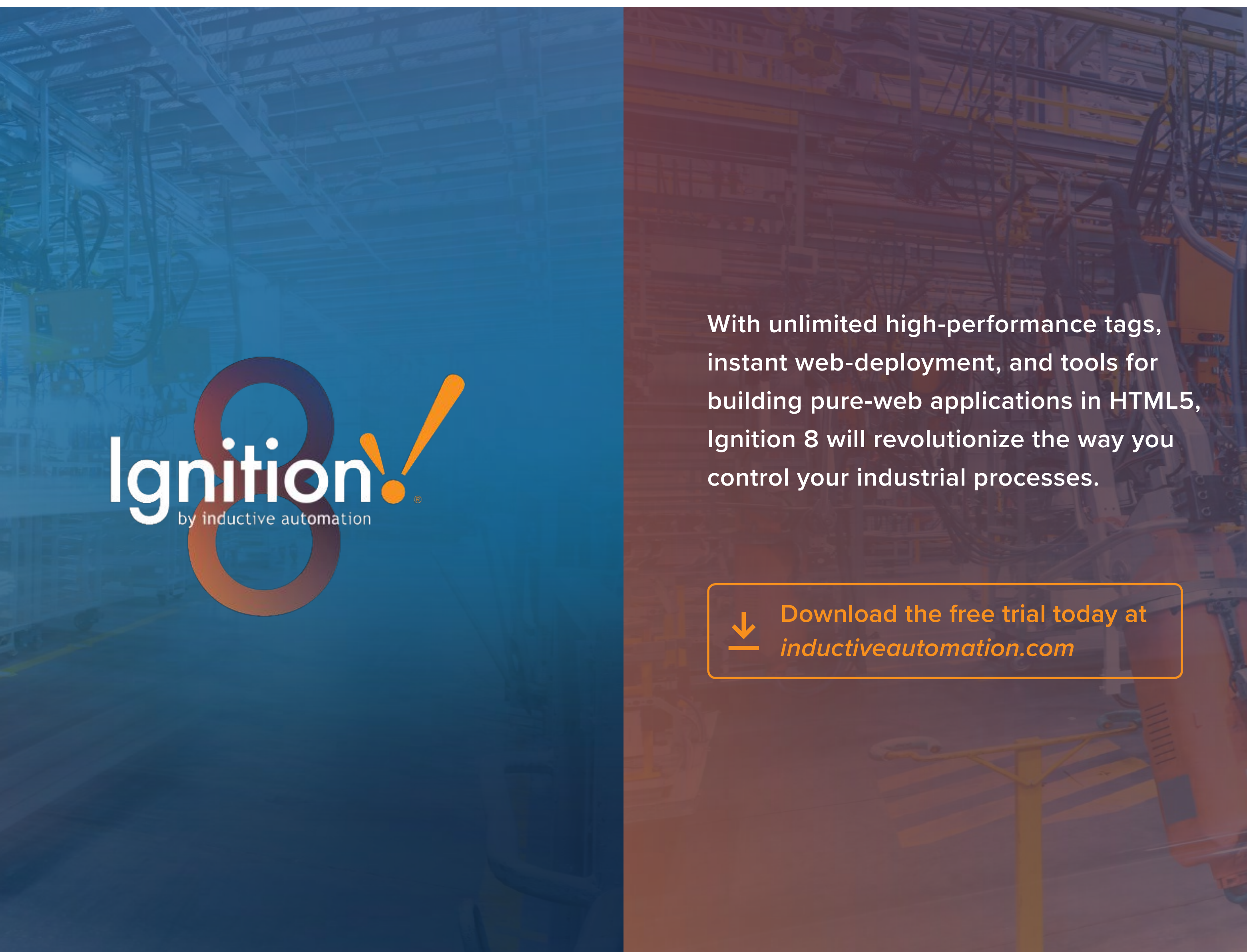
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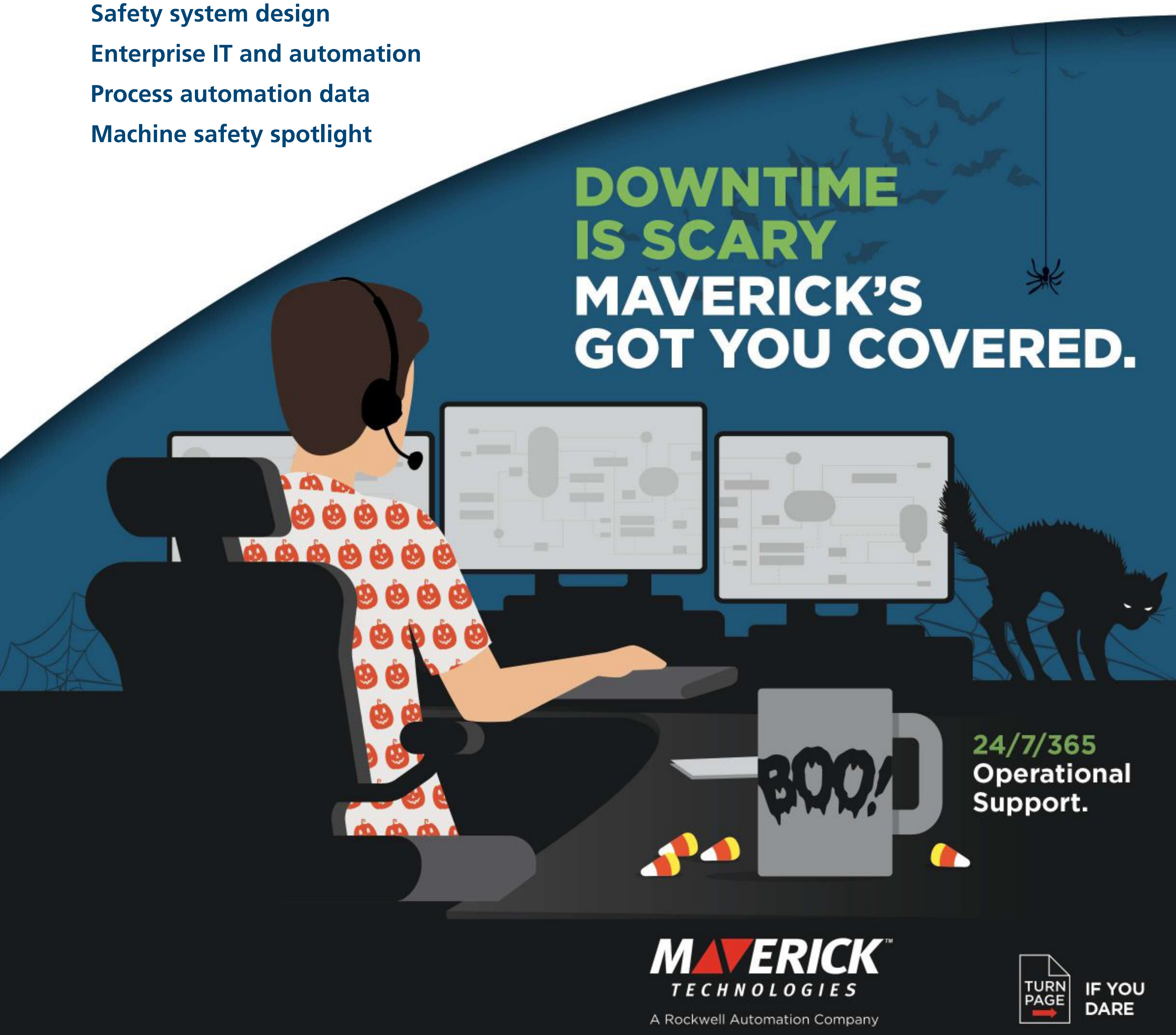

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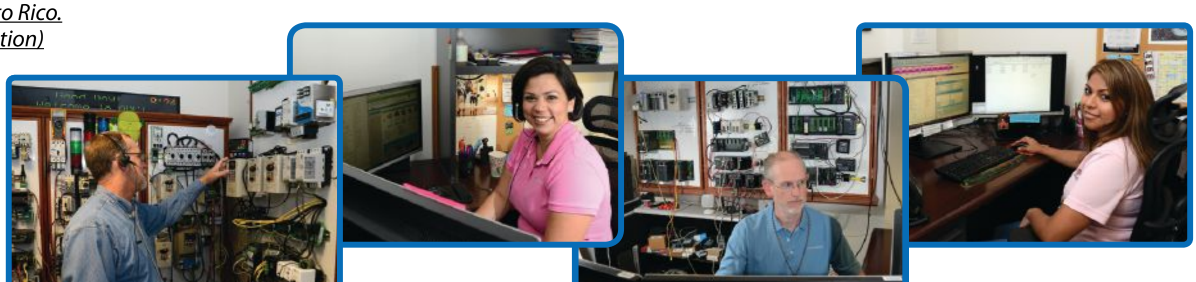

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