September/October 2018

InTech

A PUBLICATION OF THE INTERNATIONAL SOCIETY OF AUTOMATION

Global megatrends

Machine safety

Predictive maintenance

Industry 4.0

Flow spotlight

The pay raise engineers have been waiting for

Results from the 2018 salary survey

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Safety Mats and Edges

Protect personnel AND equipment for less!

Safety Mats & Edges

Safety mats and edges are used to protect people and machinery from harm. Mats detect the presence of personnel on horizontal surfaces (usually the floor), while edges can be used on any surface, usually near possible crushing or shearing points. Both mats and edges are wired to specialized safety relays for fail-safe triggering of the intended safety function.

Safety Edges

SENTIR Safety Contact Edges are pressure-sensitive sensors that ensure safety at the edges of crushing or shearing points which are prone to accidents. Install near automatic gates, machines, handling equipment or moving elements in order to protect individuals from bodily harm or machinery from damage.

25 x 30mm Profile

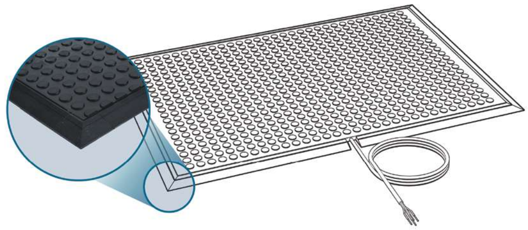
Starting at $36.00 (2-ft length)

- Available in 2ft, 5ft, 20ft and 82ft lengths
- Sections can be easily daisy chained
- Requires aluminum mounting rail (included with 2ft and 5ft edges)

25 x 45mm Profile

Starting at $40.00 (2-ft length)

- Available in 2ft, 5ft, 20ft and 82ft lengths
- Sections can be easily daisy chained
- Requires aluminum mounting rail (included with 2ft and 5ft edges)

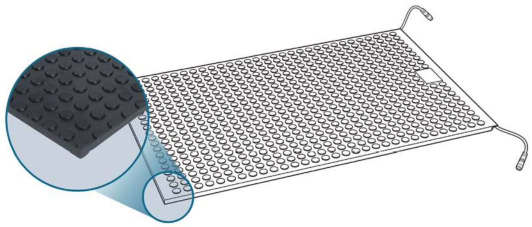


Tapered Safety Mats

Starting at $310.00 (24″ x 36″)

SENTIR tapered mats have an integrated taper profile ideal for placement without requiring additional edging.

- 6m cable ideal for 4-wire circuits
- Anti-slip surface
- Tested to more than 6 million activations
- Standard sizes available
- Resistant to contaminants and moisture up to IP65



Straight Edge Safety Mats

Starting at $285.00 (24″ x 36″)

SENTIR straight edge mats are designed with flexibility in mind. The straight edge allows butting of additional mats and use of optional metal trim kits for securing to floor.

- Supports 4-wire or 2-wire circuits (optional terminating resistor)
- Quick disconnect ends allow for easy single or multi-mat wiring
- Anti-slip surface
- Standard sizes available
- Resistant to contaminants and moisture up to IP65

Also Available

Safety Mat & Edge Relays

Safety Light Curtains

Interlocking Safety Switches

Non-contact Safety Switches

Safety Limit Switches

Research, price, buy at:

www.automationdirect.com/safety-mats

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ISSN 0192-303X

***InTech* is published bimonthly by the International Society of Automation (ISA). Vol 65, 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 members in the U.S., $10.38 annually is the nondeductible portion from dues. Other subscribers: $175 in North America; $235 outside North America. Multi-year rates available on request. Single copy and back issues: $20 + shipping.

Opinions expressed or implied are those of persons or organizations contributing the information and are not to be construed as those of ISA Services Inc. or ISA.

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

Printed in the U.S.A.

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

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

List Rentals: For information, contact ISA at info@isa.org or call 919-549-8411.

InTech magazine incorporates *Industrial Computing*® magazine.

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

Your most important asset

By Bill Lydon, *InTech*, Chief Editor

A person's most important asset is the ability to think, create, and implement. This requires keeping focused on some key elements:

Lifelong learning

Lifelong learning is an ongoing and self-motivated pursuit of knowledge in your personal life and profession. This continuous personal development expands the scope of your knowledge, keeps your mind active, and increases your ability to contribute to your profession and society. It makes you a more valuable employee. Learning is not confined to the classroom but takes place throughout life and in a range of situations. In addition to formal training, impactful learning takes place in our daily interactions with others and with the world around us. ISA is an important source for automation professionals to continue learning with formal training and informal networking opportunities.

Open mind

Keeping an open mind may seem obvious, but becoming more experienced many times leads to an automatic rejection of new ideas. History illustrates the rejection of new ideas that turned out to be winners; here are some from the past:

Those who loaned Robert Fulton money for his steamboat project stipulated that their names be withheld, for fear of ridicule were it known that they supported anything so "foolhardy."

In 1881 when the New York YWCA announced typing lessons for women, vigorous protests were made on the grounds that the female constitution would break down under the strain.

Men insisted that iron ships would not float, that they would be damaged more easily than wooden ships when grounding, that it would be difficult to preserve the iron bottoms from rust, and that iron would deflect the compass.

"I think there is a world market for maybe five computers." —Thomas Watson, president of IBM, 1943

"There is no reason anyone would want a computer in their home." —Ken Olsen, founder of Digital Equipment Corporation, 1977

A major contributor to progress is new ideas that first were met with rejection and skepticism. Recent industrial automation industry examples include the initial rejection of Direct Digital Control and Ethernet for industrial plant communications.

"The important thing is to not stop questioning. Curiosity has its own reason for existing." —Albert Einstein

Creativity

Taking time to look at things differently can yield brilliant results. One useful mechanism I learned at the Creative Education Foundation is to develop a number of alternatives by asking, "*in what ways might we*," about the issue, challenge, or application. This works when you initially suspend judging the ideas, no matter how strange they seem. Later you can go back to logically review them, and many times combining these thoughts leads to new insights.

"Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world." —Albert Einstein

Any intelligent fool can make things bigger and more complex . . . It takes a touch of genius—and a lot of courage—to move in the opposite direction." —Albert Einstein

Collaboration

Better ideas and solutions can be created by collaborating with others who have different perspectives and ideas. In the context of industrial automation, this could include maintenance people, operators, IT people, and business managers.

Action

To be effective, the ability to think, create, and implement needs to be coupled with action that will lead to greater personal development.

Try not to become a man of success, but rather try to become a man of value. —Albert Einstein ■

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Deloitte reports distinctive traits of digital front-runners in manufacturing

Though the fourth industrial revolution was born in the factory, many manufacturers are falling behind in adopting broader digital transformation initiatives for the entire enterprise. In an August 2018 report, "Distinctive traits of digital front-runners in manufacturing," Deloitte surveyed 193 C-level executives around the globe to identify the organizations in manufacturing that are leading on the path toward digital maturity and the distinctive traits they possessed. The report discovered these front-runners demonstrated the following characteristics:

- Adopting a long-term, dynamic approach to digital strategy: Front-runners were nearly two times more likely to connect investments in advanced technologies to increasing customer engagement than stragglers were.
- Using the power of the ecosystem: Leaders are 2.3 times more likely than stragglers to seek out ecosystem relationships that create new value for customers.
- Confidence in leadership and workforce talent: Front-runner manufacturers seem to have higher confidence in their ability to address these changes than overall respondents.
- Customer-centric innovation powered by technology: Front-runners are more likely to be adept at translating technology into innovation that delivers customer value.

For more information, download the full report (www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-leaders-in-manufacturing-fourth-industrial-revolution.html). ■

Emerson acquires Aventics

Emerson announced it has completed the purchase of Aventics, a specialist in smart pneumatics technologies that power machine and factory automation applications. The acquisition is intended to expand the company's reach in the $13 billion fluid automation market and solidify Emerson's automation technology presence in Europe.

Aventics is a complement to Emerson's capabilities and solutions in significant discrete and hybrid automation markets and creates a portfolio of fluid control and pneumatic devices that incorporate sensing and monitoring capabilities.

With central offices in Laatzen, Germany, Aventics has approximately 2,100 employees around the world and five manufacturing locations. ■

Partnership for process safety integration

Honeywell Process Solutions (HPS), an automation control, instrumentation, and services company, has entered into a reseller agreement with the software products division of Applied Engineering Solutions, Inc. (aeSolutions). Through the reseller agreement, aeShield is integrated into Honeywell's Process Safety Suite, which centralizes and synchronizes disparate process safety data.

This integration pairs the hazardous operation/layer of protection analysis, safety requirements specification, and safety integrity level verification requirements from aeShield with Honeywell's Safety Builder, Process Safety Analyzer, and Trace into a Process Safety Suite. This suite will allow safety personnel to monitor process conditions by comparing actual performance from the plant historian with predefined hazard conditions from the risk analysis. ■

Partnership to enhance industrial cybersecurity solutions

AVEVA signed a partnership agreement with Virsec giving AVEVA customers access to in-memory cyberprotection for industrial control and supervisory control and data acquisition systems. Virsec's technology reduces the risks posed by targeted cyberattacks across information technology (IT) and operations technology (OT) systems.

Digital transformation at industrial and engineering organizations has prompted a renewed focus on securing digital assets. As IT and OT converge, there have been an increase in high-profile attacks targeting critical infrastructure that has raised security concerns. Virsec Trusted Execution provides a layer of protection against these advanced attacks by ensuring applications perform only as designed.

On 30 January 2018, a partnership with Cylance was announced to provide end-point protection to AVEVA's industrial software portfolio. This protection—combined with the complementary in-memory security protection enabled by Virsec—strengthens the overall security of AVEVA's industrial software portfolio. ■

Automation by the numbers

$50 million

Codelco, the National Copper Corporation of Chile, has awarded a major contract with an approximate value of **$50 million** U.S. to Rockwell Automation to supply a number of important systems for the Chuquicamata underground mine, a "super cave" mine in Chile.

Rockwell Automation will collaborate in the transformation of the century-old, open-pit mine into a technologically advanced "super cave" mine that uses a block-caving extraction process. This advanced method is expected to extend the life of the mine by at least 40 years, improving its asset utilization.

Cave mining techniques are becoming increasingly popular, because they yield high production rates at lower costs. Block caving is a mining method in which blocks of ore are undercut to induce caving, allowing it to break up and be drawn off, pulled by gravity.

The contract includes a detailed engineering, supply, configuration, and assembly of four systems that comprise the mine's control system. This consists of an integrated operational platform, security system, supervision and control network, predictive maintenance, and a general administrative network.

Rockwell Automation is currently working on the engineering and construction phase, in advance of a project startup by mid-2019. Annual production is projected to be 320,000 tons of fine copper and 15,000 tons of molybdenum. ■

22 percent

Manufacturing technology orders capped the first half of the year with another strong month in June, gaining 5 percent compared to June 2017 and bringing the annual growth rate to **22 percent** for 2018. The latest *U.S. Manufacturing Technology Orders Report* from The Association for Manufacturing Technology (AMT) showed that orders totaled $417 million for the month, down 14 percent compared to May's totals, and at $2.55 billion for the year.

"While many manufacturers are expressing concerns about trade wars, it doesn't seem that it has slowed their need for additional capacity, and orders for new capital equipment remain strong," said AMT president Doug Woods. "Trade issues and supply chain delays are certain to have an impact on the equipment market as we head into the fall. AMT supports a quick and fair conclusion to the issues."

The only region to show month over month growth was the Northeast, where power generation and aerospace showed great strength in June. Metal cutting equipment in the South Central region posted a 25 percent decline in June from May levels but is nearly 40 percent ahead of the previous year's order pace through the first six months of 2018. The strength is largely due to higher oil prices and growth in the contract machining industry, but significant orders in automotive have also pushed the numbers up. Activity in the North Central-West was softer in June but posted strong year-to-date growth thanks to the mining and recreational equipment industries gearing up for additional demand. The strongest customer industries in June were aerospace and power generation equipment.

The key leading indicators for manufacturing technology were all positive in June. The purchasing managers' index again moved above 60, suggesting strong order growth through the end of the year. Consumer sentiment and auto sales bounced back in June after small setbacks in May. Capacity utilization for manufacturing continues to edge upward (76 percent in June), closer to the 80 percent that has historically signaled rapid acceleration for manufacturing technology orders. ■

26 percent

IFS, a global enterprise applications company, has released a primary research study of 200 North American manufacturing executives that reveals more than half of respondents expect their budgets for digital transformation to increase in the next two years. The IFS study also reveals that substantial investments have already been made in digital transformation initiatives. These investments led to a **26 percent** increase in companies saying their enterprise software did a very good or good job preparing them for digital transformation since a 2015 study. Based on the results from the study, IFS believes digital transformation will continue to accelerate in coming years, as only 5 percent of respondents expected their budgets to decrease.

IFS's results are corroborated by analyst research indicating a groundswell of investment in digital transformation. According to a study by IDC, spending on global digital transformation will reach $1.7 trillion by 2019, increasing 42 percent over 2017. According to the 2018 Gartner digital business survey, 59 percent of midsize enterprises intend to pursue their digital ambitions by both optimizing and transforming their business for the digital era.

Rick Veague, IFS CTO, North America, said, "There are simple wins to be had by leveraging more accessible technologies like mobility and, increasingly, IoT [Internet of Things]. Now that enterprise software vendors have planned their offerings around these technologies, the pace of change can pick up quickly. Those who cannot change at the pace of their competitors will be left behind."

The study also sheds light on the type of digital transformation projects respondents have budgeted for. Analytics and mobility projects were the most frequently funded among respondent companies. ■

The pay raise engineers have been waiting for

Results from the 2018 salary survey

By Cory Fogg

FAST FORWARD

- Incremental salary growth was greater than 5% for the first time in eight years, and salary growth for entry-level engineers in the U.S. was more than 10%.
- Engineering consulting and process, plant, and manufacturing engineering received the largest raises, while engineering management and operations and maintenance decreased in average salary.
- Oil and gas continued to pay the biggest salaries, but was the only industry segment to report a decrease in average salaries.

The financial situation of the average automation engineer got a nice boost in 2018. As the salary of the average automation professional rose for the fifth consecutive year, our salary survey found incremental growth greater than 5% for the first time since 2010 (5.3% in the U.S., 1.5% globally). So are today's automation engineers finally getting their due? A bigger boost in salaries has been anticipated for quite some time. Manufacturing and automation analysts have long pointed toward a looming skills gap, estimating more than 3 million jobs will need to be filled in the next decade. As this year's survey shows, that certainly seems reflected in automation salaries, as a career in the industry is increasingly becoming a financially rewarding decision.

With the rise of the Industrial Internet of Things and increasingly connected technology requiring advanced considerations in both cybersecurity and system design, the role of today's engineer is more crucial and complex than ever. Yet for the past few years of this survey, we saw only modest gains in salary. From 2013 to 2017, the average salary rose a total of 5.6%, just barely above the gain for 2018 alone. Some of the most prominent gains were:

- Average salaries for entry-level professionals in the U.S. (fewer than two years of experience) increased 13.7%.
- Average salaries for professionals with graduate school/advanced degrees increased 7.2%.
- The two largest raises, proportionally, went to engineering consulting (9.9%) and process/plant/manufacturing engineering (10.7%).

While we still have not seen any signs that the labor gap is being bridged, we can say that the increasing demand for automation professionals has finally taken that significant step up that we have been expecting for years. With the need for experienced professionals still growing, we anticipate the demand to remain strong for engineers for the foreseeable future, with a great deal of opportunity for young graduates and those who are interested in a STEM career.

Five factors of salary determination

Through our years of conducting this salary survey, we have identified the five major factors that determine salary:

- geographic region
- job function
- level of education
- industry segment
- years of experience

Our survey collected more than 1,900 responses from automation professionals located around the world, including 1,290 from the U.S. Salaries from country to country and region to

Average salary by region of the world

Region of world	Average salary	Percent respondents
U.S.	$119,354	72.1%
Canada	$104,615	6.5%
Mexico	$48,611	0.5%
Central America (including Caribbean)	$74,000	0.6%
South America	$54,384	3.6%
Europe (western)	$95,526	5.3%
Europe (eastern)	$44,230	1.5%
Africa	$46,700	1.3%
Middle East	$81,275	2.7%
Australia and New Zealand	$105,769	0.7%
Asia and South Pacific	$54,574	2.6%
South Asia	$52,840	2.5%

region vary greatly, so our analysis separates the U.S. responses in order to avoid skewing results. All of the results quoted in this article, other than average salary by region of the world, represent U.S. responses only.

Who were our respondents?

Our primary respondent (making up nearly 27% of total respondents) was a U.S.-based automation/control engineer, but the 1,903 respondents come from all over the world, with a variety of job functions. Our respondents tended to be heavily experienced, with 63.2% counting more than 21 years of experience. Engineers continue to become increasingly educated with over 70% of respondents having at least a bachelor's degree and 21.6% an advanced degree. On the whole, 76.4% of our respondents reported some sort of salary increase this year, with the largest percentage (31.4%) seeing about a 3–4% increase.

Just over a fifth of our global respondents (22.1%) reported a salary in the $100,000–$124,999 pay range. The second largest pay range reported (14.8%) was from $125,000 to $149,999.

Around the world

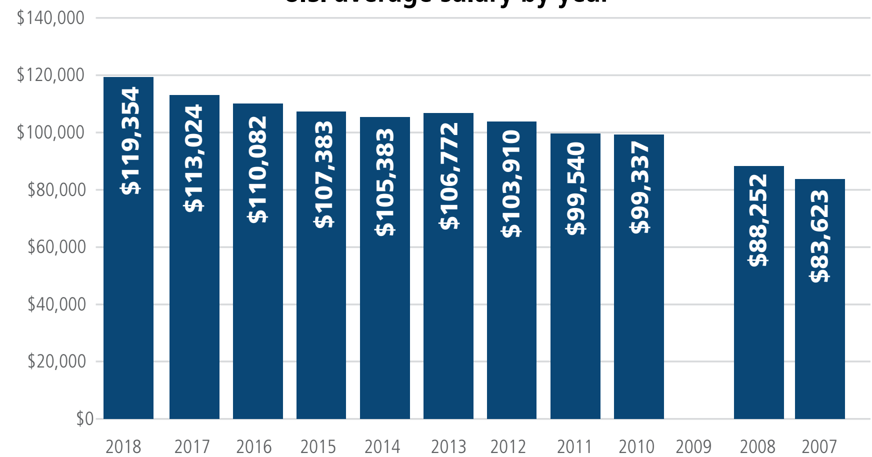
As the chart indicates, the typical engineer salary depends heavily on region, and more heavily on country. The typical U.S. engineer, for example, can expect 2.5 times the compensation of an engineer in neighboring Mexico. Similarly, engineers in eastern Europe should expect to make less than half as much as a western European engineer. Talking about the western Europeans, they also saw the highest growth in salary (17.3% average rise!). South Asian respondents reported a 24.4% increase in salary. That moves the region up four spots and out of the bottom in engineer compensation, where it was last year. African, South American, and Mexican respondents all reported salary decreases from last year.

Spotlight on U.S. engineers

Where the U.S. engineer is concerned, however, the financial future continues to be bright. The average salary continues to rise, posting its biggest incremental gain in nearly a decade during 2018.

As we mentioned earlier, the period between 2013 and 2017 saw salaries rise by a cumulative percentage that was just higher (5.6% to 5.3%) than 2018 alone. Over that five-year period, the average salary increased around $6,200, compared to an average $6,300 raise in 2018. This continues a decade of strong growth that shows U.S. engineers increasing their average salary by more than $20,000 per year since 2010. Where we have voiced concern in past surveys that the financial compensation of engineers had not been rising significantly with the demand, 2018 showed the U.S. engineer's value clearly on the rise.

U.S. average salary by year



Note: Survey was not held in 2009.

Does location matter for U.S. engineers?

Much like the world, all U.S. regions are not equal when it comes to engineer pay. The West South Central region, which includes engineer-rich Texas, has long held the title of best pay for engineers. The region was highest again in 2018, but the statistics showed the Pacific region, especially California, right on its heels. (*Regions are defined on Wikipedia.)

Only one region in the U.S., the South Atlantic region, reported an average salary decrease in 2018. The largest percentage increases were in the Pacific region (9.5% increase) and the West North Central region (6.9% increase).

U.S. average salary by region of U.S.

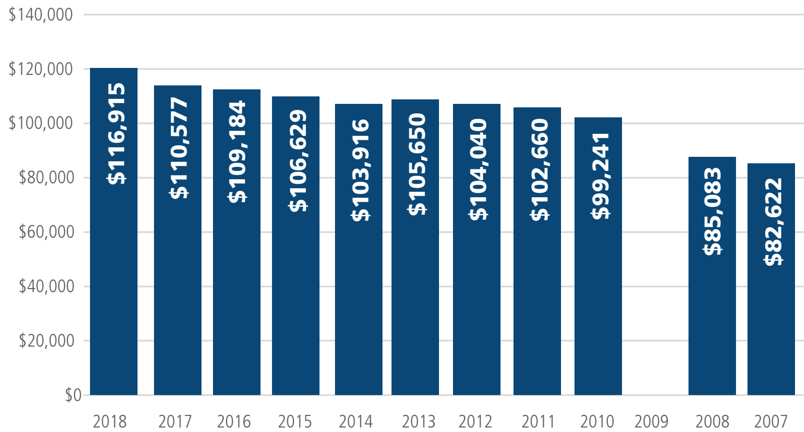
Region of the U.S.*	Average salary	Percent respondents
New England (Northeast)	$123,389	4.6%
Mid-Atlantic (Northeast)	$114,961	10.2%
East North Central (Midwest)	$111,518	17.0%
West North Central (Midwest)	$110,698	10.1%
South Atlantic (South)	$106,083	13.4%
East South Central (South)	$114,675	3.5%
West South Central (South)	$134,188	21.0%
Mountain (West)	$105,500	8.1%
Pacific (West)	$133,483	12.0%

In-depth look at automation/control

As nearly 40% of our U.S.-based survey respondents are in the automation/control job function, we always take an in-depth look at the statistics of this particular engineer. The automation/control engineers got their share of the pay increase, registering their own pay rise of more than 5%.

After seeing just a $6,487 (6.3%) rise in average salary over the 2012–2017 timespan, and a miniscule $1,393 (1.2%) in 2017, automation/control engineers reported an average gain of over $6,300 in 2018. With all the concern about a looming skills gap, and the number of aging and retiring engineers

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



Note: Survey was not held in 2009.

continuing to rise, this significant increase in compensation is a nice trend to see. Although automation/control engineers probably cannot expect 5% gains every year, we see a favorable environment for today's engineer and no signs of that environment waning any time soon.

Job function matters

Of course, there are plenty of job functions for engineers other than automation and control, and we did not ignore them. In fact, the number of functions and specializations available for today's engineers continue to increase, as we included infor-

U.S. average salary by job function

Job function	Average salary	Percent respondents
Automation/control engineering	$116,915	39.5%
Consulting engineering	$140,566	4.1%
Design engineering	$113,591	5.3%
Engineering management	$149,650	7.8%
General or operations management	$132,546	4.2%
Operations and maintenance	$93,275	10.0%
Information technology	$141,578	1.5%
Process/plant/manufacturing engineering	$115,818	4.3%
Project management	$125,735	4.3%
Sales – business development	$131,573	6.9%
Teaching/instruction	$107,954	0.9%
Other	$110,184	11.4%

mation technology and education functions in the 2018 survey to better reflect all the options open for today's engineer.

Every single job function registered an increase in the past year, save two. Engineering management and operations and maintenance were the only two functions that *decreased* in average salary. Engineering consultants were apparently in very high demand. They reported an average salary increase of almost $14,000 over 2017; their rise was followed closely by the process/plant/manufacturing engineers, who reported an increase of around $12,500.

ROI for engineering degrees

Although we cannot guarantee a return on investment (ROI) on a liberal arts degree today, engineering is very clearly a field where a degree can be quite lucrative. Seventy percent of our respondents were college graduates. Engineers with a graduate degree averaged salaries that were nearly $14,000 higher annually than those with a bachelor's, and $29,000 more annually than those with solely a high school degree.

Student debt is the bane of many a young professional's existence, but those with engineering degrees should statistically not have much of a problem. With the increases for each level of degree, and the current financial statistics, the average engineer should be well placed to pay off his or her degree in just a few years.

Average salary by highest level of education

Level of education	Average salary	Percent respondents
High school graduate	$106,854	2.4%
Technical/trade school graduate	$100,117	14.9%
Attended some college	$105,593	11.8%
College graduate	$121,792	49.6%
Graduate school/advanced degree	$135,725	21.6%

Choosing the right industry

While education level is a big salary separator, the industry an engineer works in also has a very significant impact. The average oil and gas engineer, for example, makes nearly $40,000 more than the typical water/wastewater engineer.

It is fascinating to note, however, that despite being the highest-paying industry segment, oil and gas was the only

Average salary by industry segment

Industry	Average salary	Percent respondents
Chemicals	$130,373	10.1%
Education	$111,562	1.2%
Engineering consulting or systems integration	$125,191	23.3%
Food and beverage	$109,396	6.7%
Industrial machinery and equipment	$115,000	10.5%
Oil and gas	$134,150	11.6%
Pharmaceuticals	$129,234	3.8%
Utilities – electrical, natural gas, nuclear	$121,444	7.0%
Utilities – water/wastewater	$96,000	7.8%
Other	$110,172	18.0%

segment to report a decrease in annual salary. Every other segment posted an average annual raise of more than $3,000. The chemical industry (9.4% increase) and the industrial machinery and equipment segments (9.3%) saw the highest average growth over the past year.

Pay your dues

Of all the salary differentiators, however, none matters nearly as much as experience. As it has for every year of the survey, the 30-year veteran's salary greatly outstrips that of the rookie wrench turner. This year's numbers continue to tell the same story.

If you have passed your 30-year mark in engineering, you are likely sitting pretty financially compared to the entry-level engineer, to the tune of an average salary almost $60,000 higher. This seems to be common sense, but it also gives us the biggest red flag when it comes to future engineering salaries.

Although engineers at all levels of experience saw raises in 2018 (except for the 21–25 years of experience group, interestingly), we also noted that 63.2% of respondents came in with 21 or more years of experience, and just 6% with less than five years. There are many variables that prohibit us from reading into this statistic too heavily, but it does raise the question whether or not closing the skills gap would actually decrease the average engineer salary.

Here again, however, this salary survey does not give us a definitive conclusion on how the skills gap is affecting the industry, more that engineering is an increasingly lucrative field to get into, with a significant capability to improve that standing throughout a career.

Average salary by years of experience

Years of professional work experience	Average salary	Percent respondents
2 or fewer	$72,954	1.7%
3–5	$83,526	4.3%
6–10	$97,704	9.5%
11–15	$117,485	9.5%
16–20	$122,697	11.8%
21–25	$116,381	14.7%
26–30	$126,898	18.7%
31 or more	$130,313	29.8%

Job satisfaction on the rise?

While a high salary can be a big driver to that end, job satisfaction is not necessarily based on financial compensation. As such, we ask respondents to tell us if they are seeking other opportunities, in order to help gauge the mindset of today's engineer. Positively, over half of all respondents tell us they are not seeking new opportunities, passively or actively. Pay appeared to be a factor, as U.S.-based active job seekers had an average salary of $110,275—more than $14,000 less than those who were not seeking a new opportunity. The majority of job seekers, however, were just passively looking. They made up 37% of respondents, making about $3,000 more than active seekers and $10,000 less than nonseekers. Appropriately, the average salary was $119,354, above the averages for active and passive seekers, but below the average salary for nonseekers. ■

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View the online version at www.isa.org/intech/20181001.

RECIPE

Recipe to maximize your salary

As we do every year, we conclude our survey with a time-tested recipe* for how automation professionals can 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 type of engineering will do). Then get your advanced degree (bonus points if you get your company to pay for it).
- Live in the U.S. or Western Europe. California and Texas remain the highest-paying states for today's engineers, but every U.S. region averages six figures.
- Get into engineering/integration consulting, an area of great momentum. Chemical and oil and gas are also well-paying options. If money is your primary goal, avoid water/wastewater.
- Show off your leadership attributes and get into management. Management gets paid.
- Become indispensable to your managers and company. Become an expert on useful, new technology and trends. Your company will not want to lose you if you make or save money.
- Stick with your profession—engineering has a lucrative career ladder. There are not many industries that have six-figure earning potential within 10 years of entry.
- Advocate for yourself. At the end of the day, any profitable organization's priority is the bottom line, which means the person who will best look out for *your* bottom line is you. Other companies want your skills, and it is not wrong to remind your boss of that with an offer sheet.

*Results may vary depending on attitude. ■

Global megatrends driving manufacturing digital transformation

Latest software systems improve business performance

By Keith Chambers

Figure 4: Handheld devices, such as tablets hosting software, can be used to digitize production line operations.

When designing software systems for manufacturers, there is a temptation to create a number of point solutions to deal with specific problems. Although this type of "bottom-up" model may temporarily fix each issue, there is often a lack of coherence among the solutions, with no clear path to overall business performance, and no vision for the future.

A better path is to design a "top-down," multisite, operational software architecture that first aligns business goals and performance with existing and expected customer demands. This architecture then drives each aspect of the system—with all solutions aligned, coherent, and contributing to overall performance. Point solutions can still be delivered within this architecture, but the coherence and synergy among those solutions will now by assured within a future-proofed architecture. To do this, one should start by looking at the global megatrends directing present and future consumer demand.

Global megatrends

Economists and others who study trends often say demographics is destiny, in large part because these types of changes can be predicted with a relatively high degree of accuracy. There are three megatrends now driving how manufacturers must manage their operations while planning for the future.

1. The first megatrend encompasses two related demographic changes:
   - *An explosion of growth in the global middle class:* More than 50 percent of this demographic group now lives in the developing economies of the Asia-Pacific region. There is a direct correlation between this newfound affluence and increasing demand for branded products.
   - *An aging of the worldwide population:* In just a few years, there will be more people in the world older than 60 than under age 6. This will affect manufacturers differently depending on what types of products they make and the regions they serve. For example, a company making toothpaste might now focus more on products geared to those with sensitive teeth. Further, each of these shifts will have a major effect on the manufacturing workforce, demanding more efficient use of human capital and improved knowledge transfer from retiring to younger workers.

FAST FORWARD

- Manufacturing operations should be designed using a top-down approach, starting with a high-level look at global megatrends.
- This approach can produce a future-proof software system architecture.
- It will also allow organizations to incorporate current and future technologies, including hybrid architectures, big data analytics, IIoT, and mobility.

2. The second important global megatrend is the push toward greater sustainability. For instance, agriculture is the leading user of freshwater worldwide, and water deficits are already a reality in many areas, creating a demand for more intelligent use of this resource. Water treatment and other processes related to the environment must also contend with heightened regulatory compliance.
3. The third megatrend has to do with consumer expectations, with customers demanding an ever-wider variety of products tailored to their individual needs. A good example is the passenger car market, which has come a long way from Henry Ford's "any color you want as long as it's black" thinking.

After identifying the global megatrends, the next step is to examine their specific effects on manufacturing.

Manufacturing impacts

The first impact is pressure on margins due to volatile commodity prices, labor costs, and supply-chain shifts—affecting already thin margins. Sustainability affects commodity pricing, while aging populations increase labor costs, especially for those companies providing health care insurance. Supply-chain shifts are driven by changing consumer expectations.

Another impact is the need for variety. It is easy to see how this will affect manufacturers. Just take a trip down the "free from" aisle at your local grocery store to see how many consumer preference and allergy subsegments are being targeted, with corresponding higher prices.

Increasing regulatory obligations are driven by the sustainability trend—with safety, environmental, and labeling regulations becoming increasingly pervasive. Consumer expectations also play a role, because brands with a poor reputation for environmental stewardship or unsafe products are rapidly shunned as stories go viral and global in minutes.

On the flip side, those firms seen as forward looking in this area can often charge higher prices, as with organic and fair-trade food offerings. The aging population plays a part in labeling regulations and packaging requirements, as older consumers need clear and readable instructions, along with easy-to-open containers (figure 1).

In today's "always on" world, manufacturing cycles have compressed to quickly meet changing customer tastes or respond to a safety recall. This has led to the need for real-time customer engagement. Connected consumers react immediately to safety and quality incidents, potentially eroding brand equity. The global megatrend of changing consumer expectations directly drives this effect, as does sustainability to a lesser extent. After identifying megatrends and the corresponding impacts on manufacturers, the next step is to see how manufacturers can best cope with these changes.

Coping with change

In today's market environment, as described above, a traditional manufacturing approach no longer applies. These market dynamics dictate the need for a digital transformation.

Five strategic "pillars" are essential for a manufacturing business to successfully achieve a digital transformation (figure 2). These pillars are to empower employees, optimize operations, engage customers, transform offerings, and adopt new business models. The pillars are an idea foundation to simultaneously address the market environment, manage costs, and increase revenues while using today's technology trends to achieve transformation.

Figure 3 shows just what digital transformation means within a manufacturing operations context. The five pillars of digital transformation are shown on the left (depicted as symbols), as well as each of the five technology enablers: the cloud, industrial IoT, business process management, cybersecurity, and big data/analytics.

Together, these pillars harness technology trends to achieve operational excellence, encom-

Figure 1. Manufacturers of packaged goods for consumers are affected by global megatrends, because they are required to make their packaging materials more sustainable and offer a greater variety of products to meet the demands of demographic changes in their markets.

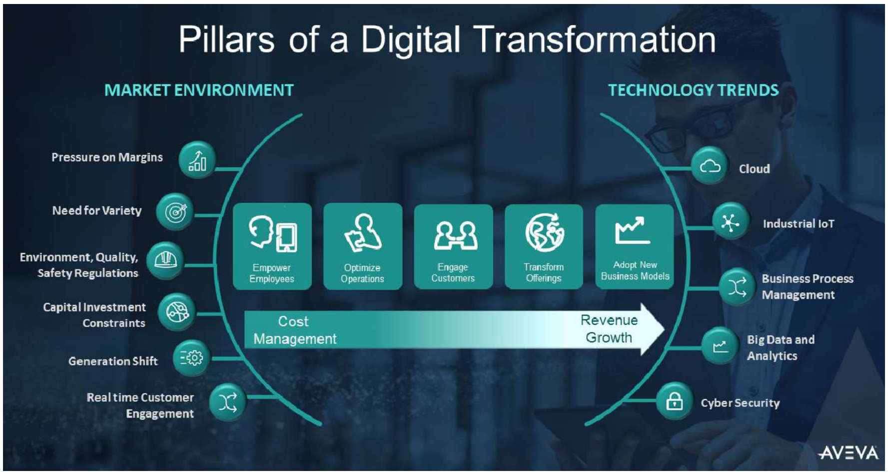

Figure 2. The five pillars of digital transformation link the market environment and its impact on manufacturers with technology trends.

Figure 3. Digital strategies and technology enablers drive operational excellence initiatives via new operational architectures.

passing most digital transformation initiatives across manufacturing organizations—beyond just implementing a manufacturing execution system (MES). Leading initiatives include asset performance management, environmental health and safety, quality management, new product introduction, manufacturing operations management, and industrial energy management, just to name a few. In the digital age, the lines blur between these initiatives, because the same data can be used in different ways to improve processes and achieve operational excellence.

New digital framework

New operational software architectures are required to better enable and accelerate implementation of these initiatives, including hybrid deployments (edge + cloud), mobile access, social collaboration, and access to big data and machine learning to better predict actions.

The text at the bottom right of figure 3 shows the value proposition for implementing digital transformation to drive operational excellence, encompassing the delivery of a host of capabilities. As companies begin their digital transformations, this type of operational architecture is critical for long-term success. It is tempting to simply skip over this step and start applying point solutions to achieve specific results. This is a mistake, as it results in a fractured landscape of disjointed systems that do not interoperate, with data often replicated, inaccessible, or siloed.

But just how does one design this type of operational architecture?

Model-driven approach

Using a model-driven approach to create an operational architecture means building upon an industrial software platform to:

- define requirements via process mapping
- implement using "low code" technology
- separate "content" from technology
- reuse engineering
- avoid custom coding

Following these steps separates processes from the underlying software technologies, allowing deployment across a wide range of activities and tasks. The first step is to define requirements via process mapping, using a methodology similar to business process management mapping, long practiced with great success in commercial environments.

Process mapping requires manufacturers to digitize, standardize, and improve. Digitizing means assessing and documenting current processes—along with touch points to other systems, such as automation and lab. Digitizing a task simply means to take what is in the minds of plant personnel when they perform an activity and to document it by putting it in writing, and then to enter this information into the appropriate software system (figure 4, see page 16). It also requires the creation of needed workflows and user interfaces—along with integration to MES and other systems.

Although standardizing a task or activity without digitizing it is theoretically possible, it is very difficult and expensive, and it is almost impossible to integrate with all of the other tasks required to produce products. Once a task or activity has been digitally transformed, it can easily be standardized, because all plant personnel follow the same steps. Standardization allows manufacturers to:

- account for needed variations among sites
- create libraries of practices that are centrally governed
- define and measure performance metrics
- build deployable packages and push to the sites

Figure 5. Truck unloading liquid to a tank. Digitizing the unloading of liquids from trucks to tanks can help plants and facilities standardize and improve operations.

- establish and document baselines to measure future process improvement

Digitization and standardization beget improvements, because performance can now be viewed, tracked, compared, and optimized. As the old saying goes, nothing can be improved until it is measured, and this is as true for manufacturers as it is for other businesses.

With digitizing and standardizing, manufacturers manage governance of each point solution centrally, with remote deployment and support of local software solutions. The result is continuous improvement of processes based on rich data collection. To illustrate how this model-based approach works in practice, let's look at an application example.

Material receiving and tracking

Many plants and facilities receive raw materials via truck (figure 5), as with this example where a food plant receives vegetable oil for use in its baking operations. As with many plant processes, this one can be digitized, standardized, and improved.

The first step is to notify appropriate personnel when a truck arrives. A sample of the vegetable oil is then taken and sent to the on-site lab for analysis and recording of results. If the sample fails, the truck is sent away. If the sample passes, the operator connects the truck to a nearby tank and starts the pumping process. If the tank fills before the truck is empty, the operator must disconnect the truck from the first tank and hook it up to a second tank. This process is repeated until the truck is empty.

Although seemingly simple, there are many ways this process can go wrong if the proper steps are not taken in the right sequence. There are also numerous opportunities to digitize, standardize, and improve upon the process.

When the truck arrives, the operator should ask the driver how long he or she has been waiting. This data should be digitized by entering it into the appropriate software platform, perhaps using a handheld tablet. The waiting time can be tracked, recorded, and improved upon if it is excessive, perhaps by using a sensor to indicate truck arrival and sending this information to plant personnel via a mobile alert.

The times when personnel take a sample, send it to the lab, and receive results are also measured as part of the digitalization. This shows how long it takes the lab to turn the sample around and can also indicate when escalation to a supervisor is required because the lab is behind. These types of indicators are all apparent in the data, allowing for continuous improvement in this collaborative process.

There are many ways to determine when a tank is full or a truck is empty, and various plants across the enterprise do things differently. For example, one plant may measure tank level by weight, while another may use a continuous liquid level instrument.

Once all the steps are digitized, a standard procedure for unloading vegetable oil from trucks to tanks can be created. This procedure can be adjusted as required to describe unloading of all types of liquids from trucks to tanks throughout the plant and across the enterprise.

During the standardization step, areas for improvement will be revealed as different truck unloading events are compared within a plant or across multiple plants within a company. For example, the time taken to sample product in a lab may be excessive across all plants, leading to implementation of an online analyzer to provide near real-time results at the unloading station. Level measurement by weight at a few plants might be found to be lacking due to changes in product density, so all plants within a company might implement continuous level instrumentation for a local reading of tank level.

Once this process is digitized, standardized, and improved upon—the next process can be mapped. The company can then make further improvements by linking one process to the next to optimize the operation of an entire plant or a facility.

Looking to the future

Taking a top-down approach when implementing a software architecture in a manufacturing enterprise ensures a future-proof solution closely aligned with business performance goals. The technologies and techniques discussed above enable this type of approach now, with three future trends expected to further ease implementation.

The first is a move toward hybrid architecture, a combination of on-premise and cloud-based software solutions. This change is already underway. Certain functions, such as real-time control, are best left on premise. Big data analytics, however, is an example of an activity best performed in the cloud, to take advantage of higher performance processing power and to ease collaboration of the results. And of course, these two types of scenarios must readily communicate with each other securely. Data from real-time control systems feeds big data to cloud-based analytics, which in turn feed information regarding suggested improvements to plant personnel.

The second trend is the growing proliferation of big data, as a direct result of now living in a digital age. When tasks are accomplished without written instructions, or when such instructions are written on paper, little or no data is produced. But when tasks are digitized, data is produced in the form of instructions, and more data is produced as each task is accomplished and recorded. This data becomes the basis for the continuous improvement at the heart of most operational excellence programs.

The third trend feeds directly from the second as this big data from the plant becomes filtered and contextualized, becoming valuable business intelligence. An example of this activity is the use of materials traceability data. When recorded digitally within the plant, this data can be used to more effectively inform consumers of a product's provenance should the need arise for a safety recall or to identify counterfeit or stolen products.

These digital trends are happening today and are only gaining momentum. Those manufacturers that look to implementing more than just a traditional manufacturing execution system—but instead to an operations architecture and platform to manage their digital transformation—will be better prepared to adapt quickly to new opportunities in the digital age. Implementing an enterprise-wide software architecture, one designed from the ground up to deal with current and future global megatrends and corresponding manufacturing impacts, is a great strategy to be best prepared for the future. ■

ABOUT THE AUTHOR

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RESOURCES

"HMIs Evolving to Serve the Enterprise in an Industrial IoT World"
www.automation.com/automation-news/article/hmis-evolving-to-serve-the-enterprise-in-an-industrial-iot-world

"Realizing more value from automation projects"
www.isa.org/intech/20150404

"Using the cloud to store and distribute manufacturing data"
www.isa.org/intech/20160205

Start with risk assessment to enhance safety

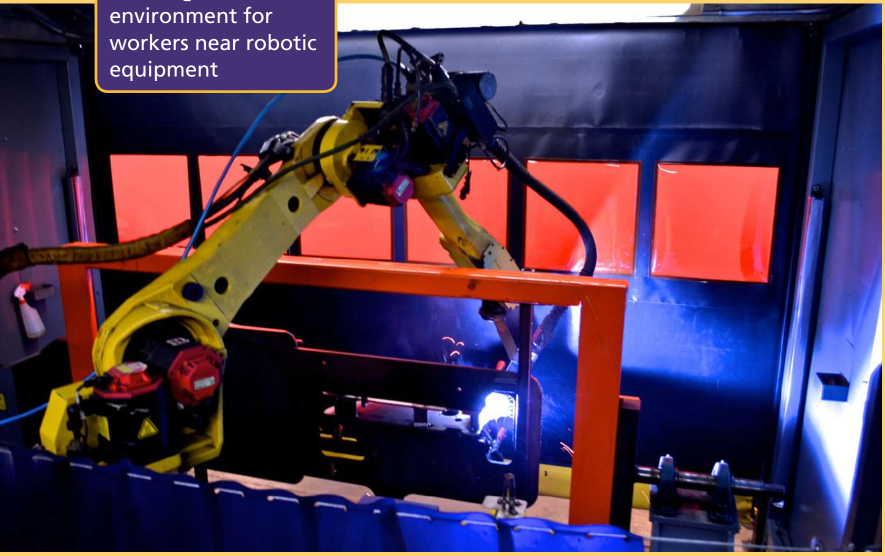
Automated barrier doors create safer workflow

By John Ritter

Look before you leap. This sage advice holds true in today's manufacturing world, especially as it pertains to machine guarding. That is why it is always a good idea to perform a proper risk assessment before installing or upgrading new equipment. Understanding all of the possible dangers associated with new operations can help a facility protect against hazards before an accident occurs.

And yet, according to the Occupation Safety and Health Administration (OSHA), "machine guarding," which pertains to machine general requirements for general industry (29 CFR 1910.212), consistently falls in the top ten most frequently cited OSHA standards violated in any given year. The multitude of robotic applications and the growth of robot use and automation in all industries seemingly make ensuring safety more difficult. But facility managers who start with a risk assessment need not be troubled by these advances in technology.

Creating a safe environment for workers near robotic equipment



Unfortunately, understanding and assessing these risks—and ensuring compliance—is not a simple task. Let's break it down by starting with risk assessments, before diving into possible machine guarding solutions, and then ending with a brief history lesson on some of the industry's changing safety standards.

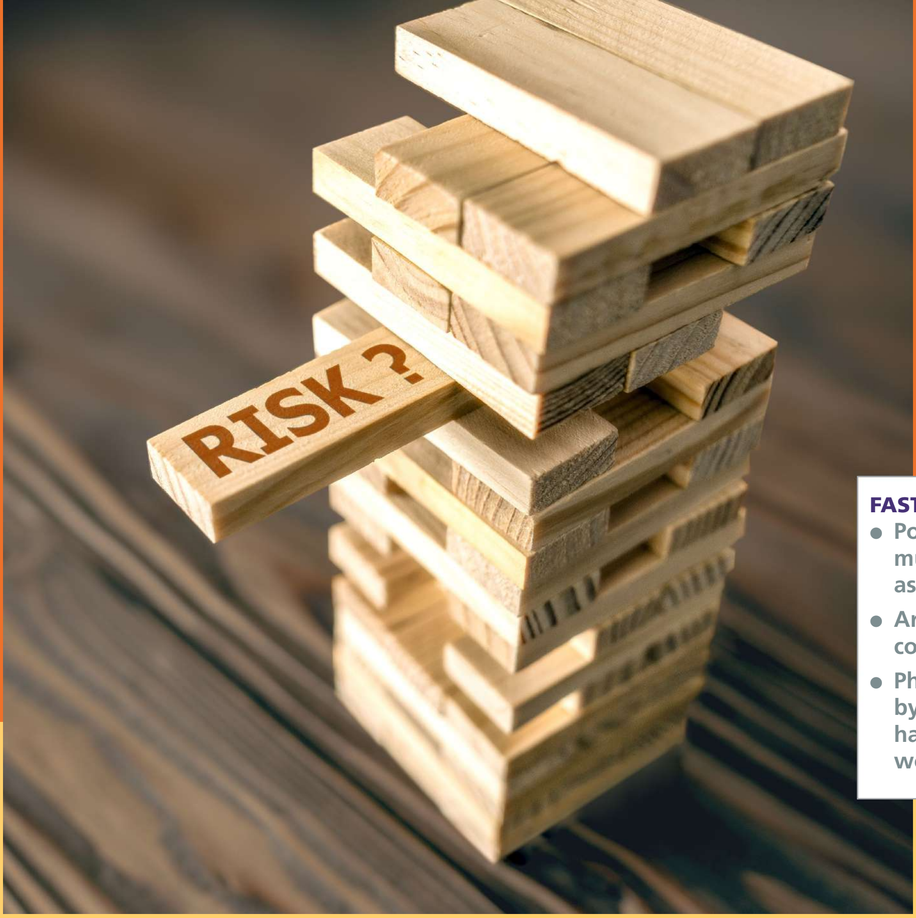
The basics

The first step for facility and safety professionals is to identify and understand all codes and regulations that are applicable to their facilities and operations. For managers who have stayed up to date, this is not a difficult task. For those who have not, this might not be quite so simple.

The second step is to examine the prevailing machine guarding choices for those operations to validate their safety system and its components. Although many guarding methods and products are available, not all can be applied universally. Every machine guarding application has its own unique challenges and associated risks. The choices a facility manager makes for one application might not be the same—or appropriate—for the next.

In most cases, safety-conscious managers would not guard an industrial robot the same way they guard other equipment, because the risk associated with each differs greatly. Risk may even vary between similar operations, depending upon employee exposure and other factors.

Conducting a thorough risk assessment is the best way to maintain a safe work environment, especially when adding new automated processes. Proper risk assessments are not just good practice, however. When RIA R15.06-2013 went into effect several years ago, they became mandatory.



FAST FORWARD

- Point-of-operation dangers become much more apparent after a proper risk assessment.
- Are you taking advantage of "safety-rated" control allowed by RIA R15.06?
- Physical barriers can improve worker safety by minimizing primary and secondary hazards that are common to hazardous work cells.

RIA R15.06-2013

When it arrived earlier this decade, the RIA R15.06 standard made life easier for manufacturers and end users by being compliant with international standards already in place in Europe. RIA R15.06-2013 references ISO 10218-1 & 2, which addresses robots, robot systems, and integration. This standard requires better hazard identification related not only to robotic motion, but also to the task being performed. Additionally, it requires validation and verification of the safety systems employed and requires designs that incorporate protective measures for the robot cell and the operator.

Some of the biggest changes with the RIA R15.06 industrial robot standard have to do with safety-rated motion and allowing advanced programmable safety devices to be used. This means software is allowed "safety-rated" control of various aspects of the robot's function, limiting the area in which the robot operates and the speed of robot motion. This is a departure from older standards, which did not allow programmable safety controls.

As mentioned earlier, risk assessments are required as part of this standard. Many professionals responsible for plant safety have been conducting risk assessments to increase safety as a matter of practice; the new regulations mandate them.

Point-of-operation danger

When performing a proper risk assessment, point-of-operation guarding is probably the most involved aspect. It is relatively easy to place perimeter guarding around the entire process. However, in most situations, a machine operator needs to interact with the process by loading or unloading materials (such as metals to be welded) and "running" the machine.

Point-of-operation guarding is where things get tricky. Many details must be considered when it comes to this area, including the layout or design of the process and the limits of the system. Also, facilities must properly identify all associated hazards and devise methods for hazard elimination and risk reduction.

Once the severity of the potential hazard has been determined, the frequency or duration of exposure and the possibility of eliminating or limiting exposure should be considered before making any machine guarding decisions. Also, using the distance formula identified in OSHA guidelines can help in this analysis. Per this formula, the safeguarding device has a prescribed location based on a number of factors, including secondary hazards that might harm a machine operator.

Presence-sensing devices

Light curtains, laser scanners, and other presence-sensing devices are a commonly used and widely accepted method of machine guarding in manufacturing facilities—from tier 1 automotive to small machine shops and fabrication facilities. With presence sensing, the automated process ceases once the safety device's infrared beam is tripped.

These devices often provide acceptable safety.

However, they are not always the best choice in all applications, especially after a risk assessment is performed.

Physical barriers offer more protection

Although light curtains may be the right choice in some applications, a fast-acting automated barrier door or roll-up curtain may be the better choice. They restrict workers' access into hazardous areas and can eliminate exposure to both the dangerous movement of the machine and secondary hazards produced by the process, such as smoke, flash, splash, mist, and flying debris. Thus, they more comprehensively diminish the potential risk and the severity of exposure.

Another benefit to physical barriers is that they take up a much smaller footprint than presence-sensing devices. This is because barriers with properly integrated safety interlocks (up to PLe per EN ISO 13849-1) render certain aspects of OSHA's distance formula moot. With no depth penetration factor, automated barriers can be placed much closer to the hazardous area. This reduced safety zone allows workers to be much closer to the automated process, which saves floor space.

ISO 13849-1 and EN 62061 emerge

The move from EN 954-1 to ISO 13849-1 and EN 62061 represented one of the largest regulatory shifts in decades. While approval of this harmonized standard was a hotly contested fight 10 years ago, all has been well since it went into effect in 2012.

At its core, ISO 13849-1 is a clearly defined set of rules to follow when designing the safety system as applied to industrial machine control systems. Officially defined as "safety of machinery, safety-related parts of control systems, general principles for design," this regulatory shift was made necessary by advances in technology for safety control systems and methodology.

The ISO 13849-1 standard is more quantitative than EN 954-1. It applies common sense and forces facility managers to validate their safety systems. Previously, EN 954-1 was conceptual and only required facilities to apply safety devices (controls), properly specifying non-programmable, out-of-date technology.

Increasingly complex manufacturing processes require more complex systems to monitor their safe operation and keep machine operators safe. Automated processes, robotics, and even time-tested operations all require considerable attention to ensure they are both efficient and safe. EN ISO 13849-1 is ultimately making a much safer manufacturing environment, because it accounts for the regulatory gaps that were starting to show in the older standards.

RIA R15.06 is similar to ISO 13849-1 in that it takes on a quantitative approach to hazard identification. A functional safety requirement of D (performance level [PL] "d") will be required of all robotic systems, as well as structure category 3 (dual channel), unless a risk assessment determines otherwise. PL safety and category ratings will offer a much more measurably reliant way to gauge safety.

Safety begins with a proper risk assessment

As regulations like RIA R15.06 and EN ISO 13849-1 are adopted, it is important to adopt the latest and greatest safety technologies available to match the right product to the right process, taking not only potential machine hazards into consideration, but the task being performed. Advances in design and available technology make automated barrier doors an option to guard the machine and protect operators, ultimately increasing productivity and the level of safety for years to come.

Regardless of the safety device selected for machine guarding, facility managers need to remember to perform a proper risk assessment. Although they can be tricky, this process will ultimately make a facility safer for workers and stay in compliance with RIA R15.06. ■

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View the online version at www.isa.org/intech/20181003.

Steam trap monitoring enables predictive maintenance

By Tom Bass

Monitoring identifies steam traps and downstream equipment issues to maintain plant efficiency

Figure 2. Steam is a valuable way to heat products in the pharmaceutical and food and beverage industries, as in these brew kettles.

FAST FORWARD
- If not properly monitored and maintained, steam traps waste energy and can often cause catastrophic failure of downstream equipment.
- Manual inspection rounds are expensive, labor intensive, and often ineffective.
- Wireless acoustic monitors are a better solution, with continuous updates and early warning of impending issues.

Steam distribution systems support manufacturing across a huge range of industries, from craft brewing to oil refining and most everything in between. Steam can carry enormous amounts of energy, and it is valuable as a highly controllable heat source. On the other hand, producing steam is energy intensive, and an ineffective distribution system can be wasteful. Boiler designs can be highly efficient, but this efficiency can be rapidly lost with a poor distribution system.

Boiler design and efficiency factors have been the topic of countless articles, so here we will concentrate farther downstream and examine the distribution itself, especially steam traps (figure 1). They are the primary tools for separating condensate from steam. A steam trap failure can be predicted to some extent through nonintrusive ultrasonic acoustic event detection using data generated by a wireless acoustic transmitter. Fixing failed traps early can also help to prevent problems in downstream equipment caused by passing condensate slugs through traps.

Condensate is sent back to the boiler as feedwater, which makes it valuable for two reasons. First, boiler feedwater is heavily treated with expensive chemicals to avoid boiler fouling, so any that can be recaptured saves money. Second, condensate is usually hot, which reduces the amount of energy needed to turn it back into steam. Consequently, condensate collection is critical for overall system efficiency, and it depends on steam traps.

Steam for heat transfer

We will explore more about transferring heat from steam in a moment, but steam is also used to capture heat. The term *heat-recovery steam generator* (HRSG) has become more common with the higher energy costs and carbon footprint concerns of recent years. Where older plants might have simply blown hot exhaust or process gases out a stack, they are now more commonly channeled into an HRSG and used to generate steam (see sidebar).

A prime example is a combined-cycle gas turbine power plant. Where a few years ago the hot exhaust from the gas turbine would have been blown to the atmosphere, now it is put through an HRSG and the steam runs a second turbine. This ability to recover what was regarded as waste heat contributes to the high efficiency of these generating units.

Steam is typically used to transfer heat to another fluid, such as a large-jacketed reactor or kettle used in a brewery (figure 2) or other food-and-beverage applications. Steam flows through passages and heats the product through the kettle walls or an internal coil. This can provide very even and carefully controlled heat, so the product is not burned. During the initial heating phase when the product is cold, steam condenses quickly, and the condensate collects in the lowest point. A steam trap separates condensate from the incoming steam and sends it back to the boiler as feedwater.

This is a critical point in the process and has a major effect on the efficiency of the kettle. To transfer all the heat possible from the steam, all of the steam should condense in the jacket. Early in the heating process, the temperature

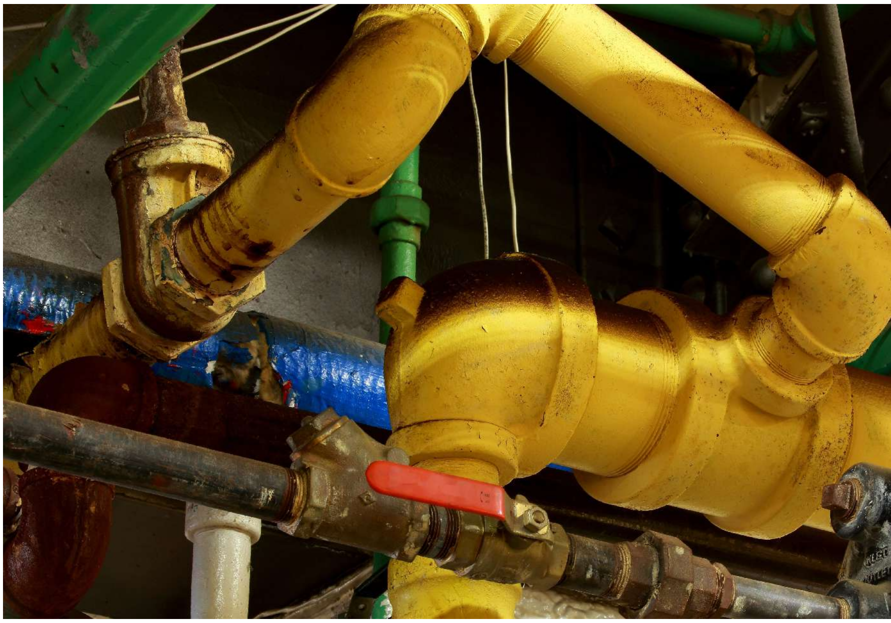

Figure 1. Steam traps are an important part of a distribution system, but often receive little attention.

Figure 3. An acoustic transmitter mounts next to the steam trap on the pipe, so no shutdown is required for installation.

differential between the steam and product is at its greatest. The steam transfers its heat into the product quickly and condenses. If the process is aiming at the quickest heat up, this is the time when steam flow is highest. As the product temperature increases and heat transfer slows, steam flow has to be reduced or steam will be blown from the outlet, which wastes heat.

Condensate runs into a steam trap, which allows the liquid to escape and return to the boiler via a collection system, but the trap stops steam, trapping it in the jacket. A steam trap is actually a condensate separation device. It has an enormous effect on the efficiency of the application. If it does not remove condensate fast enough, the condensate backs up into the steam passages, which reduces heat transfer. If it allows steam to blow past, heat is wasted. If the steam trap is sized properly and uses an appropriate design for the application, its action should be automatic, provided it is functioning correctly.

Steam trap designs

The discussion so far suggests that all condensate needs to be removed from steam, but the situation is more nuanced. Small amounts of condensate in a high-pressure steam line will be at a high enough temperature that it will flash into steam if it reaches a point where the pressure drops. Condensate carries a great deal of heat itself, so removing it when it is not needed also wastes energy. Consequently, there are different steam trap designs that remove condensate under different circumstances. Again, there are many more in-depth resources available, but some types of steam traps only release condensate when its temperature falls below a specific threshold; whereas others are simply concerned with liquid volume. The application will dictate which is most appropriate.

Functionally, a steam trap is a valve that opens and closes automatically in response to its situation. All designs, therefore, have some moving parts and a seating surface. Thermodynamic traps are very simple with only a single moving part; whereas mechanical designs (e.g., float and inverted bucket) are more complex. Unfortunately, where there is a mechanism, there is an opportunity for malfunction, but these types of problems can be predicted.

Steam trap failure modes

Steam is not always clean. Although feedwater is heavily treated, it is still possible for scale, which can break free and be carried by the steam and condensate, to form in the system. Such particles have an uncanny ability to come to rest in problematic spots, such as valve seats or mechanisms. Similarly, if feedwater treatment chemicals get out of balance, excess corrosion can result. Operating conditions, such as water hammer and vibration, also take a toll on valves, fittings, and steam traps.

A steam trap can fail in one of two ways: it sticks open and releases steam, or it sticks closed and does not release anything. Inspectors on plant rounds checking traps generally classify them by diagnosis:

- There is an obvious steam leak—a major mechanical failure.
- The trap is too hot—it is the same temperature as the steam line, because it is releasing steam directly into the condensate line or to the atmosphere.
- The trap is too cold—it is stuck closed, and no condensate is being released.
- The trap is just right—it is releasing warm condensate.

Finding these "Goldilocks" units performing correctly, and tagging the bad actors for maintenance, requires an appropriate tool to evaluate temperature, such as an infrared viewing device. These can do the job, but a technician has to get to wherever the steam trap is and make the evaluation. Unless manual rounds by a very highly qualified and experienced technician happen regularly and frequently, one or many steam traps can malfunction for quite a while. A recent study suggests that 18 percent of steam traps in a large chemical manufacturing facility can fail in a given year, resulting in wasted energy costs up to $16,000 per trap.

One traditional approach to monitor a steam trap involves finding a way to mount a temperature sensor on the trap itself to measure the trap's condition. But this is an invasive solution, and the data it provides requires extensive interpretation and knowledge of what the just-right temperature should be under the operating conditions.

Hearing the solution

Most steam traps do not release condensate continuously. Although such situations are possible, under normal conditions and if sized correctly, all steam trap designs open intermittently and discharge condensate in slugs. The internal turbulence when this happens creates noise that transmits through the adjacent piping. Someone listening to a properly working steam trap should hear these periodic releases interrupting times of silence as appropriate amounts of condensate accumulate.

An acoustic transmitter mounted on the pipe adjacent to a steam trap (figure 3) can listen to the noise it makes. It is sensitive to ultrasonic frequencies, so it can hear the cycling, and an algorithm can be applied to learn the characteristic activity for each trap. Data can be sent from the transmitter via WirelessHART to a central data collection and analysis platform, where operators can see how the steam traps equipped with acoustic transmitters in all parts of the plant are performing.

Dashboards display (figure 4) which steam traps are working correctly and which are in one failure mode or the

WORRIED ABOUT A DCS MIGRATION?

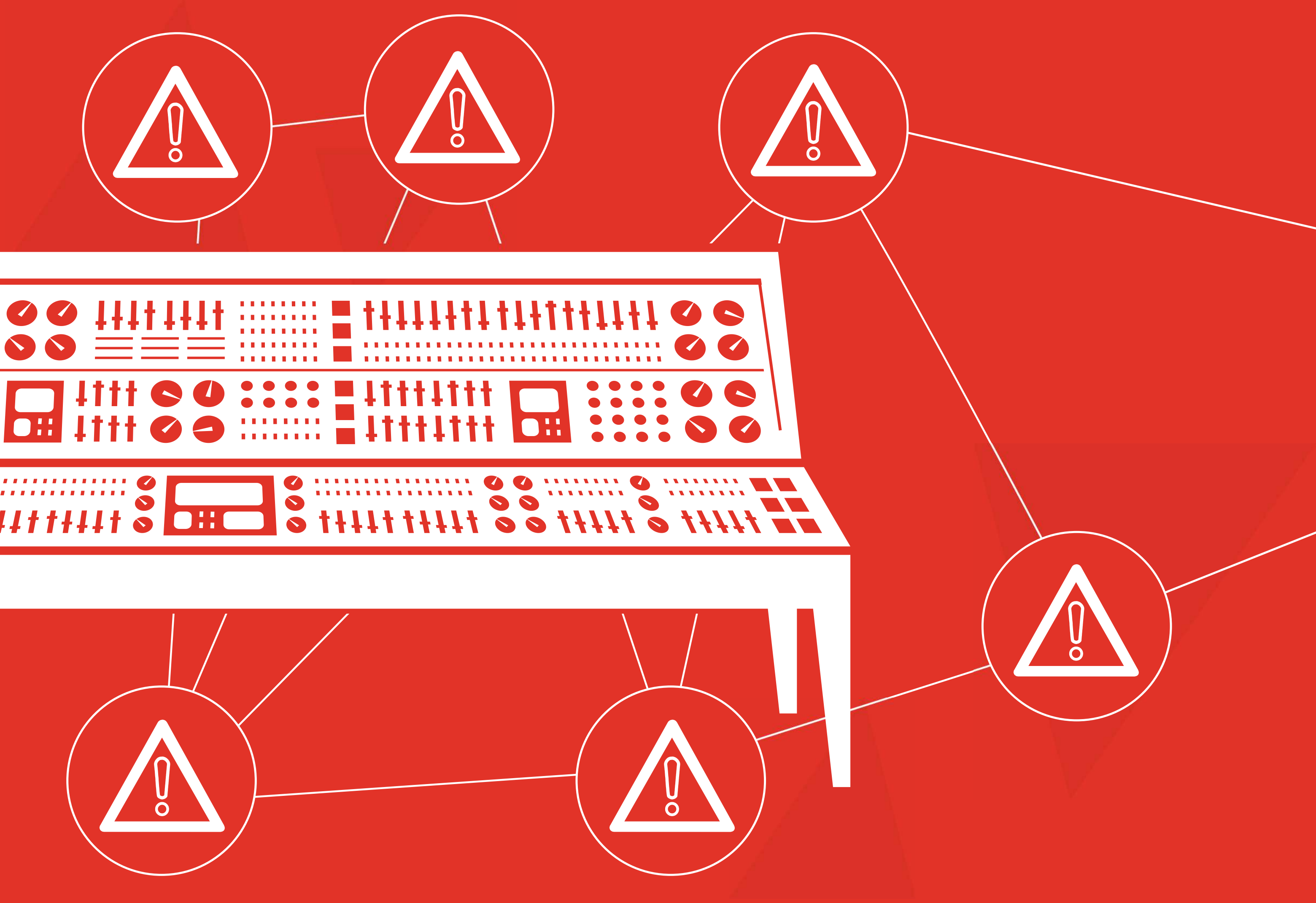

Figure 4. A dashboard supported by analytical software can capture and display performance and condition information for steam traps throughout a facility, enabling a predictive maintenance program.

other. The software can estimate lost energy and resulting costs at any time. Maintenance can see at a glance which steam traps need attention, so they can plan activities appropriately and can predict and deal with small problems before they become serious issues.

Naturally the data may need some interpretation. For example, a steam trap reported as cold could be malfunctioning, or it could be cold because the equipment only operates intermittently and may simply be shut off. On the other hand, a steam trap attached to a process that runs continuously or at least regularly should develop characteristic discharge patterns. If these change, such as from a sudden increase in condensate volume, there may be some other cause for a deviation from the normal process operation.

Predictive maintenance can take many forms and provide many types of information. Just as measuring and watching process variables gives insight into what is happening with the process, the same applies to production assets. Steam traps are just one example. There are now many sensors and analysis tools available to use with a range of plant assets, such as pumps, heat exchangers, and pressure relief valves. When data is available, maintenance departments can find new ways to develop better predictive maintenance programs to treat problems sooner, or before they even fully surface. This saves maintenance costs, but more importantly reduces losses from unscheduled shutdowns, and often prevents serious incidents. ■

ABOUT THE AUTHOR

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RESOURCES

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Case study: Steam generation, distribution, and efficiency

A major North American snack food manufacturer was undertaking a project to improve energy efficiency and reduce its carbon footprint across its fleet of manufacturing facilities. In one location, built around three large-scale production lines, it was clear that an enormous amount of energy was being wasted, blown out of stacks from the main cooking units. Early research determined that exhaust volumes and temperatures were high enough to make adding HRSGs practical (figure 5), and these units would be capable of creating much of the steam necessary for the plant.

This installation would be part of a larger project to determine the amount of energy used in the facility, divided by each production line on a British thermal unit per ton produced basis. Looking at the larger data picture would indicate to unit leaders how well each line was performing and if there were wasteful areas needing to be fixed within the context of a predictive maintenance program.

Adding the HRSG units was a major step toward higher efficiency, because the steam they generated did not have to be produced by conventionally fired boilers. Building on this initial gain would have to include serious analysis of the plant's steam distribution system, since steam production was one of the most energy-intensive elements of manufacturing.

Adding the HRSG units was a major step toward higher efficiency, because the steam they generated did not have to be produced by conventionally fired boilers.

To give an indication of the size of the steam system, the plant had about 400 steam traps distributed throughout the facility. At the beginning of the larger improvement program, none of the steam traps had any type of diagnostic sensor installed. The only monitoring was an annual audit where technicians compared actual performance against ideal parameters. This was a largely manual and very time-consuming undertaking. Unfortunately, it was also inconsistent and inaccurate. To make matters worse, given the time interval involved, a steam trap that developed a problem shortly after the audit could malfunction for almost a year before being discovered.

The larger efficiency program created a list of objectives to improve steam generation and distribution efficiency, including:

- improve boiler efficiency
- maximize condensate capture and return
- maintain heat exchangers more consistently
- repair and upgrade pipe insulation
- reduce system upsets that cause releases through pressure-reducing valves
- monitor and maintain steam traps by implementing a predictive maintenance program

Figure 5. HRSGs added to the exhaust stacks from the main cooking lines provide steam capacity, so conventionally fired boilers do not have to produce as much steam.

The last point proved to be particularly critical. Implementation began with purchase and installation of 50 acoustic transmitters on the most critical steam traps based on capacity, criticality to the process, and difficulty of inspecting by manual methods. Installation was not without its challenges. The facilities manager responsible for the project observed, "The bulk of our time was spent getting to the traps, since many of them were in hard-to-reach places. We discovered that proper installation is crucial. We had to ensure proper pipe contact with each device to prevent false cold readings."

The new monitors provided continuous data on those units, which maintenance technicians began to analyze using a specifically designed data collection and analysis software tool. Within the first two months of operation, they identified 12 malfunctioning steam traps—24 percent of those being monitored.

With the ability to check steam traps daily, maintenance soon began to schedule service and repairs much more quickly, stopping leaks and problems before they wasted significant amounts of energy. The facilities manager calculated that fixing just those 12 steam traps resulted in annualized savings of $27,800 and a CO_2 reduction of 205 metric tons. Payback for the initial deployment was 20 months. More detailed analysis allows predictive maintenance by anticipating the development of major problems, virtually eliminating complete failures of any of the monitored steam traps. The plant now monitors 100 steam traps using acoustic transmitters and plans to add 100 more as the savings that have been realized pay for the next group. ■

Scale *and* scope

By J. Patrick Kennedy, PhD

A large steel manufacturer wanted to use its operational data to improve its competitive position. By concentrating on condition-based maintenance and product quality, the manufacturer increased equipment availability by 13 percent and boosted the percentage of "prime" product from 76 to 91 percent, while slashing the percentage of maintenance conducted in the more costly reactive mode from 80 percent of the total to 20 percent.

On paper, the company looks like a success story for Industry 4.0 or a similar Internet of Things (IoT) initiative, but this story is older than either of those buzzwords. The above example comes from a presentation by Dofasco (now part of ArcelorMittal) in 2002. The phrase "Industrie 4.0" would not be coined at Hannover Messe for another nine years.

The automation industry has always liked buzzwords and standards. People debate the definition of concepts like big data, IoT, machine learning, Industry 4.0, digital transformation, and digital twins, but they are all a single effort to drive change by increasing two factors: scope and scale. By increasing scope (the number of data sources) and scale (the amount of data collected), companies broaden and deepen the information they tap into for a more accurate, actionable picture of reality. The greater the scale and scope, the greater the opportunity to increase the productivity, efficiency, safety, and ultimately the health of your business.

FAST FORWARD

- Digital transformation is about one thing: gaining control over the expanding scope and scale of data generated by industrial operations.
- The key of success is to control expenditures by implementation, not goals.
- Transparency, usability, and interoperability of data between systems becomes increasingly important as sharing information becomes the norm.

What is different about what is occurring today versus 2002, or even 1992? From one perspective, it is business as usual. Good engineers are never happy with just the data they have on hand. They should always be (and usually are) seeking out new ways to do things better and looking for numbers that can either support their hypotheses or prove them wrong.

On the other hand, everything is different. Moore's Law, artificial intelligence, increasing global competition, and a changing economic environment have created a new business landscape. Producers now have to be more sensitive to the demands of suppliers, regulatory bodies, and their customers, and there is a new premium on intelligence, efficiency, and agility. Companies can no longer simply be manufacturers. They have to be software companies *and* manufacturers. The scope and scale of your data have fundamentally changed how industry operates.

Industry 4.0 is well documented. In this article, I will use it as a model to describe the real-world requirements of businesses and how data architectures need to be designed to meet those goals.

Quick history of historians

The new demands being wrought by increases in scope and scale have sparked an evolution in historians and data infrastructures. Early data systems collected information from individual assets. Later, those systems were expanded and enhanced to collect data across plants and entire enterprises. And right now, data architectures are being implemented that will allow enterprises to seamlessly exchange information with each other to improve supply chains. Seven years ago, many large industrial companies would have blanched at the idea of sharing their data or putting it on the cloud. Now, most are studying ways to build digital communities.

Likewise, the community of users of this information is expanding, moving from engineers and

The driving force of Industry 4.0

Figure 1. Welcome to my time machine: Dofasco main site, 2002

operators to CFOs, capital planning analysts, buyers, and others. We are also seeing old assets from the '70s and '80s being wired into the main corporate networks for the first time thanks to more robust, less expensive wireless technologies and data management strategies.

Golden rule for growth

Information gets more valuable the more people consume it, so we should always look beyond the benefits of a single project. Building too quickly, however, can also cause projects to collapse. The primary rule for balancing ambitious goals with real-world constraints on budget and time is this: Control your expenditures by rate of implementation, not your goals.

Most projects I have seen fail to return large benefits fall into two categories: either the projects were more complex than anticipated, requiring extensive on-site remedial work, or the scope of the projects was too small, requiring outsized amounts of time, energy, and money. Both are failures that must be addressed at the architectural stage, not the implementation.

In the first case, the job was not adequately scoped—it needed more than data alone could accomplish—and required expensive customization to meet user expectations. The second case was a failure to follow the rule above by attacking a problem that was too small to carry the proper benefits. There is a mistaken belief that a smaller goal involves less risk. That is incorrect. Small projects can contain as much technological risk as larger ones. With the proper goals, average engineering procedures will eventually succeed, but with the wrong goals, no amount of brilliance will succeed. The ideal situation is to create a system that can meet immediate needs while leaving headroom for the future.

To build a system that can scale, first look at the underlying models. In industrial facilities, there are three types of asset models: the physical model, the process model, and the product model. We first observe that historically scalable systems are all based on a physical model—i.e., here is a sensor, record its output with as high a fidelity as you can, and keep the data for all time. (This is the basic design principle of supervisory control and data acquisition, programmable logic controllers, distributed control systems, and other automation equipment. The applications that use today's information infrastructure are nearly 100 percent software based, but this does not mean that they will be small value. After all, the Apple iPhone is mostly software, as is Uber, Airbnb, Lime, and others.)

By contrast, manufacturing execution systems are based on the process model and, while quite valuable in some cases, have inherent issues of scale and customization when you are trying to integrate metadata into the overall system. The same is true of product life-cycle management systems, which are based on the product model. Both of these latter cases can provide immense value.

Once the architecture for scaling has been decided, there are other metadata models that need to be defined, e.g., digital twins to arrange, aggregate, cleanse, and view or analyze the data in such a way that it makes sense to people. A reliability application will pull from the same overall source as process views or other applications, but the calculations, individual data sources, and cleansing techniques can and will be different. The solution is to separate the process of data management from the applications that use the data and develop a clean, open interface between them. Once you have reliably built a data management infrastructure that can truly scale and support data, shaping, reliability, security, and privacy, you have a massive data repository.

As users expand to include other applications, such as supply chain and enterprise optimization, the scope of data projects often extends to include suppliers, vendors, and customers. Resistance to upgrades will frequently emerge. It is often rooted in the perceived reliability (or unreliability) of large software systems, which in turn creates a perception that there will be increased costs or added security complexities. This sounds like an impossible task until you go back to the original premise: to create an architecture that will scale, you need to control your expenditures by the rate of implementation, not scope. Done properly, addressing proper scope should not cost significantly more money.

How does this architecture and infrastructure approach map to the four requirements of Industry 4.0?

Interoperability

At the lowest layer is streaming data management designed for the scope of the project. Streaming is characterized by extremely high data rates and new information coming in unsolicited. Currently, there are systems that operate in the millions of new events per second, and this tendency will only increase as we dig deeper into the fidelity of the data and accommodate additional smart sensors and equipment. As noted above, take care to design information collection without regard to its use. For example, a comment from an operations user that all he needs is 15-minute averages would create a data management system that would not be useful to automation or maintenance.

The four principles of Industry 4.0

Interoperability: the ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP).

Information transparency: the ability of information systems to create a virtual copy of the physical world by enriching digital plant models through the aggregation of raw sensor data into higher-value context information.

Decentralized decisions: the ability of cyber-physical systems to make decisions on their own and to perform their tasks as autonomously as possible. Only in the case of exceptions, interference, or conflicting goals are tasks delegated to a higher level.

Technical assistance: first, the ability of assistance systems to support humans by aggregating and visualizing information comprehensively for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber-physical systems to physically support humans by conducting a range of tasks that are unpleasant, exhausting, or unsafe for their human coworkers.

Source: Wikipedia

Processing stream data, especially at these rates, is a high load on real-time systems. One of the design objectives should be to remove any unneeded calculation and processing from this layer. A comment that includes the phrase "computers are fast, and memory is cheap" is a giant red flag that there are problems in the architecture.

The next step is to design simple, discoverable microservices to manage exchange of data between modules. Discoverability is important, because it allows apps to automatically attach to the data and its history to support a "plug and play" design—an essential requirement in large systems, where building with the expectation of manual configuration limits scale.

Transparency

There can be quite a lot of information generated from sensors and other computers (e.g., NOAA Weather for a power grid). Often, a curated view is provided to allow better interpretation of the information. The Industry 4.0 standard specifically addresses the need to have models to provide this added context. While the complete function is an application, managing the shaping or metadata is an essential part of the infrastructure, so that different applications can present similar views. Although part of the digital twin definition, shaping is also used for reporting, viewing, and production calculations, as well as models. When implemented online and used for operations, the digital twin requires the same level of technical support as the streaming data infrastructure.

Technical support

Unsupported software quickly becomes unusable. Technical support includes bug and error fixes, new logic, security updates, and a "help" function. Layering the parts of Industry 4.0 and defining the service architecture provides the base requirements for serviceable software and addresses the need for both interoperability and an open infrastructure. Finally, the system needs to be designed to be resilient in the face of abnormal events, whether caused externally (e.g., an exploit from a hacker), internally (e.g., fault or error in logic), or by a standard procedure (e.g., a system update). This often results in the use of high availability or redundant systems. In addition, the infrastructure needs to be monitored for detectible faults.

Decentralized decision making

The final requirement of Industry 4.0 includes two requirements for the architecture. I would like to emphasize caution on this: Automation should be done by a control system designed for the task. Most articles that extoll the value of having IoT start your car, open your door, or take other actions have not sufficiently addressed the potential for abnormal events that could bring harm to people or equipment. The same is true on alerts and alarms. At one of the American Petroleum Institute committees on alarms, a user noted that there are multiple cases in a refinery where it is safer to burn down a heater than shut it down. The procedure for handling alarms is thus more complex than it appears and requires knowing the larger context of the action.

In another example, one cause of the Northeast blackout of 2003 was the transient caused by the protective equipment. From an architecture perspective, the best protection is to provide all the information needed, a robust system, and tools for implementing automation. My belief is that control belongs in the on-premise equipment designed for this task.

Many of the new efforts to use computers to improve the management of industrial processes, variously called big data, Internet of Things, artificial intelligence/machine learning logic, Industry 4.0, or digital transformation, are merging into an approach that Professor Michael Porter called the "system of systems."

No individual system or piece of equipment has exclusivity on the use of digital computation, from lowest (e.g., the hardening of a sensor or smart meter processor) to highest (e.g., better management of the power balance of a country). The only difference between a small system and a large one is scope, and to have the proper scope, the system of systems must scale. ■

ABOUT THE AUTHOR

J. Patrick Kennedy, PhD, the founder and CEO of OSIsoft, has been at the forefront of bringing digital technology to the energy industry for more than three decades. Contact Michael Kanellos (mkanellos@osisoft.com) with questions or comments.

View the online version at www.isa.org/intech/20181005.

Shipped NGL producer improves commissioning, troubleshooting, and safety

FDT technology for smart instrumentation information monitoring and asset management

By Glenn Schulz

Device configuration and commissioning tasks are traditionally time consuming, tedious, manual, and prone to errors. Yet, they are vital for the reliability and safety of an industrial facility. Canadian company Inter Pipeline Ltd. streamlined plant startup and safety procedures with smart instrumentation information monitoring and asset management solutions. Having open access to device intelligence is essential to enhanced reliability, reduced failures, and faster startup times.

The following article describes how Inter Pipeline recently commissioned a new liquids extraction plant with smart HART devices, and how it used field device tool (FDT) technology to access information to effectively streamline precommissioning, configuration, and troubleshooting of field instruments.

Inter Pipeline is a major petroleum transportation, storage, and natural gas liquids (NGL) processing company based in Calgary, Alberta, Canada. It owns and operates facilities throughout western Canada and Europe.

In 2016, Inter Pipeline acquired a Canadian midstream business. The company now operates the Pioneer 1 and Pioneer 2 liquids extraction plants near Fort McMurray, Alberta, a fractionator near Redwater, Alberta, and a pipeline system that connects these facilities.

The Pioneer 1 extraction plant, which began operations in 2002, processes off gas from oil sands upgraders. The Pioneer 2 plant began production in February 2016 and is committed to boosting domestic NGL production while reducing emissions of carbon dioxide (CO_2) and sulfur dioxide (SO_2).

Challenges with field devices

The "connected plant," with its promises of smart equipment sharing data and allowing manufacturers to make informed business decisions, can only be a reality if instruments are properly set up and successfully connected to the plant's network. Commissioning and configuring field devices typically is one of the final, critical tasks before a plant can be formally started up. However, completing these tasks accurately and on time often winds up being a critical hurdle before actual production.

Configuration and commissioning must be performed for each device—each with many configurable parameters. With many devices in a typical process plant installation, technicians have mountains of data to enter and verify. For example, a typical guided wave radar level and interface transmitter has more than 500 parameters to configure.

During commissioning and startup at Inter Pipeline's Pioneer 2 facility, approximately 700 HART instruments from different suppliers were connected throughout the plant. However, intermittent failures occurred with specialized radar and magnetic level measurement instruments. These devices are part of a crucial safety control system in voted configuration, whereby taking sensor signals and comparing them in the central processing unit (CPU) and executing the application logic accomplishes the voting elements.

Inter Pipeline's lead instrumentation and control engineer, Japan Shah, stated, "Voting degradation on Pioneer 2's safety system had the potential to cause unwanted downtime and also lowered confidence in the installed instrumentation. This situation was unacceptable to plant management and created an urgent need to an effective device troubleshooting and maintenance solution."

Integration and data delivery agility

To optimize device configuration and commissioning and ensure the continued safety of plant personnel and assets, Inter Pipeline's project team employed FDT for smart instrumentation information monitoring. Recognized as an international (IEC 62453), North American (ISA-103), and Chinese (GB/T 29618) standard, this enabling technology creates a common communication method between devices and control or monitoring systems for life-cycle management—to configure, operate, maintain, and diagnose intelligent assets.

FDT remains one of the automation industry's best-kept embedded software secrets. It is not a communication protocol, but rather an integration and data delivery technology powered by an open architecture that is independent of protocols and vendors. This allows seamless interoperability and integration in support of fully connected operations. The data collected by various management systems from

FAST FORWARD

- Proper device configuration and commissioning are vital for a reliable and safe industrial facility.
- Canadian company Inter Pipeline streamlined plant startup and safety procedures with smart instrumentation information monitoring and asset management.
- Open access to device intelligence enhanced reliability, reduced failures, and improved startup times.

Figure 1. Inter Pipeline's Pioneer 2 plant is a testament to innovation in the production of NGLs and olefins, and the reduction of emissions.

field instruments and other assets can be used to schedule preventive maintenance—avoiding costly plant downtime from breakdowns.

Ongoing advancement of FDT leverages major developments like the Industrial Internet of Things (IIoT) and Industry 4.0 through the FDT IIoT Server to help end users realize the potential of decentralization, interoperability, integration, as well as a unified view of all data and functions across process, factory and hybrid control applications.

FDT technology comprises two main software components: the FDT Device Type Manager (FDT/DTM) and the FDT FRAME. The FDT/DTM is a software component for an intelligent device or communication component within a digital network. It is similar to a device driver (like the driver used to set up a new printer),

Figure 2. Today's "connected plant" can only be a reality if instruments are properly set up and connected to the plant's network.

which is created by the instrument supplier, who has the most knowledge of the full capability of the device. DTMs can range from a simple graphical user interface for setting device parameters to a highly sophisticated application that can perform complex calculations for diagnostics and maintenance. They include a user-friendly graphical interface to simplify device configuration, maintenance, and troubleshooting. Their simple and clear interface standardizes the training required to configure an intelligent field device—shortening setup time and reducing configuration errors.

Conversely, the FDT/FRAME provides access to all devices, gateways, and communication components with single-point access to operational assets. It can be embedded in any control system, configuration tool, or engineering application that needs seamless access to the installed base of intelligent devices. This component allows DTMs to extract performance-driven data from all connected devices and multiplexers on a control network.

Inter Pipeline used FDT/DTMs to ensure field devices were precommissioned and configured properly. Device manufacturers provide FDT/DTM software for their products, and the FDT/FRAME communicates and reads those DTMs—regardless of protocol—for each device. This enables complete life-cycle access for configuration, operation, and maintenance, no matter the supplier, device type/function, or communication protocol.

Inter Pipeline monitored and troubleshooted multivendor instruments at the Pioneer 2 facility using PACTware software. An open-source program available to members of the PACTware Consortium, PACTware functions as a frame or "container" application that instantiates DTM driver objects (including displaying the device user interfaces) and allows connections between them. It is intended for flexible parameter adjustment of field instruments, remote I/O, and communication modules in digital bus systems and networks. It supports integration and interoperability capabilities that allow users to operate field devices from different manufacturers and communication protocols with a single, standard PC-based application.

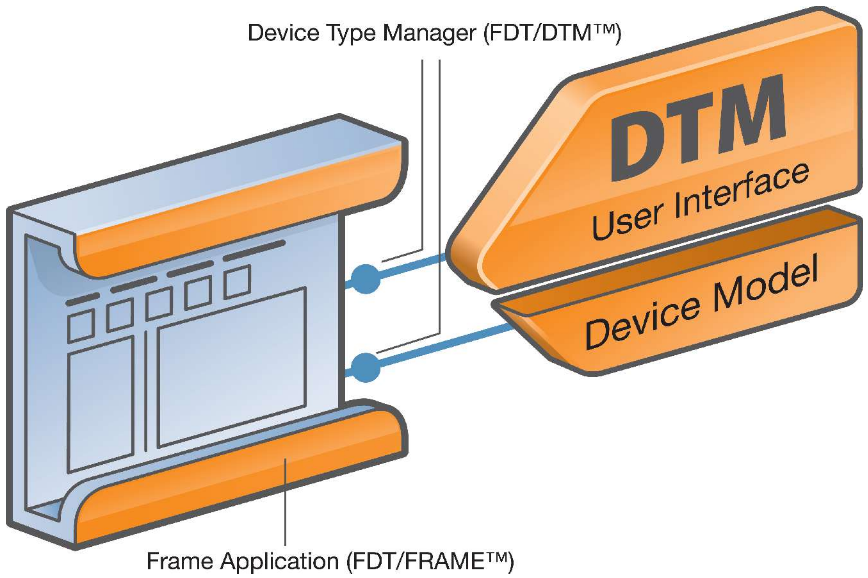


Figure 3. The FDT/DTM has a user-friendly graphical interface to simplify device configuration, maintenance, and troubleshooting.

PACTware is a simple solution for device configuration, and at the same time, it provides a path from basic applications to complex asset management. The incorporation of .NET technology not only enables greater independence from the hardware platform, but it also opens up new opportunities for a more advanced graphical user interface.

Addressing instrument failures

Inter Pipeline instrument technicians integrated DTMs with PACTware software to investigate, analyze, and correct instrument failures. In doing so, they eliminated spurious trips during startup of the Pioneer 2 facility. According to Shah, personnel at the Pioneer 2 facility found that using DTMs did not require a high level of technology expertise, but rather provided graphical access to smart device measurements and diagnostics for quick problem identification and resolution. "Device DTMs proved to be valuable when configuring and troubleshooting complex instruments like radar and magnetic level gauges," Shah said. "Technicians were able to see the devices clearly, know their condition in advance, and act with agility throughout their workflows."

DTMs support a more robust diagnostic capability than Device Descriptions (DDs) and Electronic Device Description Language (EDDL), which provide minimal information on how to address malfunctions and configuration issues with smart instrumentation. The DTMs are a handy tool for less experienced technicians to solve instrument problems in a short time.

Device suppliers can embed intelligence in a DTM in a way that is very difficult to accomplish with DD files, such as graphical constructs that cannot be expressed within DD technology. Moreover, the DTM is specific to the device and revision, so it has knowledge about the particular version of each device on the control network. For example, magnetic level gauges installed at the Pioneer 2 plant have a DTM interface with a user-friendly troubleshooting menu. Being able to set sensitivity values through the intuitive DTMs helped resolve device performance issues and allowed personnel to do remote configuration, trending, and diagnostics.

In another instance, guided wave radar instruments had problems during tank filling. Personnel could adjust signal suppression and other parameters via DTMs. They gained visualization of echo curves, trends, and vessel configuration, along with the ability to store, review, save and email data on instrument configuration.

Simon Huang, lead electrical instrumentation tech for Inter Pipeline,

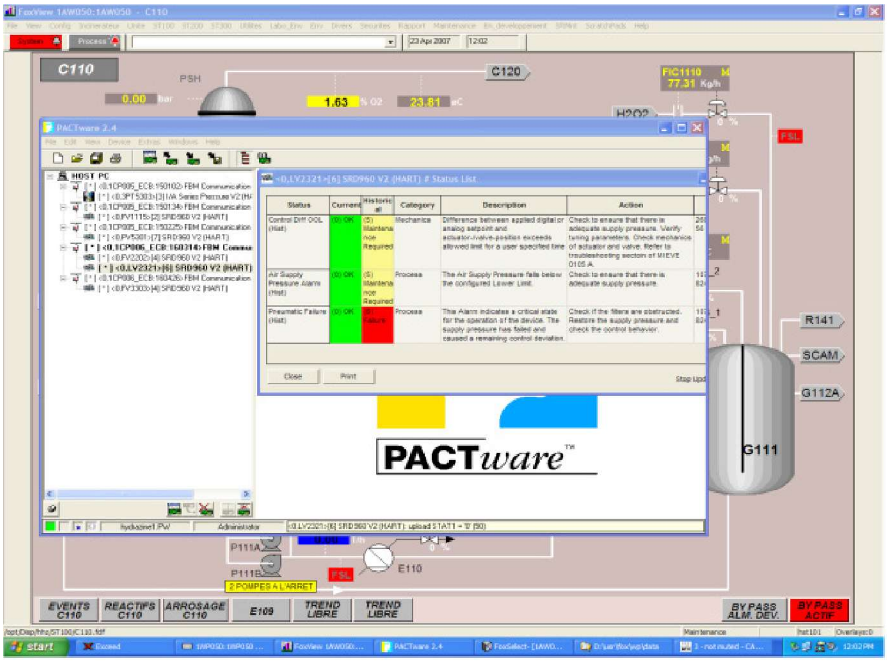


Figure 4. Monitoring and troubleshooting multivendor instruments at the Pioneer 2 facility was performed using PACTware software.

believes FDT technology will be an effective, long-term maintenance and operations solution for the Pioneer 2 facility. He said, "Our site maintenance teams now use DTMs as a day-to-day tool to tune a wide range of process and safety instruments—ensuring the plant runs without downtime, and, most importantly, stays safe. Personnel can remotely monitor the health of installed assets from a laptop in the control room without having to endure harsh conditions in the field."

Rakesh Keezhuveetil, DCS engineer at the Pioneer 2 site, stated, "The combination of measured values and device diagnostics helps in identifying specific deviations in operation and instrument performance, and has substantially reduced troubleshooting time. This capability also allows the rapid segregation of the team that must act to address issues involving maintenance, operation, or processes. When an adverse situation arises, online information is crucial to mitigate the source of the problem."

Advancing innovation

Inter Pipeline has continued to advance the innovation of the Pioneer 2 plant by achieving a flexible device configuration and commissioning capability, as well as a higher level of efficiency across its maintenance and troubleshooting work practices. Key to these improvements was the implementation of FDT technology to make certain all installed assets are used to the best of their ability. The facility has significantly reduced device commissioning cycle times and improved the quality of configuration. Operators, engineers, and technicians can now be confident in the reliability of their plant's safety system and instrumentation loops. ■

ABOUT THE AUTHOR

Glenn Schulz joined the FDT Group as managing director in July 2009. Most recently, Schulz was the managing director and vice president of engineering at Dorner. Schulz was instrumental in establishing the legal, nonprofit structure of the FDT Group that culminated with incorporation in Belgium as an AISBL. He has international patents and patents pending in the area of industrial asset management and industrial network security, while also holding CISSP and ISSAP certifications with a focus in cryptography. Contact maggie.carlson@fdtgroup.org with questions and comments.

View the online version at www.isa.org/intech/20181006.

Facing a faster world

By Bob Felton

Editor's Note: ISA continues its tradition of honoring leaders throughout the automation profession. The Automation Founders Circle features the personal stories of outstanding automation professionals who carry on the legacy of industry pioneers and ISA founders Albert F. Sperry, innovator and first ISA president (1946), and Arnold O. Beckmann, inventor, founder of Beckman Instruments, and ISA president (1952).

Shaping tomorrow's communications technology

For leading a global effort to solve the skills gap in automation control systems through new development and education in industrial data communications, this year's Excellence in Leadership Award goes to **Don Bartusiak, PhD**, chief engineer for process control at ExxonMobil Research and Engineering.

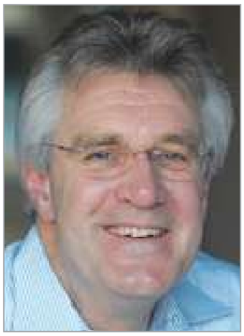
Bartusiak received a BS in chemical engineering from the University of Pennsylvania, then spent seven years researching process development aimed at minimizing waste at Bethlehem Steel. Dissatisfied there with the opportunities to contribute to environmental improvement, he followed up with master's and doctoral degrees in chemical engineering from Lehigh University. He then moved to ExxonMobil, where he has spent the past 30 years in process control and advanced computing. His process control applications have exploited artificial intelligence, linear and nonlinear prediction, and real-time optimization, and are in use in both the U.S. and the U.K. in both engineering and manufacturing facilities. Since the mid-1990s, he has held supervisory or senior technical positions with responsibility for instrumentation, process analyzers, control systems, and control applications at facilities in Texas and Virginia. From 2000 to 2002 he was a lecturer and adjunct professor of chemical engineering at Rice University.

In 2016, building upon research that he had done at ExxonMobil, Bartusiak helped launch the Open Process Automation Forum, with the purpose of developing a secure and standards-based control architecture that meets the technical and business requirements of a broad range of processes.

Though his career has been devoted to developing and implementing forward-looking technology, he attaches no less importance to mentoring young engineers and technologists. As he said when he was inducted into the Control Process Automation Hall of Fame, "My current position has two main components: to set a very forward-looking technical strategy that will make ours the best company in the world and to foster the next generation of technologists. The way Exxon Chemical's engineering group was set up, people on the technical ladder have to also train and mentor the less experienced. It's the way we learned to work. We're expected to impart our knowledge, to train and develop."

Bartusiak is a former national director of the Computing and Systems Technology (CAST) division of the American Institute of Chemical Engineers (AIChE), process control programming chairman for the Ethylene Producers Committee, and a member of Technical Committee 6.1 for Chemical Process Control in the International Federation of Automatic Control (IFAC). Currently, he is a managing director in the Standards and Practices Board of ISA and cochair of the Open Process Automation Forum of The Open Group. In 2011, he received the Computing Practice Award from the CAST division of AIChE. He was inducted into *Control Engineering's* Automation Hall of Fame in 2015, and in 2016 was named to *Smart Industry's* Top 50 Innovators. He has published 10 journal articles, addressing topics ranging from development of nonlinear predictive controllers to technical problems associated with real-time optimization, and is the coinventor of five patents answering needs as diverse as a method for recovering carbon and iron-bearing particles to developing a system for modular distributed control.

Speeding up process analytics



Don Bartusiak, PhD

Peter Geiser, PhD

For developing a new wavelength range for tunable diode laser absorption spectroscopy gas analyzers, this year's Award for Excellence in Analytical Technical Innovation goes to Peter Geiser, PhD, the chief technology officer at NEO Monitors of Norway.

Geiser earned his undergraduate and master's degrees in physics at Clausthal University of Technology in Germany in 2002, and then joined the staff of the Department of Applied Photonics at the Institute for Physics and Physical Technologies at Clausthal, earning his PhD in 2006. He then became a research scientist at Norsk Elektro Optikk AS, where he was the project leader for development of mid-infrared spectroscopy and led the development of the "LaserGas Q" product family. In 2015–2016, he served the company as acting chief technology officer, and in 2017 he was appointed to that position.

Geiser is a member of the Optical Society of America (OSA) and has served as a publications reviewer for the Institute of Electrical and Electronic Engineers and OSA. Further, he served on the technical program committee for CLEO Europe 2015 on the topic of photonics in defense and security, and in the same role for the 2018 Norwegian Electro-Optics Meeting. He is the coauthor of four refereed journal papers, on topics ranging from continuous emissions monitoring using lasers to chemical detection using lasers. Additionally, he has presented more than a dozen papers at professional conferences.

The Laser-Q sensor line developed by Geiser provides real-time determination of gas concentrations in process streams by sending a light beam through the gases to a detector on the opposite side of the stream. The sensor emits a different light frequency for each gas it measures. By measuring the intensity of the light that passes through the stream, and its absorption, the sensor returns a report of the gas concentration in less than one second. The need to sample the gas, and transport the sample elsewhere, is eliminated. As NEO describes the sensor, "The single frequency characteristic of the diode laser makes it possible to measure the absorption of a particular gas using only one single absorption line, thus avoiding effectively the interference from other gases in the same gas volume, resulting in a highly accurate instrument capable of measuring very low concentration levels when required."

A unique frequency is required for each gas, and the sensor presently measures concentrations of four gases: SO_2, O_2, CO, and CH_4. The ability to measure additional gases is in development.

In addition to measuring gas concentrations, the sensor has found application in cement manufacturing, where concentrations of explosive dust must be avoided. The improved speed of the measurement improves the speed of response to problematic conditions, enhancing safety, and the sensor is less susceptible to problems arising from exposure to dust or its accumulation, minimizing the need for service and maintenance. ■

ABOUT THE AUTHOR

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Digital manufacturing

By Hans Thalbauer

ABOUT THE AUTHOR

Hans Thalbauer (hans.thalbauer@sap.com) is the senior vice president for extended supply chain and IoT at SAP. He is globally responsible for the strategic direction for all solutions that are relevant for COOs and chief supply chain officers. Thalbauer has been with SAP for more than 16 years and has held positions in development, product, and solution management. He holds a degree in business information systems from the University Vienna, Austria.

I*nTech* had the opportunity to connect with SAP's Hans Thalbauer, senior vice president, digital supply chain and IoT, to explore digital manufacturing questions:

What should manufacturers focus on to start their journey in the new digital world?

There's no doubt we're in the midst of a fourth industrial revolution driven by large scale integration between digital and physical assets, IoT, and digital twin technologies. With manufacturers under increasing pressure to execute with speed, precision, and personalization, digital transformation is shifting from a forward-looking initiative to "mission critical" for the manufacturing industry.

But, implementing innovative technology like IoT [Internet of Things] to streamline operations isn't an easy task. According to Sikich's *Annual Manufacturing Report* published in 2018, only 10 percent of manufacturers are using IoT, and almost a third don't have a clear understanding of the technology. With a cluttered market, extensive hype, and uncertainty about true business impact, we recommend organizations start small and focus on attaining measurable, business-driven results before widespread implementation.

Digital transformation initiatives require organization-wide buy in (especially from key stakeholders), skilled talent for implementation, and often a shift in IT department structure. Change won't happen overnight, but identifying a few areas where technology adoption will align with key business initiatives and derive true ROI will help create the building blocks to develop a digitally driven organization.

How are technologies like digital twin and blockchain reshaping the manufacturing industry?

Digital twin, or digital representations of physical assets, such as a compressor or motor in a plant, can give operations managers unprecedented insight into the behavior of physical assets. They reduce the need for physical inspections and replace them with "digital inspections," meaning maintenance checks can be done regularly and efficiently, helping ensure that equipment is functioning at its best with reduced maintenance costs, increased asset availability, and improved customer satisfaction. With real-time data showing the current condition of the asset, managers are able to predict and remedy functionality issues before they even happen—eliminating setbacks and costly shutdowns.

As businesses implement IoT, digital twin, or other digital technology, they're generating a wealth of information and the ability for greater insights and transparency. Blockchain is one example that has the potential to lessen the burden of these challenges by creating a secure digital ledger that eliminates inefficiencies or inaccuracies in manufacturing operations, automation processes, and financial calculations. With blockchain, operations managers will have an accurate record of a product's entire life cycle.

How do you see the manufacturing space evolving in the next few years?

According to research firm Gartner, 20 billion connected "things" will be in use by 2020. While we're already seeing vast global adoption of the IoT, in the next few years, we're going to see a proliferation of organizations implementing connected technology to become truly intelligent enterprises. Further, as customers increasingly expect fast delivery times, organizations are going to need to adopt more distributed manufacturing models to shorten transportation time and ensure products get to consumers as quickly as possible. We're in a critical time where companies need to evolve their strategies or risk losing valuable customers. Outdated manufacturing processes will prevent organizations from thriving in our increasingly customer-centric world.

In addition, with demand for personalized products and faster delivery times growing rapidly, more manufacturers will turn to 3D printing to deliver on customer expectations. Three-dimensional printing enables businesses to create personalized products in small batches and to decentralize inventory, so there's no need for mass production, and products can be made to meet the customers' unique needs, and often, printed closer to the delivery location.

While it's an exciting time in the manufacturing space, it can also seem daunting as technology innovation quickly reshapes traditional processes, and operations managers are forced to rethink the way things have always been done. Digital transformation in manufacturing is inevitable, and it's what will allow organizations to compete in today's consumer-driven world. ■

User-created function blocks increase productivity

By Bill Lydon

One of the most powerful capabilities of programmable logic controllers (PLCs) that conform to the IEC 61131-3 standard is the functionality that allows application engineers to create function blocks that can be reused with confidence, increasing project efficiency and quality. In addition, the growing demands for more control system functionality can be efficiently satisfied by creating functions for applications. These include:

- real-time data links to information technology systems
- "make to order" manufacturing demands
- process synchronization
- control to optimize processes (i.e., increase quality and save energy)
- real-time maintenance information

Function blocks have inputs, defined operation, and outputs that are linked together to create applications. PLCs come with a number of functions that are standard, for example, ADD, SUBTRACT, MULTIPLY, DIVIDE, PID, TIMER, DELAY. PLCs conforming to the IEC 61131-3 standards enable control and automation engineers to create their own function blocks for applications. This is a powerful tool for improving quality and productivity. The application engineer simply defines:

- Inputs to the function, including data type for each (including field point inputs, integer data, floating-point data, string data, time, and array data)
- Logic and calculations for the function. This can be done using ladder logic, structured text, or other function blocks. The functions can be simple logic or complex calculations (e.g., scaling a nonlinear sensor, staging multiple compressors, part load control strategies, communicating your messages, overall equipment effectiveness calculations, and performance calculations).
- Output of the function, for example control outputs, constants, local variables, and global variables. The outputs can also be email messages, SMS messages, served-up web pages, and OPC UA messages communicating with enterprise systems using the standard IEC 61131-3 PLCopen/OPC Foundation functions. The communication versatility allows information to be sent to local displays for a wide range of purposes, including maintenance advisories, alarms, and machine fault information.

Once the function is created and tested, it can be reused with confidence over and over in any project. Functions can easily be shared with other application engineers on a server, via email, or using other methods. The function can be added to a library that is available for the project and for general use by other engineering staff members in the organization.

There are a number of advantages to creating function blocks for a project or general library of functions that can be reused with confidence, including:

- reusing tested code, which reduces errors and increases reliability
- self-documenting – easily understood
- developing password-protect functions, which protects intellectual property
- capturing and systemizing knowledge (information and procedures)
- lowered mean time to repair
- standardized specifications

Continuous improvement

The libraries of functions created can always be updated with improvements to the functions. If the logic and calculations of the functions are the only change, existing applications can be updated simply by changing the function library in the application project.

Increasing power and scope

Industry 4.0, Industrial Internet of Things, and smart factory applications are growing. Implementation is simplified with user-created function blocks and a range of other standards that conform to the IEC 61131-3 standard and others defined by PLCopen.

PLCopen was founded in 1992 as an independent, worldwide association for industrial suppliers and users to create specifications that increase the value and productivity of IEC 61131-3-based controllers. For example, the standards based on PLCopen OPC UA for controllers improve automation system device interoperability. This simplifies sensor-to-enterprise, cloud, and Internet communications with PLCopen web services function blocks based on the OPC UA standard. The PLCopen OPC UA functions are a universal, secure, and reliable network communication method in IEC 61131-3-based systems. This enables frictionless information exchange based on computer industry standards.

Function blocks are also available for direct machine-to-machine communications between multiple vendor controllers to coordinate automation. These new function blocks simplify the integration of packaging and other machines into these new architectures. Examples of PLCopen function certifications include:

For more information about PLCopen standards and certifications, visit www.PLCopen.org. ■

ABOUT THE AUTHOR

Bill Lydon (blydon@isa.org) is *InTech's* chief editor. He has more than 25 years of industry experience in building, industrial, and process automation, including product design, application engineering, and project management.

ISA announces Mary Ramsey as executive director

ISA has appointed automation industry veteran **Mary Ramsey** as its new executive director. Ramsey, who has been serving as ISA's interim executive director since January, has more than 25 years of industrial automation experience. She specializes in leadership, change management, and strategy development/execution. Before serving as interim executive director, she was senior vice president of process automation, Americas region, at Schneider Electric, where she was responsible for a $550 million profit/loss statement and 1,200 employees. She has also served as senior vice president of industry business USA and senior vice president of industry business Europe within Schneider. Before joining Schneider Electric, Ramsey held several business development roles within Matrikon International, Instrinsyc, Intellution, Inc., and GE Fanuc, among others. Ramsey holds a BSEE degree from the University of Kentucky and a MBA with a specialty in finance and strategy from Loyola University.

A search committee comprised of nine ISA members and leaders from around the world reviewed dozens of resumes and conducted a series of interviews over the past several months. "The search committee has dedicated significant time and effort to make this decision. We are confident that Mary's leadership and extensive experience will serve the organization, its members, and the automation community well for years to come," said executive search committee chair Steve Pflantz.

"It's an honor to serve as ISA's executive director," said Ramsey. "I'm excited to work with staff, members, and leaders to bring a fresh perspective to this important organization. ISA is truly unique in its ability to bring the automation community together to solve difficult technical problems and provide leadership on critical issues facing our industries. We have a lot of work to do, and with the help and support of individuals and companies around the world, we will advance ISA's mission and create a successful future." ■

In memoriam

Frederick Albert Meier, PE, died on 14 July 2018 in Chapel Hill, N.C., where he was a long-term resident. Born in Morristown, N.J., Meier served in the Army Reserve Specialized Training Program during World War II. After the war, he graduated from Stevens Institute of Technology in Hoboken, N.J., as a mechanical engineer and later earned an MBA from Rutgers University.

Meier had an interesting engineering career that took him to four continents, and he closed out his work career as the staff engineer for ISA in Research Triangle Park, N.C. He also coauthored a popular book, *Instrumentation and Control Systems Documentation, Second Edition* (www.isa.org/instdocument), with his son Clifford A. Meier.

His son and coauthor said, "Dad was happiest outdoors on Sunday hikes . . . He was a caring teacher, scout master, and unconditionally loving father. He was almost always the smartest guy in the room, but he was also the quietest until something needed to be said, or if he was laughing, or, to be honest, sneezing, which could be heard a block away." ■

ISA and The Open Group to advance interoperable process control architecture

ISA and The Open Group have agreed to a liaison memorandum of understanding (MOU) to facilitate cooperation in advancing and harmonizing the development of a multivendor, interoperable, and secure control architecture for application across the process industries. Activities will include sharing best practices, document review, and joint forums.

The Open Group is an industry consortium that develops open, vendor-neutral technology standards and certifications. The new liaison agreement pertains specifically to The Open Group Open Process Automation Forum (OPAF), which develops a standards-based, open, secure, and interoperable process control architecture.

ISA is known for developing standards in an open consensus process accredited by the American National Standards Institute (ANSI). The Geneva-based International Electrotechnical Commission (IEC) has adopted many of ISA's American National Standards as international standards.

Key ISA/IEC standards on cybersecurity and enterprise-control integration are primary motivating factors in the agreement, points out Dennis Brandl, cochair of the OPAF Standards Working Group, chair of the OPAF Technology Architecture subcommittee, and long-time leader and primary editor in the development of the ISA-95 series of standards. "This MOU shows the commitment from ISA and The Open Group to develop open standards that implement the best practices in the industry," states Brandl. "The widely used ISA/IEC enterprise-control system integration standards [ISA-95] and ISA/IEC 62443 standards [ISA-99] for the security of automation and control systems are key elements of the OPAF specifications. In addition, elements from ISA/IEC standards on alarm management [ISA-18], process safety [ISA-84], and batch process control [ISA-88] are being considered for inclusion as part of the OPAF specifications. We look forward to both groups working together." ■

New CAPs and CCSTs

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

Certified Control System Technicians

Name	Company	Location
Level 1		
Kirk D. Snyder	Bayer Crop Science	U.S.
Michael R. Murphy	Bayer Crop Science	U.S.
Daryl McGill	Bayer Crop Science	U.S.
Phillip J. Bliss	Bayer Crop Science	U.S.
Travis L. Dieckmann	Bayer Crop Science	U.S.
Michael A. Romanowski	Bayer Crop Science	U.S.
Jordan C. Sullard	Bayer Crop Science	U.S.
Robert Craig Tompkins	Bayer Crop Science	U.S.
Brandon Lee Taylor	Zeon Chemicals	U.S.
Greg J. Norman	None	U.S.
Timothy J. Nichols	None	U.S.
Jacob W. Santonas	Williams	U.S.
Timothy A. Majewski	Williams	U.S.
Richard H. Fitzsimmons	None	U.S.
Raymond J. Eye	M David & Sons Inc.	U.S.
Stanislaus M. Mrozek	None	U.S.
Philip S. Price	Ethos Energy	U.S.
Derek S. Harrison	None	U.S.
Kevin D. Whitlock	Virginia Tech	U.S.
Joel Mosebach	None	U.S.
Isai Garcia	None	U.S.
Chidiebere Kenneth Opara	None	U.S.
Matthew D. Walker	None	U.S.
Christian Humberto Perez Cruz	None	Mexico
Felipe Moniel Pascual	None	Mexico
James J. Timony	Invenrgy LLC	U.S.
Jeremy R. Mitchell	None	U.S.
Marc Nick Lubenetski	None	U.S.
Bradley A. Betzen	None	U.S.
John M. Mills	Invenrgy LLC	U.S.
Chad E. Buchanan	None	U.S.
Erik M. Sherman	Nestle Gerber Products	U.S.
Christopher E. Wilbur	None	U.S.
Scott C. Grimm	None	U.S.
Joseph C. Howes	None	U.S.

Name	Company	Location
Level 2		
Richard A. McIntire	None	U.S.
Brandyn D. Nelli	None	U.S.
Jose E. Mixon	None	U.S.
Jeremy D. Jones	Elanco	U.S.
Arlan I. Gozon	None	U.S.
John D. McPheron	None	U.S.
Scott M. Atkinson	None	U.S.
Lamngern Keonakhone	D.C. Water & Sewage	U.S.
Paul M. Kuebrich	Lewis & Clarke Community College	U.S.
Level 3		
Donald K. Burton	BAE Systems Inc.	U.S.
Craig A. H. Johnson	None	U.S.
Brian C. Hetzel	Flint Hills Resources	U.S.
Nicholas A. Chaplin	Williams	U.S.

Certified Automation Professionals

Name	Company	Location
Yousef Khalil Alyousef	SABIC	Saudi Arabia
Kenneth C. Kmack	None	U.S.
Kyle Cook	None	U.S.
Patrick D. Bunce	Columbia River Carbonates	U.S.
Jeremy W. Schlosser	None	U.S.
Matthew L. Walter	Wavid Solutions	U.S.
Andre P. Wedderburn	Champion Controls Inc.	U.S.
Kevin J. Castille	None	U.S.
Amit Kumar	None	Japan
Abdulelah Muhammad Al Shawareb	None	Saudi Arabia
Kevin M. Curtin	None	U.S.
Zain Ali	Fatima Fertilizer Co. Ltd.	Pakistan

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

Why must voltage be reduced along with frequency in a variable frequency speed controller?

A. to let the motor cool off
B. because of capacitive reactance
C. to maintain the volt/hertz ratio
D. to keep the motor from over speeding

CAP answer

The correct answer is *C,* "to maintain the volts/hertz ratio." To maintain a constant (rated) flux density, the applied voltage must also be changed in the same proportion as the frequency (per Faraday's law).

Varying the frequency affects both the motor speed and the strength of the magnetic field. When the frequency is lowered (to obtain a slower motor speed), the magnetic field increases, and excessive heat is generated. When the frequency is increased (to obtain a higher motor speed), the magnetic field decreases, and lower torque is produced. In order to keep the magnetic flux constant, the V/Hz ratio must remain constant. This keeps torque production stable, regardless of frequency.

References:

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

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

The Reynolds Number for a flowing fluid is most affected by which of the following parameters?

A. viscosity
B. pressure
C. friction factor
D. temperature

CCST answer

The answer is *A,* "viscosity." The Reynolds Number for a flowing fluid can be generalized as the ratio of kinetic (or inertial) forces divided by viscous forces. Although friction factor and temperature do affect inertial forces and viscosity to some degree, and therefore, Reynolds number, viscosity has the most direct effect upon the value of the Reynolds Number.

Reference:

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

New ISA/IEC 62443 standard specifies security capabilities for control system components

The ISA/IEC 62443 series of standards, developed by the ISA99 committee and adopted by the International Electrotechnical Commission (IEC), provides a flexible framework to address and mitigate current and future security vulnerabilities in industrial automation and control systems (IACSs). The committee draws on the input and knowledge of IACS security experts from across the globe to develop consensus standards that are applicable to all industry sectors and critical infrastructure.

A new standard in the series, ISA-62443-4-2, *Security for Industrial Automation and Control Systems: Technical Security Requirements for IACS Components,* provides the cybersecurity technical requirements for components that make up an IACS, specifically the embedded devices, network components, host components, and software applications. The standard, which is based on the IACS system security requirements of ISA/IEC 62443-3-3, *System Security Requirements and Security Levels,* specifies security capabilities that enable a component to mitigate threats for a given security level without the assistance of compensating countermeasures.

"The standard definition of the security capabilities for system components provides a common language for product suppliers and all other control system stakeholders," emphasizes Kevin Staggs of Honeywell, who led the ISA99 development group for the standard. "This simplifies the procurement and integration processes for the computers, applications, network equipment, and control devices that make up a control system."

The new standard follows the February 2018 publication of ISA/IEC 62443-4-1, *Product Security Development Life-Cycle Requirements,* which specifies process requirements for the secure development of products used in an IACS and defines a secure development life cycle for developing and maintaining secure products. The life cycle includes security requirements definition, secure design, secure implementation (including coding guidelines), verification and validation, defect management, patch management, and product end of life.

Looking ahead

Another key ISA/IEC 62443 standard expected to be completed in the coming months is ISA/IEC 62443-3-2, *Security Risk Assessment, System Partitioning and Security Levels,* which is based on the understanding that IACS security is a matter of risk management. That is, each IACS presents a different risk to an organization depending upon the threats it is exposed to, the likelihood of those threats arising, the inherent vulnerabilities in the system, and the consequences if the system were to be compromised. Further, each organization that owns and operates an IACS has its own tolerance for risk.

For these reasons, ISA/IEC 62443-3-2 will define a set of engineering measures to guide organizations through the process of assessing the risk of a particular IACS and identifying and applying security countermeasures to reduce that risk to tolerable levels. A key concept is the application of IACS security zones and conduits, which were introduced in ISA/IEC 62443-1-1, *Concepts and Models.* The new standard provides a basis for specifying security countermeasures by aligning the identified target security level with the required security level capabilities set forth in ISA/IEC 62443-3-3, *System Security Requirements and Security Levels.*

ISA99 is also working on converting ISA/IEC TR62443-2-3, *Patch Management in the IACS Environment,* into a standard by adding normative language. The current technical report addresses the installation of patches, also called software updates, software upgrades, firmware upgrades, service packs, hot fixes, basic input/output system updates, and other digital electronic program updates that resolve bug fixes, operability, reliability, and cybersecurity vulnerabilities. It covers many of the problems and industry concerns associated with IACS patch management for asset owners and IACS product suppliers. It also describes the effects poor patch management can have on the reliability and operability of an IACS.

The technical report provides a defined format for the exchange of information about security patches from asset owners to IACS product suppliers, and definitions of activities associated with the development of the patch information by IACS product suppliers and deployment of the patches by asset owners. The exchange format and activities are defined for use in security-related patches, but may also be applicable for other types of patches or updates.

For information on viewing or obtaining any of the ISA/IEC 62443 standards, visit www.isa.org/findstandards. For information on ISA99 and the ISA/IEC 62443 series of cybersecurity standards, contact Eliana Brazda, ISA Standards, ebrazda@isa.org or +1-919-990-9200. ■

Standards meetings at the 2018 ISA Leaders Conference, Montreal, Quebec

ISA112, SCADA Systems
12 October

ISA101, HMI (working groups)
15–17 October

ISA18, Management of Alarms
16 October

ISA75, Control Valves
15–16 October

ISA96, Valve Actuators
17–18 October

For more information, visit www.isa.org/isa-annual-leadership-conference

By Raymond Mulley, PE

Editor's note: The Basics department this month is an excerpt from the ISA book Flow of Industrial Fluids – Theory and Equations *by Raymond Mulley.*

Some material in this section may seem self-evident to recent engineering graduates. However, it is worth establishing some basic concepts as a springboard to what follows. It does not hurt to review basic material from time to time. It is surprising what one forgets—or never learned.

Compressibility of all fluids

Many terms used in the field of hydraulics are simplified descriptions of reality. Sometimes these didactic simplifications are useful; sometimes they are not. They help younger people over early hurdles and hinder them in their later comprehension. The name of the term, itself, can lead to conceptual errors. For instance, the distinction between an incompressible fluid and a compressible one is just a matter of degree. There may be orders of magnitude between the compressibility of a gas and that of a liquid; nevertheless, it is wise to bear in mind that all fluids are compressible to some degree—even the ones we call "incompressible." Later, we will show how compressibility helps explain another logical inconsistency—fluid friction.

Mechanism of flow

It is obvious to anyone who has ever used a garden hose that water flows when there is a higher pressure upstream than downstream. When we open a tap, or faucet, the higher pressure in the pipe causes water to flow. This common observation leads to the assumption that a higher pressure upstream than downstream is always associated with flow. The assumption is not correct. It is true a higher pressure is required upstream to start a fluid flowing across a restriction. However, once a fluid is flowing, it has momentum. As will be developed in greater detail when we discuss the Bernoulli equation, pressure is associated with one form of energy, static energy, and energy can take on different forms. One of these forms is kinetic energy. When a high velocity fluid flows from a small diameter pipe through a swage to a larger diameter pipe, the fluid slows down because of the continuity principle. In slowing down, some of its kinetic energy is changed to static energy. This change can cause the pressure downstream to be greater than the pressure upstream of the swage. This phenomenon is called pressure recovery.

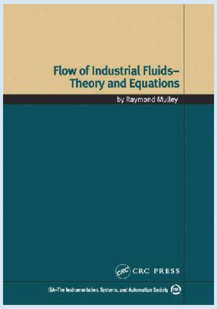
It is not necessary to have a higher pressure upstream in order to initiate flow. If a pipe is connected to an open reservoir—for instance, a water tower in a city water distribution network—flow will begin once a valve is opened. The pressure on the surface of the water in the reservoir is approximately equal to the pressure in a kitchen sink. In this case, there is no difference in pressure between the ends of the piping system, but flow occurs. There is more than just pressure difference involved in the flow of water. An unbalanced force in the direction of the flow is necessary.

Reestablishing equilibrium

The phenomenon of flow in conduits (pipes) is best thought of as an attempt to reestablish an equilibrium state in a fluid constrained by conduit walls. In a closed system under pressure, when all valves are shut, all forces are accompanied by equal and opposite forces. The fluid is stationary. In an open system, when valves are open, there is an imbalance of forces, and the fluid moves in a direction that will reestablish equilibrium. If mass and energy are added continuously to an open system, flow will be continuous.

The mass added could be water flowing to a reservoir behind a dam, or water pumped to a head tank. Once there, the water has energy by virtue of its position. This energy is potential energy or the potential to do work. Upstream of a closed tap, faucet, or valve, the water will be subject to the weight (force) of the water above it. It will exert a pressure (force per unit area) to equilibrate this force. This pressure is the result of repulsion arising when molecules approach one another. The pressure is associated with a static fluid and with a form of energy called static energy.

It is not necessary to have a higher pressure upstream in order to initiate flow.



ABOUT THE BOOK

Flow of Industrial Fluids–Theory and Equations provides context—both theoretical and practical—to all who wish to understand fluid flow. The book's purpose is to link fluid flow theory to practice in sufficient detail to give readers understanding of both theory and practice. The theoretical detail is limited to that necessary to understand practical problems—to the application of equipment and devices, not to their design. Insight is the primary goal. Basic theory and equations of fluid flow are given in an understandable but not overly simplified manner. To satisfy a broad intended audience, the book has a parallel structure of chapters and appendices. The chapters contain a logical, common sense description of the concepts and the equations of fluid flow. The appendices contain detailed derivations of the equations and detailed explanations of the subject matter of the corresponding chapters. More than 60 illustrations and 20 tables graphically represent data and ideas and allow the reader speedy access to precise data. Technical caveats found throughout the book also encourage the reader to pay particular attention to specific topics and thus avoid costly errors or misunderstandings. Many texts deal with instruments to measure and control the flow of fluids. They describe how devices work and only discuss fluid mechanics and dynamics incidentally. This text takes a different approach and is intended to be complementary to the above-mentioned ones. It discusses fluid flow in a way that gives the reader a clear grasp of the fundamentals that affect his or her work. The fundamentals are then linked to entire fluid systems.

Flow of Industrial Fluids – Theory and Equations is available at the ISA bookstore at www.isa.org/store/flow-of-industrial-fluids-theory-and-equations/116438.

If the valve is opened, the water will flow through it by virtue of the pressure difference across it. The pressure upstream of the valve will decrease for two reasons. First, some of the pressure energy has been converted to kinetic energy, the energy a body has by virtue of its motion. Second, some of the energy of the water has been converted to internal energy because of what is commonly called "fluid friction" in the upstream piping. The increase in internal energy is accompanied by an increase in temperature—hence, the loose term, "thermal energy." This loose term shortly will be explained more fully.

The kinetic energy is recoverable. It can be transformed back to static (pressure) energy by closing the valve or to potential energy by connecting an open, vertical pipe to an elevation equal to that of the reservoir. The incremental internal energy is not completely recoverable to one of the mechanical forms of energy. This is the reason the water in the previously mentioned vertical pipe cannot quite reach the original elevation of the surface of the reservoir. The incremental internal energy flows as heat through the pipe walls and is lost to practical use. It warms up the atmosphere. In a well-insulated pipe, it remains with the fluid for a longer period of time and is seen as a higher fluid temperature.

Logical inconsistency of fluid friction

The term "fluid friction" is commonly used to explain losses in mechanical forms of energy associated with fluid flow. A little knowledge of physics shows it is a poorly chosen term. Friction is a macroscopic phenomenon—such as when two blocks of wood slide over one another, or when the rubber hits the road. There is a definite resisting force to be overcome—the force of friction.

Fluid molecules do not touch

Fluids are made up of molecules, and molecules do not touch in the fluid state. Collisions of gas molecules are actually repulsions that prevent the molecules from touching. Liquid molecules are less energetic than gas molecules. They slide past one another or remain at an equilibrium distance. The equilibrium distance is established by a balance between an attractive force and a repulsive force. If molecules do not touch, how can there be "friction"?

The answer is found in the compressive forces that occur when local flow is slowed down by obstructions of any kind. These obstructions can be large objects, such as valves or fittings; they can be eddies within the flowing stream; they can be other molecules that have diffused between two layers of fluid moving at different velocities. ■

ABOUT THE AUTHOR

Raymond Mulley, **PE**, was the author of the book, where he shared his more than 30 years of professional experience, which included Flour Daniel, Dravo Chemplants, International Nickel, and private practice in the field of process hazards and control. Mulley passed away in 2008.

Coriolis mass flowmeter

The Promass A flowmeter measures substances drop for drop. Promass A measures values with repeatability, even in cases where process and ambient conditions fluctuate. The measuring device is suited for installations including modular process facilities and skids.

The sensor system is mounted on a base plate that acts as a "shock absorber," shielding the Coriolis measurement from outside interference, such as pipe vibrations. Other contributing factors are the oscillation frequency of the measuring tube and its completely balanced oscillation behavior. At a specified maximum measured error of ±0.1%, high-precision measurements down to 8 g/min are possible. If the maximum error is permitted to be ±1%, even a quantity of less than 1 g/min can be measured.

Device options include nominal diameter, material, process connection, certification, and transmitter type or degree of protection, and it can be used in numerous applications. The measuring device has a nominal diameter DN 1 (1/24"), so it can also be installed in extremely tight spaces, such as in skids. There are a multitude of process connections available, such as flanges, lap joint flanges, couplings, internal threads, and tri-clamps. Promass A can be used at process temperatures between –50°C and +205°C (–58°F and +401°F).

The wetted parts are manufactured from stainless steel or Alloy C22 and are compliant with the requirements according to NACE MR0175/MR0103. As a result, the entire measuring system has high corrosion resistance and is suited for applications in the chemical and process industries. Because the entire sensor housing surface consists of corrosion-resistant stainless steel, it is especially suited for harsh ambient conditions in the offshore and onshore sectors where there is aggressive, salty air. Process connections are available in different pressure ratings up to a maximum of 430.9 bar (6250 psi).

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

Mass flow controller with onboard pressure sensor

EL-FLOW Prestige in the company's line of mass flowmeters and controllers for gases can now be equipped with an onboard pressure sensor. In combination with the "differential temperature balancing" sensor technology and an incorporated gas database with physical properties, the instrument automatically compensates for inlet pressure variations. As a result, the accuracy and control stability will not be affected by these pressure changes.

The multigas and multirange functionality of the device enables the user to select any of the installed gases and to adjust the measuring range within the boundaries of the device. Also, the dynamic behavior of the mass flow controller can be tuned on site, by adjusting the controller speed parameters. These settings can be changed using free software tools FlowTune or FlowPlot. The latter tool can also be used for device diagnostics or alarm and counter settings.

Bronkhurst
www.bronkhorstusa.com

Flow switch monitor

Machinery manufacturers and plant engineers relying on the pneumatic control of automated assembly lines and end-to-end packaging equipment are a focus of the FS10i flow switch monitor. The measurement of compressed air flow lines with the FS10i switch/monitor gives information to the equipment's control system to optimize the air flow. It monitors and alarms for air leaks, which can occur due to failures of process piping, tubing, or compressor seals.

The dual function flow switch/monitor is suitable for trending the rate of air flow with its 4–20 mA flow monitoring output. It includes a relay output for low-flow trip point detection. The trip point and flow range are set in the field by technicians under actual operating conditions using tactile feedback buttons. By simulating a high and low flow while in the calibration mode, the FS10i will range the 4–20 mA output signal over that span and indicate flow.

The switch/monitor operates over a flow range from 0.25 FPS to 400 SFPS. Repeatability is ±0.5% of reading. It is designed for simple insertion into threaded tees in a 0.5-inch (13-mm) or larger diameter pipe.

The FS10i is repeatable to both increasing and decreasing changes in flow rate. This capability gives engineers the ability to adjust compressed air levels to variable production line demand. The device has a top/front-mounted 10-LED array. It has both a visual indication for plant technicians that the trip point has been exceeded (LED flashes on/off) and of the relative flow rate (10 percent increments) across the flow range. The switch/monitor's wetted parts are 316L stainless steel with the flow sensor's thermowells constructed of corrosion-resistant Hastelloy C-22.

Fluid Components International
www.fluidcomponents.com

Flowmeters and transmitters

The sister companies have expanded their TRICOR line of Coriolis mass flowmeters. It now includes both standard and advanced flowmeters and the TCD 9000 series transmitters that incorporate digital signal processing (DSP).

The TCM "CLASSIC" series meets general industrial requirements out of the box, while the TCMP "PRO" series has units with performance specifications and diagnostic capabilities for operation in challenging environments. The classic series includes TCE 8000 transmitters with an interface, standard calibration, and optional custom-calibrated meters with specifications.

The pro series includes TCD 9000 transmitters with digital signal processing and diagnostics, applicability for challenging liquid fluid conditions, logging and traceability functions, report fraction concentrations of two-part mixtures, I/O configurations with one-to-four channels fully configurable with programmable I/O options. The TCD 9000 series of transmitters has performance, diagnostics, and connectivity options. With a modern human-machine interface and a logging functionality, the DSP transmitters are a configuration and analysis tool.

Other site features of the TCD 9000 series transmitters include gas void fraction improvement, application adaptive filtering, and sensor-checking and troubleshooting wizards. Operating from one universal power supply (24 V to 240 V), the TCD 9000 series flow transmitters have a graphical display, SD card connectivity, and logging and traceability functions. Units are available with direct or remote mounts and Profibus PA, Profibus DP, Modbus, or HART communication protocols. The transmitter is also available with Modbus-only communication without display.

AW-Lake Company
http://aw-lake.com
KEM Küppers Elektromechanik GmbH
www.kem-kueppers.com

Modbus flow totalizer

The ModQ Sentry is a Modbus flow totalizer that interfaces with pulse-type inductive turbine (and other) flowmeters to provide flow rates, accumulated totals, and status information. Units are configurable for volume and time settings and offer options to configure the K factor to match the turbine.

Powered by an internal lithium battery for standalone operations or an external 6–36 VDC power source, the ModQ Sentry provides a local display along with a Modbus RS485 data port to integrate with programmable logic controller/supervisory control and data acquisition and distributed control systems. The ModQ Sentry maintains an internal thirty-day log of daily flow totals for historical analysis or backup storage.

The ModQ is pending Class 1 Division 2 certification for usage in hazardous locations. Packaged in a polycarbonate housing rated NEMA 4X, the units are weathertight for outdoor environments. Configured with local LCD and push buttons (or by using the company's tool kit), the ModQ manages data of turbine flowmeters in new and retrofit installations for a variety of industrial applications, such as oil and gas, metals and mining, water and wastewater, chemical, power, food and beverage, pulp and paper, aerospace, and pharmaceutical.

SignalFire Wireless Telemetry
www.signal-fire.com

Explosion-proof flow computer

The E126 explosion-proof flow computer for corrected gas and liquid volume measurement measures the actual flow, temperature, and pressure and converts it with a gas formula to gas volume at reference conditions. Daily and plant operations for running work permit procedures are not interrupted, and even partial plant shutdowns can be avoided, as the covers do not need to be opened to operate, set, and modify the display functionalities because of the through-glass keypad.

Fluidwell
www.fluidwell.com

Gas metering

Measurement IQ monitors the health of midstream metering systems for operations, maintenance, and leadership teams. With diagnostics, dashboards, and intelligence analytics, the system enables operators to increase metering reliability in the face of skills shortages, dispersed operations, and a complex hydrocarbon mix. Users can detect and correct mismeasurement and anticipate equipment failure.

The system connects assets across all enterprise metering stations and captures the data in the company's secure data center. Users can connect from any device with a web browser and receive customizable alerts on their mobile phones with the Experion App.

Honeywell Process Solutions
https://honeywellprocess.com

Gas measurement rate and total computer

The HIT-4G is a gas measurement rate and total computer with temperature, pressure, and AGA-8 compressibility compensation. The HIT-4G is the second release in the company's HIT-4 series.

The HIT-4G provides temperature- and pressure-compensated gas flow measurement and also has dual totalizers, Modbus, and data logging. With a six-digit rate display and separate eight-digit resettable and nonresettable flow totalizers, the computer is configurable for 4–20 mA loop power or DC power.

Several enclosure options are available, including the explosion-proof enclosure (North America, ATEX, and IEX), which is available in a powder-coated aluminum or stainless-steel option for maximum flexibility to meet harsh installation conditions.

Hoffer Flow Controls
www.hofferflow.com

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Sample of Jobs Available at Jobs.isa.org

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E&I maintenance technician

Alsip MiniMill LLC: The technician is responsible for maintaining the safety and operational readiness of mill facilities through planned, preventive, and emergent maintenance, with a primary emphasis on electrical systems in this company located near Chicago. The technician will work in a multicraft team with day maintenance and operations management and technicians. A minimum of a high school diploma or GED and five years of journeyman-level electrician experience with demonstrated competence in a heavy industrial continuous-process environment is required . . . see more at Jobs.isa.org.

Senior code compliance electrical engineer

New York Power Authority: The engineer is accountable to the director of QA and code compliance in this position designated as code compliance manager for projects affecting buildings, structures, premises, and equipment under NYPA's custody that are subject to the permitting requirements of Title 19, NYCRR, Part 1204. A working knowledge of the NYS building, fire, mechanical, plumbing, and fuel gas codes; the ability to perform objective plan reviews of all disciplines; good knowledge of building construction processes and related inspection and testing within a utility environment; and ability to work effectively independently or in a team are required . . . see more at Jobs.isa.org.

Supplier manufacturing engineer

Northrop Grumman Corporation: Responsibilities of this position, based in Melbourne, Fla., include supplying base technical management to the acquisition of electronic, electrical, electromechanical, and electro-optical components and assemblies; providing producibility reviews and technical evaluations of supplier proposals; and providing technical expertise to answer supplier questions and solve process issues related to the production of electronic hardware. Basic requirements are a BS in science, technology, engineering, or math and nine years of experience in an aerospace or military engineering/manufacturing role; an active DoD secret security clearance; and the ability to obtain and maintain a Special Access Program clearance. Up to 25 percent travel is required . . . see more at Jobs.isa.org.

Mechanical design engineer

Primotek Associates Limited: The company is a third-generation, family-owned business located in Johnstone, Renfrewshire, Scotland, that designs, assembles, tests, and sells thermostatic control valves for water, steam, and gas. The engineer role is very hands on and includes design of new products and supervising all aspects of the manufacture and testing of prototypes; assessment of competitors' products; analysis of test data; and identification and implementation of product improvements. The ideal candidate will have a degree in mechanical engineering, IMechE Chartered Engineer status, and a minimum of five years of experience in a role involving product design, project management, and designing and supervising batch-manufacturing processes . . . see more at Jobs.isa.org.

Challenges of being an I&C lead engineer – One man's opinion

By Mike Laspisa

ABOUT THE AUTHOR

Mike Laspisa worked in the I&C discipline for more than 37 years before retiring in 2012. He started at an EPC firm learning the field and control devices while creating instrument indexes and project manuals. He advanced to specifying I&C devices and creating construction document packages/scopes and eventually moved to leading projects in a variety of industries. Laspisa was recognized by ISA as a 25-year senior member in 2009.

I enjoyed being an instrumentation and control (I&C) engineer and collaborating with all available resources in completing assignments, often asking for help from vendors or other engineers. That said, I have witnessed a decline in the quality of work in many areas of I&C engineering in the past 10 years. In my almost 40 years of experience in the I&C discipline, I have observed changes in instrumentation and control engineering and the shifting of engineering to vendor inside sales forces. This has affected the quality of measurement and control device specifications in the past 15–20 years. Also, reduced training budgets in engineering firms have resulted in younger I&C engineers who are not as knowledgeable as they should be to be effective. Some old work standards and methods seem to have gone by the wayside in today's engineering world.

I created a list of challenges that an I&C lead engineer faces that might help a younger engineer:

1. Proposal and budget preparation. This is sometimes frustrating, because the task "hourly factors" are not always known or transferrable from project to project and the time frame given is usually less than desirable. The "deliverables" should be identified, and for the most part can be selected from the work breakdown structure–based estimating forms.
2. Multitasking on one or more projects. Keep organized and make/update "to-do" lists either daily or weekly as necessary. Many fail at this and wind up with a lot of half- or almost-done tasks.
3. Working with the varying levels of client I&C involvement. Be open minded about the control system. Concentrate on the hardware and software functional requirements. The same is true for the I&C devices. Stay with quality manufacturers. Yes—cost is a factor. However, performance and installed life costs are more important than the lowest initial cost. It is also true that a project has a finite amount of funds, and sometimes sacrifices have to be made. Use client-approved vendors and plant standards when available, but be open to looking at new technology as well.
4. Resist the temptation to send out unchecked or incomplete work. There are many pressures, *and* we have to count on other team members to complete their assignments. We have to delegate but are also responsible for the end product. Know your team members' strengths and weaknesses. Provide extra monitoring and checking where required. It is tough to tell your boss or PM that you might miss a deadline. Maybe you can issue the document with holds or partial instrument bid packages if they are representative enough to get a bid and select the vendor.
5. Do not blindly accept the process data provided for measurement and control devices. Work with the process department to make sure you are using *good* data. Good measurements, and properly sized final control devices, are the keys to good control loop performance and flexibility.
6. I&C device specifications are about more than just filling out datasheets. The end user is paying for engineering and experienced device specifiers. It is OK to review device applications and required accessories with your quality vendors. It is not OK to leave the majority of the fields blank or with an asterisk for «vendor to furnish». I have seen more than a few datasheets using this approach with missing or misleading information. The vendor can only work off the information provided on the datasheet without the benefit of a piping and instrumentation drawing or pipe specification.
7. Accurate reporting is a pain. Juggling hours sometimes is a necessity. Try to be fair to both without worrying about the last chargeable hour. It does not help anyone to make it just "look" like everything is on schedule or on budget.
8. Total quality improvement programs are about more than just taking 10 minutes to complete a checklist. Sometimes it seems that it is only an exercise done by lead engineers at the last minute. Interdisciplinary checks require time in the design schedule that is rarely taken into consideration.
9. Project teamwork includes the other disciplines. Work with the other leads. Be aware of their needs and how you are going to support them. We have a natural tie with electrical, but piping design also requires I&C input and review.
10. Speaking of electrical, on any given job the technical strengths of the electrical and I&C leads will vary. Work out the overlapping technical design issues: motor control (including local control device requirements and intelligent MCCs), power distribution, grounding, communication cabling, etc. If there are different opinions, get the discipline manager involved. ■

September/October 2018

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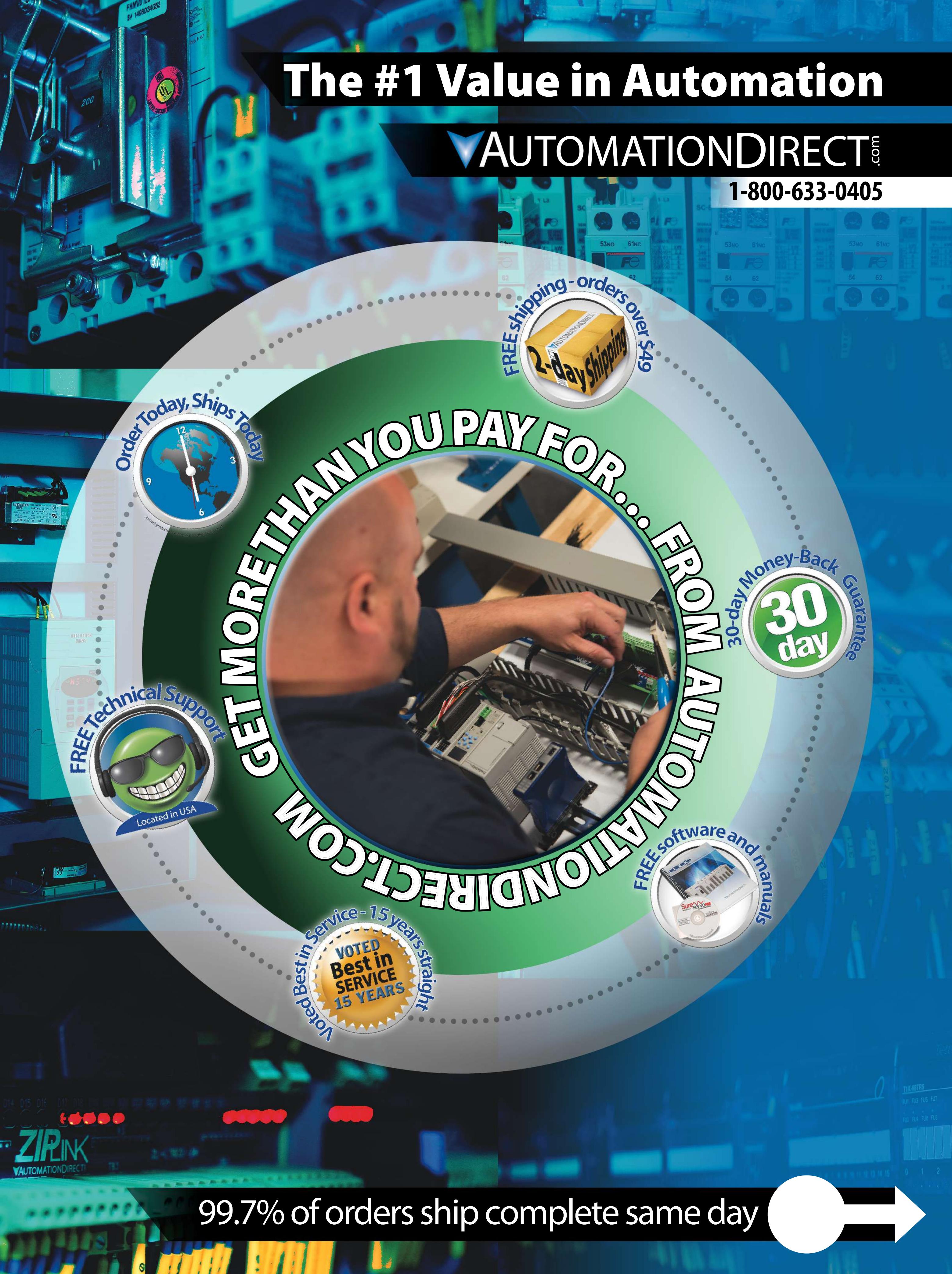

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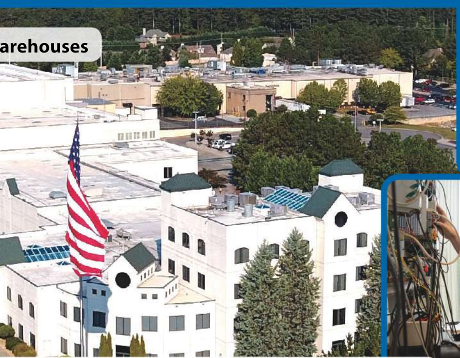

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Our team members here at AutomationDirect.com approach every day with this one goal in mind - serve the customer. It's a simple philosophy that many companies forget or make too complex and fail at. If the answer to any decision is **"Yes, this is good for our customers"**, then we do it.

It's common sense.

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Yes, this is good for our customers."

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Yes, this is good for our customers."

All these are discussions we've had internally and all have had certain aspects of "can we do that?", "that will be hard to accomplish", "no one else is doing that, how can we?". But if you bring it back to the simple answer, "Yes, this is good for our customers", then the perceived obstacles really don't matter.

Our company has evolved dramatically since 1994 and it's this type of decision making by all our team members over the years that keeps our customers coming back and new customers checking us out daily.

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