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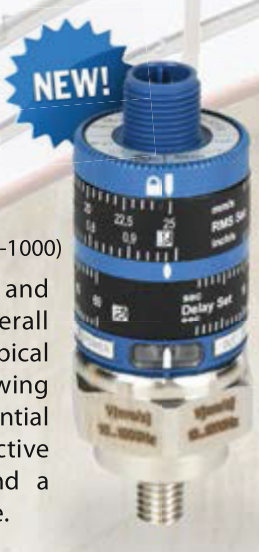

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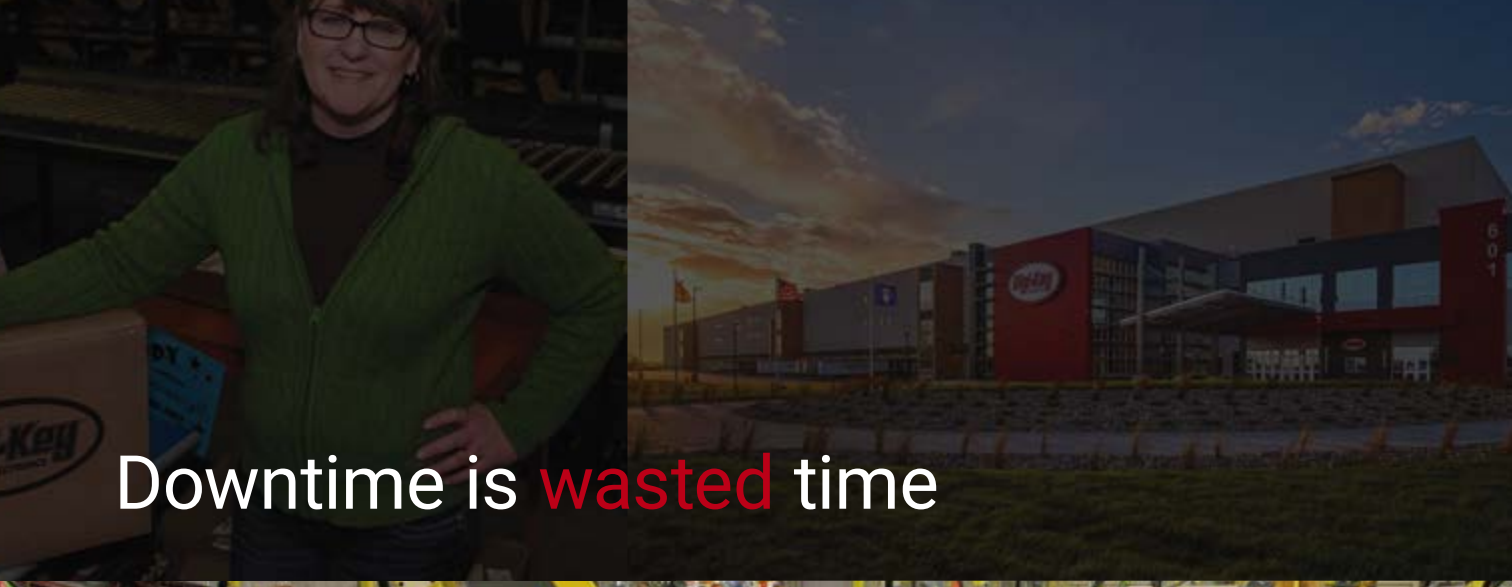

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The choice is yours

You told us. We compiled the results. Now it's time to check out this year's readers' choices for their favorite suppliers

THE times change and so do preferences. Technology advances and morphs so fast, and so much so that keeping up with customer needs, user preferences and emerging trends is a full-time task unto itself. This is especially true in the world of industrial process control, where automation and control systems have altered – for the better, mind you – the way facilities operate across a plethora of industries. These days, environmental concerns, worker shortages and a supply crunch make the needs of process automation professional a bit different today than they were even a year ago.

Over the past three decades, *Control* has brought you the preferences and choices of industrial automation professionals through our annual Readers' Choice Awards, and this year is no different. But the awards themselves? Well, they've changed a bit to keep up with the times and those ever-changing needs of the users.

As you'll see on page 36, the program has grown to 80 categories representing a wide range of instrumentation and control technologies. That's a far cry from the 50 categories at its beginning. In addition, we recognize the application expertise that transcends any one product category. That's why, this year, we added leadership by discipline to the mix.

What's important to understand is that these awards are all about you, our readers, and your choices among the many products and companies working in this space. The rankings are the result of your responses to our annual survey. To be sure, the responses come from an industrially diverse group of respondents from across the process industries. They include everyone from end-users to those working in engineering firms. While the majority come from North America, many are spread across the Asia-Pacific regions, as well as Europe, the Middle East, North Africa and South America. They come from upstream oil and gas, water and wastewater processing, food and beverage manufacturing, and much more (see our breakout chart on page 37).

As it is every year, the Readers' Choice Awards are expected to be among our most popular features. While you can flip through this magazine to the results, you'll also be able to access them on our website, ControlGlobal.com, at any time to reference just what your peers are thinking and whose products they're flocking to for process control and operational efficiency at their plants.

We hope you enjoy reading and studying this year's survey results. As always, I look forward to discussing the changing state of industrial automation technology. ∞

LEN VERMILLION
Editor-in-Chief
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"These days, environmental concerns, worker shortages and a supply crunch make the needs of process automation professional a bit different today than they were even a year ago."

Putin vs. heat pumps

How process control can help Europe meet its energy needs

BÉLA LIPTÁK
liptakbela@aol.com

"If the European Union focused on converting its many district heating systems, it could reduce much of its overall energy needs."

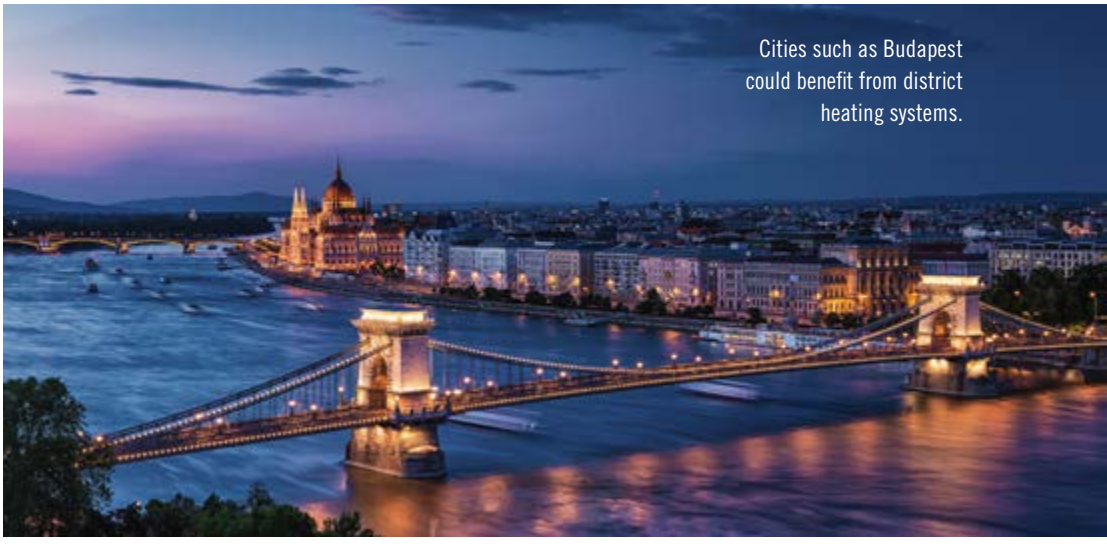
THE new tools of war are drones and energy. Russia is using both, the first against Ukraine and the second against Europe. The task for the Ukrainians is to expel this aggressor and the challenge for the Europeans is to become energy independent. This is urgent, not only because Europe's oil and gas purchases pay for operating the Russian war machine, but also because their energy storage is running low and winter is here. Therefore, new energy supplies are quickly needed.

In this column I'll show how heat pumps can help meet this need and how our process control profession can automate and optimize such a system.

Heat pumps use a working fluid to move heat from low to higher temperature levels. This working fluid, having a low boiling point, evaporates into a low-pressure gas as it picks up heat from surroundings, which are relatively cold, but warmer then the boiling point of the fluid. The gas, after being compressed, carries that heat obtained in the evaporator into a condenser where it's released into the warmer, heated surroundings of the heat pump. The air conditioner is such a device, as it removes heat from our cooled buildings and rejects it into the relatively warm air outside. If, in the winter, the flow direction of the working fluid is reversed, the air conditioner can move the heat contained in the cold outside air into our homes and heat them (Figure 1).

Why do I mention these devices in connection with the present energy war? I do it because heat pumps are readily available on the market, they cost much less than furnaces or resistance electric heaters, and can be quickly installed, plus they emit no carbon at all if the compressor is operated by green electricity. Naturally, they can also transfer heat from air or water. This is an advantage in cold regions, where outside air temperatures can drop very low, causing a drop in heat pump efficiency, while ground temperatures below the surface are relatively constant.

In the U.S., as we move from north to south, efficiencies of heat pumps used for heating in the winter increase. In the south, sizing a winter heat pump, the beat capacity needed per square foot is about 30 BTU (kW/h = 3,410 BTU), while in the north, it's about 60 BTU (in Connecticut it's about 45 BTU/ft^2). So, one weapon EU members can readily use to weaken Putin's blackmail



Cities such as Budapest could benefit from district heating systems.

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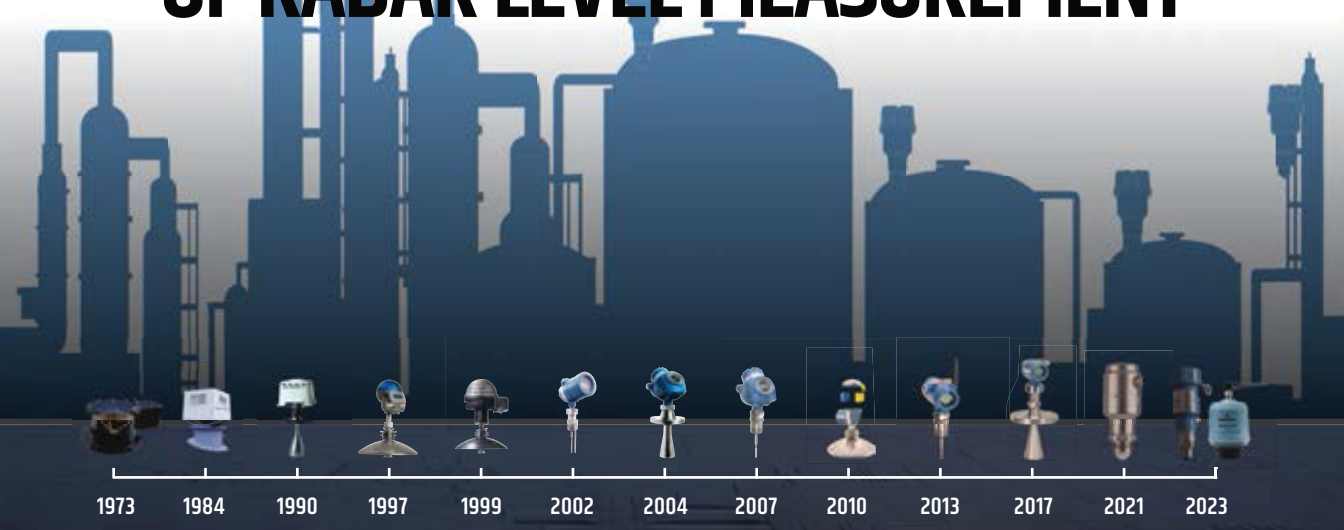

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Continuous innovation fuels journey to radar level leadership

It all started in the 1970s. At the time, crude oil tankers traversing the seven seas—typically with 16 tanks per vessel—needed a way to know how much oil was in the tanks and if there was a risk of spillage, especially during filling in the harbor or travel through storms. A few high-profile accidents—most notable, the tanker SS Torrey Canyon that broke into two pieces off the coast of Cornwall in the United Kingdom, creating a massive, deadly spill—brought the issue to the forefront. It was then that shipping companies sought to speed up the research and technology development to provide accurate level measurement in their tankers.

In 1973 a Norwegian shipowner approached what was then Saab, eventually acquired by Emerson, to determine if the high-tech defense technology developer could figure out a way to measure the level of oil in their tankers without the mechanical methods that were already in use. In short, the shipowner wanted a non-contacting, high-tech, and accurate method.

It was a serendipitous request given that the company was already working with radar technology as an altitude meter for jet fighters and missiles. Engineers at the company, led by Kurt Isaksson, who brought the business savvy, and Olov Edvardsson, who brought the technology expertise, set forth on tailoring their radar technology for use on fluid level measurement in oil tankers and a new era of level measurement innovations was born. In the process, the two men became the founders of what is now Emerson's radar level measurement business.

Thomas Ortenberg is vice president and general manager of Emerson's global level business and has worked-with the company's tank radar level technology since it was part of Saab. In celebration of the 50th anniversary of the company's Rosemount radar level technology, Ortenberg talked with Control Editor-in-Chief Len Vermillion about the history and development of radar technology for tank level measurement.

Q. On this 50th anniversary of Emerson's level measurement business can you reflect on what a storied history it has been and what this milestone means for the company?

A. It's been a fantastic journey driven by customer needs. As I reflect on the technology's 50-year history, it's impressive to see how capabilities have evolved over the last five decades and analyze what were the driving forces behind such evolutions. Customer needs have always been the driving force behind our innovation, and considering that some of our employees have been around for almost the entire journey it's really a monumental milestone for the company.

Q. How did your founders, Isaksson and Edvardsson, approach the beginning of the radar evolution in level measurement?

A. It was like Steve Jobs and Steve Wozniak, where a commercial mind and a technical mind came together and built a team around them. The first system was designed and built in less than a year, quite a major achievement considering the high requirements on electrical safety in the explosive environment onboard oil tankers. The system was the first ever to have no moving parts, no contact with the product, no maintenance, and was fool-proof. The first trial installation was on the Swedish built tanker Sea Scout in 1973 and followed the tanker's operation during both its first loading in Kuwait and the first unloading in Milford Haven in Wales. That was 50 years ago and that's how it all started. It just took a few years until the company became the global market leader for level measurement systems for crude oil carriers and other tanker types.

Q. It was a quick evolution from mechanical sensors to radar. How did the industrial needs change over time?

A. That technology transition went really fast, we're talking about a time span of only half a dozen years. After that, the interest in this new technology quickly grew even further as all these vessels went into harbor at the end of every trip to load or offload their cargo into terminal tanks in refineries or depot tanks into which they pumped

"I think that's a hallmark of this organization, the ability to get that real customer need and feed it through to our engineers and getting things done, tested, verified, manufactured, shipped, and ultimately, seeing how it helps customers."

— Thomas Örtenberg, Vice President and General Manager, Global Level Business

the crude oil. These tanks had mechanical floats, and they had the same kind of issues as the marine tankers. Those floats got stuck and the tanks could overfill, or the reading wasn't accurate enough, so the terminal operators soon started figuring out that those vessels coming into the harbor had something new—something called radar—and it seemed to work much better.

So, we started developing a radar-based level sensor system for those onshore tanks, and quickly learned that although we measure the same oil products, the customer requirements are very different. Different hazardous location approvals, different custody transfer approvals, different ways of operating the tanks, different materials of construction and so forth. By listening to the customer's needs and reinventing ourselves, we developed a second system, which was intended for land-based tanks, and that went fast as well. We had the first installation in 1983.

We then started to take the next step in our journey and realized that beyond all these harbor terminal tanks, there are many more tanks when you get into the refineries, into the chemical plants, into the power plants, and into the food and beverage industry. We realized that those customers each have different needs and hence need different solutions. Some of them want to be able to track changes in the tanks quickly, several measurements every second for control purposes, yet others want to be able to detect whether they have foam on the top of the surface inside the tank. There are all kinds of variations and versions here.

Q. How did the radar level measurement technology evolve further on?

A. Toward the end of the 1990s, we had designed yet another generation of radar-based level measurement devices to address the different needs that customers have in these different industry verticals. All along this journey there's just been a tremendous amount of innovation of which we are quite proud. We have several hundreds of patent families covering radar-based level measurements, and a large number of them resulted from interaction with customers, responding to their needs, and understanding what their pain points really are. I think that's a hallmark of this organization, the ability to get that real customer need and feed it through to our engineers and getting things done, tested, verified, manufactured, shipped, and ultimately, seeing how it helps customers.

Q. What would you say has been your main competitive differentiation?

A. As the inventor of this technology, we have had to find solutions to many new technical challenges. That would not have been possible without very solid in-house knowledge both in the radar field and in application knowledge.

What has further helped the market adoption is that the cost for the technology has come down the last 5 to 10 years. It is true that radar in the past has been cost prohibitive for some customer segments. From the beginning, this was a spinoff from military technology and that comes with a price, but as we and others have driven the technology development, things have matured and we've been able to integrate various circuits and then create smarter solutions, rely more on software, so that's certainly helping.

Q. What can we look forward to in the years ahead concerning radar technology?

A. Whether it's in our homes, at work, or where we go shopping in the grocery store, the IoT revolution calls for more sensing technology and the insight that comes with such measurements. Wherever the use-case, there is more demand for awareness than ever before and radar is proven to be a very good technology for many of those sensing needs.

Potentially, in markets like wastewater or food and beverage, you can use radar for many things other than standard applications in tanks. If you think about it, radar is a distance measurement device. Wherever you have a need to measure a distance, you could use radar.

Technology innovation takes tank gauging to new heights

Level measurement technology has evolved significantly over the last 50 years and has expanded to serve many applications over the years. The journey from such rudimentary methods as knocking on tank walls to mechanical floats and electronic servo-based methods to today, where non-contacting radar systems are at the forefront, has been swift. It's also been guided by the changing needs and automation requirements of industry. What started as a way to measure level in storage tanks on oil-tankers at sea has evolved to include more marine vessel types and applications, over to onshore petroleum storage tanks, chemical tanks, other energy storage, level measurement in food & beverage industries and many more applications.

"There are lots of storage tanks out in the world. Historically the technology was applied in the oil and gas industry, but these days, driven by automation trends and an increasing valuation of products and raw materials, tank gauging solutions are needed in a much wider range of applications," says Mikael Helmer, general manager for tank gauging at Emerson.

Helmer says tank gauging technology and associated systems has evolved, itself, over the last two decades. "The preference for non-contacting, continuous level measurements continue to grow," he says. "but in addition, tank gauging is about volumetric measurements in the end, and level with radar is a key piece to that. But associated measurements, such as temperature, pressure, volume calculations are other key measurements to deliver what a customer expects from a complete tank gauging system".

Customer needs have driven the technology innovation here as well. More accurate temperature measurements, tank and liquid pressure measurements, more volume calculations, diagnostics are a few such valuable inputs to your stored product. "Changes in how you monitor your data, what you want to do with it, the way customer expect to have easy access to data via mobile systems is driving the technology forward and demands scalability, flexibility and open communication protocols to and from the system." Helmer says.

"Safe operations of tank farms has become an extremely important piece over the recent years—you don't want to spill your product," he continues. "Tank overfills are a major concern and since many products stored are flammable, hazardous and explosive, it is critical to take actions to protect health, lives, environment and plant assets, to ensure and improve safe workplaces and surrounding communities. So, using the reliable, accurate radar technology for overfill prevention is addressing those concerns."

The ability to continuously monitor bulk liquid levels as they move around from tank, to train, to ship, to tank again is paramount. "Storage is about the movement of product, so you need to have good control of your inventory and the transfers between the different locations," Helmer says to common usage for his company's tank gauging technologies. "It's not only that you've managed to put a batch of product inside your tank. You need to know how much you got, transferred or received, all while doing it in a safe manner."

A world of firsts for Radar Level Measurement.

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1972

The world's first functioning radar level gauge was designed, marking the beginning of radar-based level measurement development.

"Radar technology involves no recalibration and less maintenance and has evolved in lockstep with the changing landscape of the industry."

— Mikael Helmer, General Manager, Tank Gauging

Soon after its introduction many years back, measuring level with radar quickly became a more precise and reliable measurement versus the older mechanical methods. Helmer says even the more modern servo solutions still present a lot of inherent challenges that come with moving mechanical parts and is often related with high maintenance costs. Radar, on the other hand, has no moving parts, no contact with the product, and essentially no maintenance. With stable, accurate and maintenance-free radar technology, the reliability and longevity offered to the customer is excellent and has fueled its rise in technology preference.

Always ready for your next challenge

Over the years, Emerson's radar tank gauging technology has been further developed, listening to customer needs and looked at customer pains to be solved. Currently the fourth generation land-based system continues to provide customers with their tank gauging needs, with focus around efficient plant operations, safety and overfill prevention solutions, accuracy of tank inventory and scalability both in terms of size of the plant but also in terms of applications and products stored. "Customers appreciate the reliability and overfill prevention capabilities in our system" Helmer says. Our 2-in-1 technology provides dual level data in two independent layers of protection using only one housing and a single tank nozzle. This unique feature has been a successful adder during the past decade, helps reduce installation time and cost, not the least in existing tanks with only one opening, such as floating roof tanks with still-pipes and LPG tanks.

Legacy technologies are still in use in many places, but the need for replacing and upgrading tank gauging systems is increasing. Our flexibility and scalability of the system allows for step by step, tank by tank upgrades, in the pace of investments the customer prefers. This means the use of the latest tank gauging technology from Emerson can be applied where the need is most prevalent.

"The operator interface, TankMaster, is another strong solution that we continue to develop and invest in. Making sure we provide net volume calculation based on major industry standards, such as API and ISO, is key for inventory management. Here connectivity to other systems and instant insights into your tank farm whenever you need it, wherever you are and by different functions of a plant is another important need that we solve through our TankMaster Mobile solutions," Helmer says.

"We are also offering a complete system solutions for cryogenic storage of liquefied gas," he continues. Full containment tanks are advanced tanks, with lots of measurement points and safety functionality. Being able to help customers with a one-stop shop solution has proven very attractive to many customers who operate LNG and Ethylene tanks in both Energy and Chemical industries.

As tank gauging systems based on radar technology continues to develop, while keeping its inherent features and capabilities, Helmer says more industries are showing interest in utilizing the technology.

1973
The first radar level gauge field trial is installed on a marine vessel in Sweden.

1976
The first mass-produced system, called SUM-21 Tank Radar System, is installed on the Norwegian vessel M/S Havdrott.

Processing operations get a boost from non-contacting radar

Non-contacting radar technology has opened a new world of opportunity for the industrial sector. The process industry is a wide range of industries and applications, including upstream oil and gas, refining, petrochemical and chemical industries.

A far cry from the days of mechanical floats, the more complex nature of chemicals makes non-contacting technology essential. In addition, the same logistical benefits of non-contacting radar technology—originally invented for military uses—for moving product around a fast-moving supply chain exists for other materials just as was deemed vital for oil tankers in the 1970s, when radar technology was adapted from military uses to fit shipping needs.

"You can have corrosive media in your tank, sticky media, and more nasty products that you don't want to get in contact with," says Sara Anderberg, manager, solutions management at Emerson. "There is a great fit for non-contacting radar. You can also have mixing tanks. Let's say if you have something moving in your tank like agitators, you probably cannot place a probe in there. So, there is a great opportunity for non-contacting radar."

Developing the technique

Taking the mechanics out of the equation and placing the heavy workload on electronics, often with a two-wire bus, Emerson has continued to refine and develop its technology. In the process industry, it's not only opened opportunities for new industries to take advantage of radar, but also for traditional industries to create more efficient operations.

"We also saw the need to help our customers within the process industry to be able to better control and optimize their processes, to help them understand what's happening in their tank," Anderberg says. As an example of how the technology has developed with the needs of industry, Anderberg points to the chemical industry, which prefers to operate with smaller tanks. "Now, we are also increasingly developing radars with a higher frequency that are a better fit for smaller tanks with more rapid fluid movement like batch processes,"she says.

She says, non-contacting radar is ideal for the chemical industry due to the huge variety of tank sizes and applications. "Our non-contacting radar portfolio offers solutions to meet all our customer needs. Different applications require different solutions and we as the market leader have all of them to help customers with their applications."

Anderberg says Emerson is on its sixth generation of frequency-modulated continuous wave (FMCW) radar, which has strategically advanced through the years.

1978

The company moves its offices and production site to Gamlestaden in Gothenburg, Sweden to support the rapidly expanding marine industry.

1983

Saab Marine Electronics becomes a limited liability company within Saab-Scania Combitech

"Maturity also translates into efficiency, non-contacting radar technology has opened a new world of opportunity for the industrial sector."

— Sara Anderberg, Manager, Solutions Management

"Earlier, the FMCW technology was more power consuming and four wires were needed. But with later platforms we have a two-wire (loop-wired) powering it up," she says. "Now it is not as power hungry as it was before. We can use the power and get it down to the surface to get a more sensitive and reliable measurement."

All of Emerson's radars today have FMCW technology, since it provides a more reliable measurement.

A maturing technology

One of its newest generations of non-contacting radar is the Rosemount 3408 Radar Level Transmitter and the Rosemount 1208 Radar Level Transmitter, which are debuting this year. Both of these new products are examples of the maturing nature of the technology. "We have now been able to utilize radar on a chip, as we call it, where we have actually made it possible to have one chip creating a faster, more efficient processing signal instead of having three different chips with key functions," Anderberg continues. "Instead of having three different chips with key functions, we now have one chip making a much faster and more efficient treatment of the signal."

This type of advancement has made radar an even more productive and beneficial technology. As radar matures the opportunities abound.

"Another great advantage with the non-contacting radar is the radar can measure through plastic. Imagine you have a plastic tank and so you don't have to make a hole for fitting the instrument. You can measure through plastic tanks," she says. "With all of those plastic tanks out there—particularly in chemical processing—we see great opportunity for this, let's say, non-intrusive measurement."

Maturity also translates into efficiency, which yields price efficiency. The cost of radar had made it unachievable for some customers in the past, but these days, radar has become more price competitive than legacy technologies, making it possible for customers outside of the traditional industries to consider its usage.

Bluetooth connectivity is frequently requested by users in order to make their daily tasks easier. "Two of our latest solutions, the Rosemount 3408 Level Transmitter and the Rosemount 1208 Radar Level Transmitter are both equipped and offer Bluetooth enabled support," Andergerg says.

She adds that Bluetooth enabled devices bring safety to the operation. "Engineers don't have to climb the tanks and be up on the tanks to read measurements out of the radar. You can be standing on the ground in a safe place doing the configuration, reading your level, just from your tablet or from your phone."

1984

Land-based tank installations of TankRadar L Radar Level Gauge start

1985

The TankRadar M Radar Level Gauge is launched to the marine market

1990

Launch of the second generation land-based TankRadar L2

Guided wave radar makes difficult processes less challenging

Non-contacting radar isn't the only technology replacing old, mechanical level measurement systems. Another type of radar, guided wave radar (GWR) has gained usage over the last few decades, particularly for difficult applications where there may be two or more liquids mixing with one another. Just as non-contacting radar has done, GWR is opening new possibilities for industries beyond traditional level measurement customers.

"The guided wave radar opens more possibilities when there's a layer where the actual interface between the two liquids is not really defined," says David Trinh, senior product manager for Emerson.

Trinh says that while radar antennas (non-contacting) are a very powerful way to measure liquid levels, GWR has the advantage of having a probe which has contact with the liquid. "It gives you better signal and the ability to measure things like interfaces between two different liquids," he continues.

Oil and gas process tanks remain a core application for GWR because inevitably they have oil and water in the same tank. With a guided wave radar probe, users can measure both the oil and the water whereas a non-contacting radar would only measure the level of the uppermost liquid. Steam boilers are another common application for GWR where vapors can disrupt the microwaves and the presence of a probe can alleviate such disruptions. Distillation columns where chemicals are boiling and are separated in levels in a tower are a related application containing steam where in each level, users would have a guided wave radar measuring the level of a particular fraction of the chemical.

In addition, GWR is useful in "dry" applications such as blowdown drums. "In the process industries, you don't want adverse effects. You could have a process running along, and then you have a drum where if suddenly something would happen in the reactor, the liquid gets sent into this drum," Trinh explains. "That's when you need a system which can quickly detect that there's liquid in the blowdown drum. This liquid can be a mix of different process fluids with rapidly changing density and level. Guided wave radar is a great technology for it. It's just a bit more responsive and can handle the rapidly changing conditions better than antenna-based radars. Certainly, compared to non-contacting radar technologies, the guided wave radar is a good fit for that type of application," says Trinh.

"We've put a lot of engineering effort into making sure our radar portfolio is capable of a lot of applications," he continues. "We're getting into tough applications where you've got very high temperatures. Those types of applications can be really challenging for more traditional technologies. Emerson has invested significantly into signal processing with industry leading Direct Switch Technology built in to GWR instruments allowing for faster, more responsive units," says Trinh.

Aside from the probes used in traditional process industry products, Emerson has designed metal probes,

1997

Launch of TankRadar PRO Radar Level Gauge, designed for applications in the process industry

1999

Launch of TankRadar REX Radar Level Gauge, as the third generation radar in the Tank Gauging System.

"Guided wave radar technology opens possibilities to measure interface between two liquids and has the advantage of improved signal strength."

— David Trinh, Senior Product Manager

which carry the microwaves. They have a plastic coating such as PTFE or PFA plastic. "Those are more for pharmaceutical industries or measuring food," he says.

Specialization of the probes

Emerson has invested in creating a wide portfolio of guided wave radar products. Its main technology offering is the Rosemount 5300 guided wave radar.

Guided wave radar is not made of one type of probe. Emerson has flexible probes for measuring solids. It also has rigid probes. In addition, it has special, high-performance products such as its large coaxial probe.

"It's a probe inside a probe. It's two probes in one," Trinh explains. "We use the difference between those to be able to really measure thin interfaces, when a liquid is on top of another liquid. That's a challenge, and that was overcome with the creation of guided wave radar."

"But when the top-level liquid gets to be a small thickness in the range of less than an inch, then the signals tend to get lost," he continues. "With the kind of large coaxial probe, we get the good signal to noise ratios and can really define these very thin interfaces."

If that isn't specialized enough, Emerson also has a Dynamic Vapor Compensation probe, which is made for boilers. "Boilers are particularly challenging for any type of measurement, any type of radar measurement because the liquid's bubbling away. So, if you visualize a boiling saucepan of water, measuring the level on that is actually very difficult because the level's not always constant," Trinh explains. Above the liquid is typically gas, the steam that's coming off the boiling liquid. It also disturbs a radar measurement. "But we have special probes, like the Rosemount 5300, with specially mounted metal reflectors and custom designed software algorithms to compensate for the disturbances," Trinh says.

Enhanced with wireless capabilities

The Rosemount 3308A Transmitter is a sibling product to the Rosemount 5300 incorporating wireless technology with GWR probes. "We are the only provider with a native built-in wireless guided wave radar," Trinh says.

Wireless capabilities open new applications for Emerson, particularly in regions where there might be a very isolated tank. "If you think an oil well in the middle of the desert and just pumping out oil from that well, and you have to put it into a tank, how do you measure that level?" Trinh asks. "You need to have a gauge, but you don't want to have a gauge which is maintenance intensive because it's in the middle of the desert. Our Rosemount 3308A Wireless Level Transmitter let's you put the gauge onto the storage tank, and it's got a battery. It sends the signal to a wireless gateway."

That means the oil and gas producer doesn't need to run power wires or signal wires from a control station up the tank. "You just have the unit itself, and it's self-contained," Trinh says. "It sends the signal wirelessly to a gateway."

2001
Emerson acquires Saab Marine Electronics and later changes its name to Rosemount Tank Radar

2002
The marine TankRadar Star Tank Gauging System is launched. In the same year, the Rosemount 3300 Guided Wave Radar Transmitter is launched for the process industry.

More connectivity yields continuous safety and diagnostic checks

Industrial safety is driven by many different reasons, but when it comes to level measurement the catalyst for increased safety measures is clear. In the days before radar, oil tankers and onshore storage tanks suffered a lot of severe accidents. Unfortunately, the older, mechanical way to measure tank levels and guard against detrimental spills wasn't quite up to the task.

"In the old days, it was common that the measurement instruments failed and thus jeopardized the safety" says Ingemar Serneby, solutions manager at Emerson.

As the industry turned to radar the opportunity to enhance safety and diagnostics capabilities increased. It also made safety and diagnostic procedures more efficient.

When the primary technology consisted of mechanical instruments such as floats, users had to go out in the field and pull up the mechanical devices to make sure that they did work. With today's radar technology, the level devices continuously test themselves. "For instance, our guided wave radar can be equipped with a reference reflector on the wire," Serneby says. "Guided wave radar uses a wire to measure the level inside the vessel. By having a reference reflector in the vapor space where you shouldn't have anything normally to measure, obviously at very high level, the reference reflector can trigger the instrument to measure it or to avoid it.

"This is just a very, very tiny echo generated by it. But by triggering it to measure it, we measure a physical target in the tank environment and that will serve as as a comprehensive proof-test," he continues. "So, in that case, all that mechanical work that you had to do previously, to go out there, climb a tank, bring a bucket, lower the float down there, see if it floats, if it alarms, it's done from the control room. That is a big help for the user."

Essential efficiency

Such efficiency is paramount as operators aim to maintain their proper safety integrity levels (SIL). "You have to assess your safety loop and see what kind of integrity level is valid for your operation," Serneby says of the continuous process. "The safety loop consists of different things like a level device, a temperature sensor, a pressure sensor, an actuator, a valve. To be within that safety level, you have to make sure that you maintain this level throughout the lifespan of the equipment. So, what happens is that you have an expected time until failures occur, and to ensure that you are not on the wrong side, you have to make proof tests."

He adds that frequent proof tests means that users can maintain their integrity level. The proof test ensures being at the right integrity level that is valid for the entire loop. The weakest part of the loop defines when it's time to do the proof tests, and to know when it's time to perform the proof test, users have several data points regarding the instruments and that's where the standards come into play.

Emerson's radar products have evolved to meet the needs of continuous safety monitoring in level measurement applications.

Connectivity and diagnostics

"I would say that connectivity and diagnostics go hand-in-hand," says Mikael Inglund, manager product man-

2004

Emerson launches the two-wire Non-Contacting Radar Rosemount 5400 in both 6 and 26 GHz versions.

2007

The world's most successful Guided Wave Radar, the Rosemount 5300, was launched.

"Connectivity and diagnostics go hand-in-hand. If you don't have any connectivity, you don't get the information you need."

— Mikael Inglund, Manager, Product Management Software

"By having a reference reflector in the vapor space, it can trigger the instrument to measure it or to avoid it."

— Ingemar Serneby, Solutions Manager

agement software for Emerson. "If you don't have any connectivity, you don't get the information you need."

When Emerson introduced radar as a level measurement technology, the industry was mainly using conventional 4-20 mA current loop as connectivity to other systems. It limited data transfer to the measured level and some basic device diagnostics.

"However, using only the measured level can provide proactive diagnostic and maintenance solutions. Our floating roof monitoring solution, which analyzes the roof movement by tracking 3 or more level transmitters measuring on the roof," Inglund says. "If the tank roof tilts or does not move smoothly it will provide early warnings in order to avoid any serious accidents."

"When digital HART communication was introduced it enabled a new way of connectivity and allowed much more data to be transmitted," Inglund says.

"That gave us the opportunity to develop advanced software features and the RadarMaster+ configuration tool, which drastically enhanced ease of use and enabled new powerful diagnostics." For example our Smart Meter Verification which performs advanced integrity and self-diagnostic checks and provides a health report" he continues. HART connectivity also enabled other features such as Signal Quality Metrics (SQM) for probe clogging detection, Power Advisory for monitoring proper power supply, guided remote proof test for functional safety and much more

The introduction of WirelessHART and Bluetooth added connectivity to level devices installed in locations previously difficult to reach, allowing for safer operation and configuration, but also added new applications and devices to Emerson's PlantWeb Digital Ecosystem.

"Connectivity is all about the device's ability to connect into systems and to provide data to software applications, enabling advanced diagnostics and process insights. New connectivity standards such as the emerging ETHERNET-APL will enable exciting solutions within cloud, built-in AI, virtual instrumented networks and much more.

Emerson is continuing to build upon its technology for the future. "By adding powerful electronics and high bandwidth connectivity, we will see data driven intelligence and advanced features moving into the level transmitter, making it even more intelligent and cybersecure" Inglund says.

2010

A new Tank Gauging System with the newly developed Rosemount 5900 Radar Level Gauge is launched. The Rosemount 5900 is the first 2-in-1 radar gauge, which can be used for both level (ATG) and separate overfill prevention (OPS-Sensor) measurements.

2013

Emerson launches the world's first wireless guided wave radar, the Rosemount 3308.

Ease-of-use and efficiency bring radar to chemical processing

One of the newest applications for radar level measurement technology is chemicals processing. Following the natural evolution from maritime oil shipping to oil tank storage, the chemical processing industry is reaping the benefits of radar, mainly due to its need for a non-contacting solution. In addition, the lower cost of radar technology has made it more viable for chemical processing.

Chemicals play a vast role in our daily lives. "You can imagine how diverse the space is," says Jenny Leion, chemical solutions manager for Emerson.

The plethora of products produced in various forms makes radar technology an ideal solution for the various substances that are stored, mixed and processed. "That's one of the challenges, to be able to measure all of them, but that's where non-contacting radar technology is really good because it is independent of density changes and steam and so on, so it still measures the surface really well," she says. "Then for chemicals, as for many industries, the focus today is sustainability, of course."

She says that among the challenges the chemicals processing sector faces, reducing waste and adding safety are paramount, and both non-contacting and guided wave radar technology as well as the point level detectors address those needs. "We are very tied to safety since level measurement is often used as a safety precaution, so you don't have overfill and risk of spill," Leion says.

Just as the oil industries in which radar technology saw its first commercial use, accurate level measurement is necessary to protect against detrimental spillage. In the case of chemicals, the result can be even more damaging given the hazardous nature of many of the formulations.

And, for waste reduction? "You can reduce waste by measuring variables and optimizing your process," she adds, noting the continuous monitoring capabilities of radar versus mechanical means of the past.

"Coming from the chemical industry, I've seen many cases of both. You're standing as an operator measuring from above with a tape measure, and that's of course not great for safety for your operators," Leion says. "For chemical, we have legacy technologies such as displacers and ultrasonic measurements that have their issues. "With the new technology advances, radar has become a more affordable choice to be able to go into more applications than it did before. Previously, it was costly, but now with the latest radar technology, it's much more affordable and can reach more applications."

Leion says customers in the chemical space utilize both guided wave and non-contacting radar from Emerson depending on the type of application. Sometimes, users want to measure both level and interface level. Guided wave radar can accomplish it. "I think that's a very cool technology that can measure two layers of a liquid with the same radar," she says.

2016

In April, the company moves its offices and production plant to a new state-of-art facility in Mölnlycke, Sweden. The facility provides optimized manufacturing capability and an enhanced range of services, support, and training for users of Emerson's radar level measurement products in the terminals, processing and shipping industries.

"Today's technology has enabled us to offer a more affordable technology that can withstand the challenges in the application."

— Jenny Leion, Chemical Solutions Manager

Non-contacting radar is ideal for when the instrument should not touch whatever is inside a tank.

Ideal use in chemical applications

The development of non-contacting and guided wave radar for industrial usage through the years has been a path from solving the issue of how to measure with radar on tanker ships, then coming to land and being able to measure accurately on tank farms and then, moving forward, to the general process industry and not the least the chemical industry

"Now, we have also had a development with frequency modulated continuous wave technology, and come from a four-wire to a two-wire device, this meant a step change in performance for non-contacting radar, where you had a wave that came back with a lot more information continuously than the pulse radar," Leion says.

"Following the release of our FMCW two-wired technology, what we saw in the chemical industry was that there's also a need for ease-of-use," she continues. "In response to this need, we worked to digitize the capabilities of the products to align with our customers' expectations and ultimately offer an easier to use device."

She points to the Rosemount 3408 transmitter, saying that when you install the device, the ability to leverage Bluetooth-enabled technology creates the opportunity for operators to easily connect via a phone or tablet. This technology also helps operators with safety because no one has to climb tanks. "You can stand on the ground or in the control room and do the configuration there. And you have a graphical interface that's much easier than it used to be, so you basically see if you do anything wrong."

This evolution puts radar technology at a usability and cost-efficiency place where the chemical industry is able to fully embrace it.

Stepping into chemicals

With the broad market opportunities for chemical industries, Emerson is evolving its radar technology to fit the challenges those markets face. Some of those emerging markets involve agrichemicals, such as fertilizers and pesticides. In the current climate, chemicals for the agriculture sector are a growing opportunity and the diminishing costs for radar technology have helped that sector embrace the technology.

Leion adds that Emerson has established a new portfolio for the water and waste water sector as well. She says it will be interesting to see how sites with chemical processing plants and wastewater facilities match radar technologies from that one portfolio.

There are many applications for radar within chemical processing and they continue to evolve. Leion and Emerson are ready to tackle the next application on the horizon.

2017

Emerson introduces the Rosemount 5408 Non-Contacting Radar Level Transmitter, a safety-certified non-contacting level radar to help increase plant safety and worker efficiency.

2018

The Interactive Plant Environment at the Mölnlycke site is inaugurated. This new environment provides a totally immersive and real-world application scenario for hands-on training and demonstrations and also allows for further development and testing of the next generation of level devices.

Differentiated solutions open opportunity for new markets

Nowadays, you can build more compact radars that are more fit-for-purpose and for industries that are more cost-sensitive, like food and beverage or wastewater.

Feeding food and beverage

"In June 2021, Emerson released the world's first non-contacting radar level transmitter, the Rosemount 1408H, designed specifically for food and beverage applications. It answered to the need for a cost-effective, highly accurate and reliable level measurement device in hygienic applications. Dedicated features help manufacturers optimize the efficiency of their operations, reduce product losses and ensure food safety," says Anna Olander, director, radar new markets.

Non-contacting radar is an ideal level measurement technology for applications that require stringent hygienic facilities and equipment. It is virtually maintenance-free, which helps it to ensure long-term reliability, in sharp contrast to legacy technologies. It has a top-down installation that reduces the risk of product loss through leakage, and it is unaffected by process conditions such as density, viscosity, temperature and pH. The compact and robust form of the Rosemount 1408H makes it a suitable solution for the small tanks and space-constrained skids commonly used in food and beverage production. The hygienic antenna is flush with the process connection that ensures the removal of process residue during clean-in-place and sterilize-in-place processes, and is insensitive to condensation and build-up. The hygienically approved, IP69-rated device has a stainless-steel housing with minimal crevices to withstand external washdowns and ensure cleanability.

The Rosemount 1408H was the first level transmitter to use 80 GHz frequency modulated continuous wave technology on a single electronic chip with embedded smart algorithms. This enables exceptional radar beam focusing, so that internal tank obstructions such as agitators can be avoided, and greater measurement accuracy is achieved. Fast sweep technology makes the Rosemount 1408H the quickest level measurement technology on the market, collecting up to 40 times more information than legacy transmitters. This increases measurement accuracy, enabling manufacturers to reduce the amount of product lost through waste maximizes production capability, and reduces production variations, leading to increased product quality and batch consistency. The technology also enables measurements all the way to the top of the tank, through elimination of radar dead-zones, enabling users to maximize vessel utilization.

The Rosemount 1408H was the first non-contacting radar transmitter with connectivity to the IO-Link communication protocol, making it easy to integrate with any automation system. The transmitter provides both conventional 4-20 mA, switch outputs and digital high-speed communication. It features innovative technology and smart algorithms to ensure installation and commis-

2021

The Rosemount TankMaster Mobile Software is launched to the market in April, and the Rosemount 1408H Non-Contacting Level Transmitter and Rosemount 1408A Level and Flow Transmitter are launched in June and October respectively.

SMART METER VERIFICATION

2022

The Radar Level portfolio advances its process and diagnostic insight capabilities with Smart Meter Verification and Bluetooth™ enabled products.

"Next-generation radar solutions offer highly innovative electronics that maximize technology capabilities and expand the overall technology use-case."

— Anna Olander, Director, Radar New Markets

sioning are made easy, saving time and helping ensure trouble-free operation. Testament to its innovative design, the Rosemount 1408H received the 2021 Red Dot Award for product design. The annual international awards, adjudicated by a jury of significant engineering and design professionals who assess thousands of new products each year, recognize those products which demonstrate outstanding design and innovation.

Working to suit water and wastewater

While Emerson has "built on" to its existing products for food and beverage, it recently launched the Rosemount 1208 Radar, which is built upon the same platform, according to Olander. This product is focused as fit-for-purpose for water and other simpler applications. "The Rosemount 1208 Level and Flow Transmitter Series features a resistant and compact plastic housing, making it ideal for water and wastewater or other process utility applications. Immune to outdoor conditions and environmental variables such as sunlight, wind, or flooding, the 1208 Series will offer improved monitoring and help optimize processes with the demands that this market requires, such as compactness, mounting flexibility or ease of integration. It's really done to help the customers by offering them better technology that is cost-efficient, compared to ultrasonic and hydrostatic devices, which are old and prone-to-failure technologies used in this market," she says of the new launch.

Rosemount 1208 is simple to order, install, operate and maintain. Designed specifically for these applications, it provides a step-change increase in measurement performance and process visibility to help operators maximize the potential of their plant. Water is an essential natural resource, and it needs to be managed effectively to ensure its quality and safety, but also to achieve sustainable development. It is launched together with the Rosemount 3490, an intuitive controller that features a color LCD display to provide an improved user experience. The controller can be paired with compatible transmitters and provides control functionality and visual presentation of the values. "So, focus is on ease-of-use," Olander concludes.

On the horizon

Looking further into the near future, Emerson is focused on several horizons for its radar technology. One is more incremental optimization of its existing technology. "We already know radar well, so we are targeting new industry or market segments. Now we have the ability to make it specific to market needs," Olander says.

Other areas are the use of data from radar to help customers optimize their processes, as well as looking at disruptive, radical, or architectural innovations that can help Emerson's customers.

The future holds boundless opportunities for radar level measurement technology. As the market leader, Emerson is ready to take on the new challenges.

2023

The Rosemount 3408 Non-Contacting Radar Level Transmitter, which is designed to suit many applications in the process industry, and the Rosemount 1208 Non-Contacting Radar Level and Flow Transmitter Series, designed for the water and wastewater industry and general simple applications, are launched. To complement these products Rosemount 3490 for control functionality and visual presentation will be launched in the coming months.

Go Connect.
Go Boldly™

Emerson's Non-Contacting Radar Level Transmitter, enabled with Bluetooth® technology, allows field personnel to access device information from a safe location using less equipment and spending less time in hazardous areas.

Learn more at **www.emerson.com/rosemount3408**

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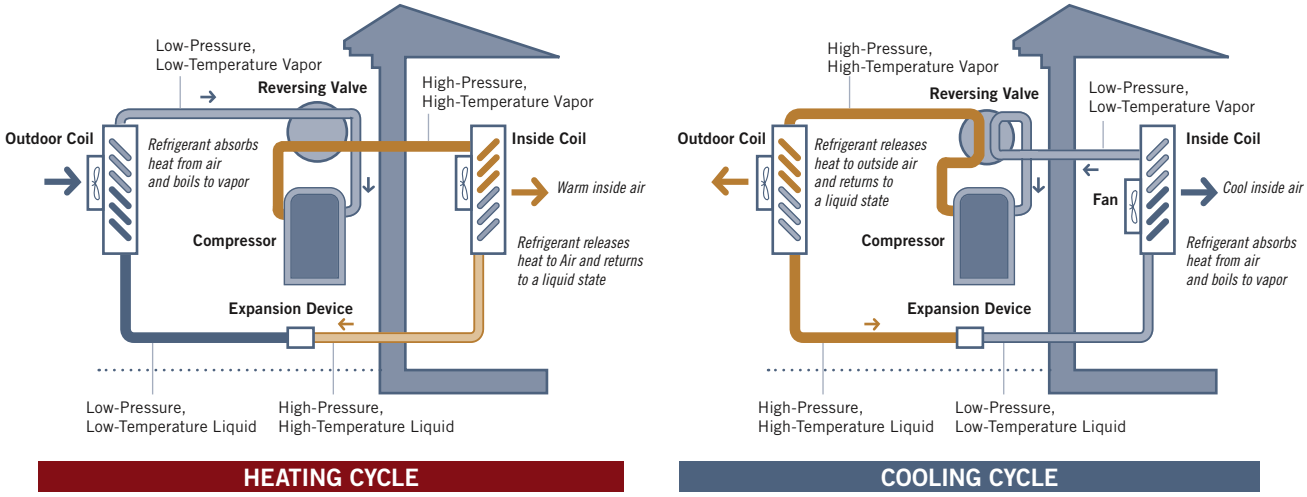

Figure 1: The reversible heat pump

is to change the working fluid in their A/C units, and install a reversing valve around their compressor (or just buy a new two-directional A/C unit).

Another application of heat pumps is district heating. In many European cities, hot water (90 °C to 95 °C) for buildings is centrally generated and distributed by long pipelines. Compared to using individual furnaces in served buildings, the cost of centralized district heating is about half, regardless of the heat source. On top of that, when the heat source is free, the costs are further reduced. Since these types of districts and distribution networks are already in place in many cities, if the groundwater is hot, then it can replace fossil fuel heat sources with direct heat sources. To meet the winter heat load of a heated district, large heat sources are required, which exist in many areas where groundwater temperatures are above 90 °C.

If groundwater temperatures are below 90 °C, heat pumps are needed. In both direct and heat pump-based district heating systems, the heat source is free, and the total system can also be free of carbon emissions if the pumps and compressors are also operated using green (geothermal or solar) energy. Unfortunately, among the thousands of district heating systems worldwide, most of their heat sources are still fossil fuel. The proportion of those using geothermal energy is less than 10%. If the EU focused on converting its many district heating systems, it could reduce much of their energy needs.

The total energy needed to operate such district heating systems is the sum of the energy needed to operate three circulation loops (ground, working fluid and district water loops). In older systems, the two pumps and the compressor are often constant speed and manually controlled. In a fully automated and optimized system, all three loops are throttled by speed variation, which eliminates valve pressure drops.

The heat demand of the district is the sum of all the supply valves in it. A high signal selector picks the control signal that throttles the most open valve, and sends it to a valve position controller (VPC). The VPC compares that percentage opening with its setpoint of 90%, and throttles the pump speed. This increases the total district supply pressure to keep the most open valve from opening beyond 90%, and operates to keep the openings of all valves under that value.

The flow in the district heating loop indicates the heat load on the district and informs the flow ratio controller, which throttles the ground loop speed to continuously hold the heat pump load at the optimum ratio with the district load. Finally, the speed of the compressor is throttled by the district supply temperature controller having a setpoint, which is continuously optimized by the overall system algorithm to keep the total cost of operation at a minimum.

Again, these control functions are performed by the VPC, which measures the opening of the most open valve from among all the valves served. Because of its 90% setpoint, it keeps the openings of all the valves under that value. The flow in the district heating loop through the flow ratio controller adjusts the speed of the geothermal ground loop pump in turn, and consequently mantains the ideal ratio required. In the end, the compressor's speed is throttled by the district supply temperature controller, which has its own setpoint that's continuously tracked and optimized by the system algorithm to minimize production expenses. ∞

How old is too old?

At some point, your instruments are too long-in-the-tooth to be considered reliable

JOHN REZABEK
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"The question becomes can we justify expending the relatively scarce capital of the enterprise to preemptively replace such devices after, say, 20 years?"

MANY of us have known someone like Orlando. He's changed the oil in his 1967 Ford Fairlane faithfully every four months or 5,000 miles, and he still drives it to work to this day. While he lacks anti-lock brakes, seat belts and forward-looking radar, can we dispute the reliability of his vehicle?

At the neighbor's refinery, a few facilities had been added in the past 10 to 20 years, primarily to meet tightening fuel regulations to remove sulfur from diesel, jet fuel and gasoline. These relatively "youthful" hydrotreaters run with few reliability problems, especially with respect to measurement and control systems. Other parts of the refinery have instruments and control systems dating back to the 1990s and before, yet even these aging installations were rarely the cause of an unforeseen upset or process interruption. Nonetheless, failures or malfunctions were, unsurprisingly, more common among the older generation.

Safety instrumented systems (SIS) standards incorporate a concept that equates to "useful life." At some point, your instruments are too long-in-the-tooth to be considered "reliable" as their probability to fail dangerously (PFD) would indicate. You might be inclined to accept it. Of course, a 20-something instrument is more likely to have a component fail, which diminishes its ability to participate in mitigating a hazard. But what if the service is benign?

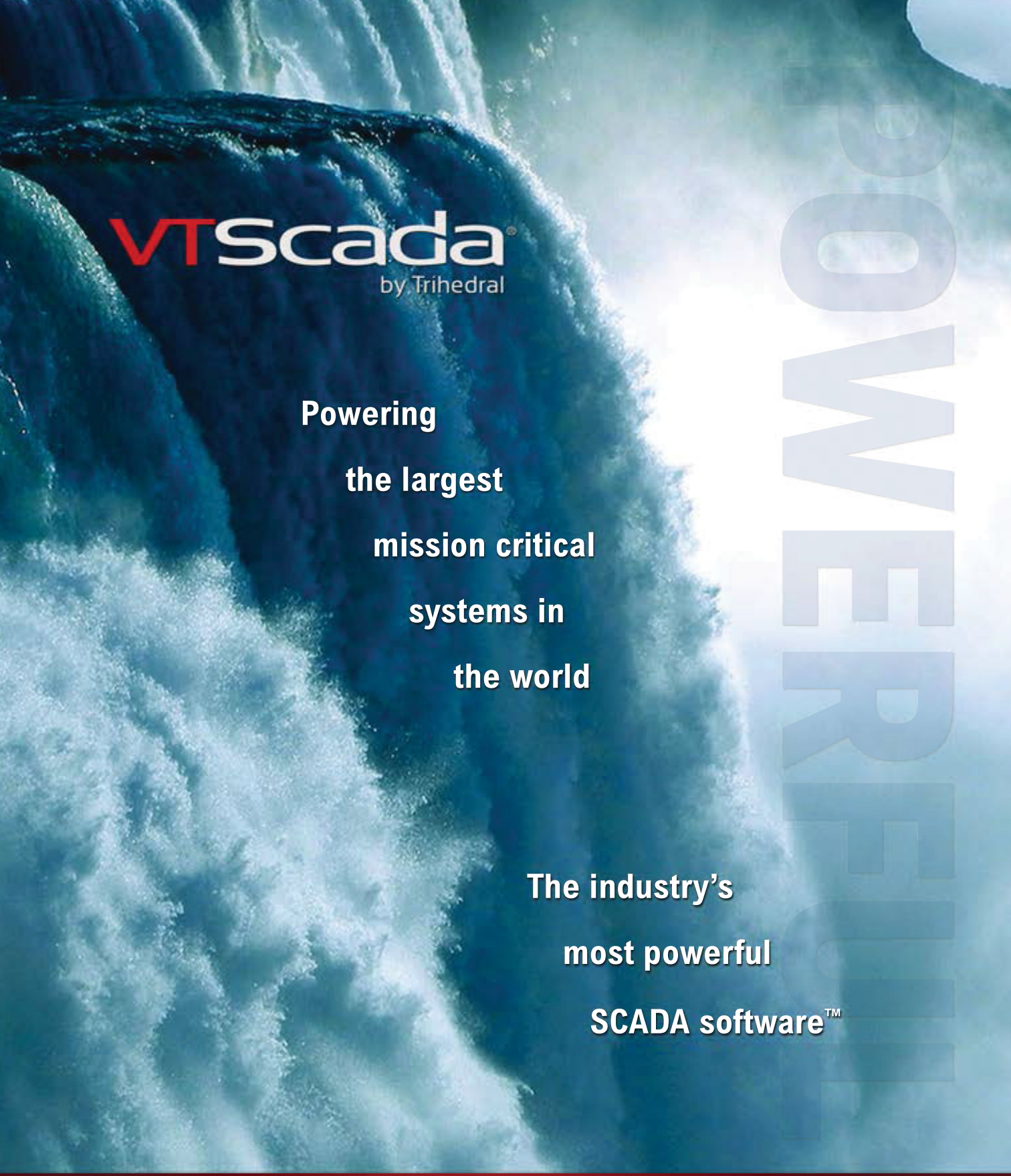
Similar to the vehicle driven only to church by an elderly lady or gentleman on Sundays, a pressure transmitter in a service like natural gas is unlikely to show excessive wear and tear. In many process plants, such instruments have remained energized via UPS power–uninterrupted–for as many decades as the process has been underway. The question becomes can we justify expending the relatively scarce capital of the enterprise to preemptively replace such devices after, say, 20 years?

This becomes a conundrum for our supplier community. While it would be great to get a PO for scores of 20-something-year-old transmitters, who'd want to put in print that their excellent instrument from days of yore was–at some point–no longer reliable? I've found even our premier suppliers a little dodgy on the question. "Well yes that model is obsolete, and you'll have trouble getting parts for it, but there's no reason to think it won't function another 10 years," they might say. No one wants to assign a "useful life" to their device, lest their competitors declare superior longevity. Logic favors the belief that the 20-something device is more likely to fail tomorrow than its more recently hatched kin.

New devices have been in the crucible of cost reduction on all levels–from the suppliers of silicon and chip-ware to the mills that manufacture the wetted parts. A newer and leaner generation of designers and engineers are directing manufacturing. Have they been seasoned by hardships and mishaps that their now-retired mentors experienced? The fashionable and growing homages to environment, social and governance (ESG) could divert talent and focus from manufacturing excellence. Is it safe to presume the new instrument is indeed more rugged than its grandpappy?

Those employing two-out-of-three (2oo3) voting logic have a more options to determine "useful life" because it's unlikely any two will succumb to old age simultaneously. Once one fails, it's probably time to ensure you specified a couple more. On the other hand, should anyone opt for "run to failure" if the device is part of a critical loop, such as feed to the crude furnace or as part of a safety interlock? If your logic configuration is such that a device failure amounts to a "vote to trip," and there are no "fail in position" or "shed mode to manual" options for a conventional loop, then preemptive replacement is a less complicated choice. In these cases, we need to sit down with operations and ask, how bad a day will it be when this device malfunctions or dies? We can sleep more peacefully if we categorize each application, e.g., replace now/next opportunity, ensure a spare is on site, or run to failure.

When the 1967 Ford finally failed, Orlando found another ride to work. For the antiques in the process plant, a thoughtful team evaluation of criticality will ensure "bad days" are uncommon. ∞



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Examining the wireless future

It's time for a look at what's in store for wireless technology

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"The future of wireless continues to amaze with is potential. However, this potential requires careful planning, especially because there's a limit on available spectrum."

THOUGH WiFi6 was only widely deployed recently, WiFi7 devices with 320 MHz channels (2x size) will soon be available with capabilities like 4K quadrature amplitude modulation (QAM). This enables each signal to more densely embed more data compared to 1K QAM with Wi-Fi 6/6E, and achieve a potential maximum data rate of almost 5.8 Gbps. This is 2.4x faster than the 2.4 Gbps possible with Wi-Fi 6/6E and could easily enable high-quality 8K video streaming or reduce a massive, 15 GB file download to roughly 25 seconds versus the one minute it would take with the best legacy WiFi technology.

In addition to WiFi7, the more significant impact to OT and IIoT is the continued development of cellular communications. Though 5G is still being introduced, discussion is already underway within 3GPP (www.3gpp.org), which develops cellular specifications, and has started working on 6G and 7G. It defines three services (see table):

- Ultra-reliable low latency communication (URLLS) for real-time data collection,
- Enhanced mobile broadband (eMBB) for high data requirements, and
- Massive machine type communication (mMTC) for "slower" updates (report by exception) in high-density situations.

6G will integrate high-precision localization (with centimeter-level accuracy), sensing (both radar-like and non-radar like) and imaging (at millimeter-level) capabilities, including passive sensing of objects that may not require broadcasting.

With a targeted increase of 20x bandwidth, 6G makes better use of existing spectrum by expanding the carrier bandwidth from 100 MHz to 400 MHz to provide up to 4x increase in capacity, while improving antennas with multiple-input multiple-output (MIMO) also increases capacity by sending more streams of data simultaneously. More antenna elements have been added to each generation, and 6G may support 1,024 antenna elements in the new mid-bands.

As the table shows, 6G will need added spectrum, Terahertz radio with new spectrum space, and integration with non-cellular communications WiFi, satellites, and the ability to accommodate reflective surfaces.

Unlicensed spectrum also has a role in dedicated subnetworks, such as private networks or dedicated spectra for specific purposes. To better support IIoT and real-time requirements for control, future sections of greenfield unlicensed spectra should be allocated to subnetworks, with new regulatory rules tailored to their requirements and traffic types, while still ensuring fairness among devices. Germany already does this by dedicating certain spectra to critical infrastructure.

Of course, someone must pay for all the new 6G infrastructure and providers will want to get return on their 5G investment before implementing 6G. In a typical mobile network today, CapEx is approximately 30% and OpEx is approximately 70% of the TCO over a 10-year period. 6G has a target to reduce OpEx by 30% over 5G, which will help with the overall migration return on investment costs.

The future of wireless continues to amaze with is potential. However, this potential also requires careful planning, especially as there is a limit on available spectrum. Part of that planning is to work with regulators to allocate frequencies in each of the URLSS and mMTC ranges as a minimum to support real-time OT requirements. ∞

Service	Capability	5G	6G		
		Requirement	Spectrum	Target	Spectrum
URLLS	Latency	1.0 millisecond	600 – 260 MHz	0.1 millisecond	470 – 690 MHz
eMBB	Bandwidth	Gigabit per second	2.5 – 4.9 GHz	Terabit per second	7 – 20 GHz
mMTC	Density	1 per m3	24 – 71 GHz	100 per m3	>92 GHz

This table summarizes some of the differences between 5G and 6G

Automation/controls growing 10% per year

Worldwide market expected to pass $377 billion from 2022 to 2030

THE global industrial automation and control systems market is expected to increase at a 10.3% compound annual growth rate (CAGR) from 2022 to 2030, reaching $377.25 billion by 2030, according to a new study by Research and Markets (www.researchandmarkets.com) in Dublin.

The report, "Industrial Automation and Control Systems Market Report," states this growth is attributed to the expanding adoption of process automation across various industries, such as automotive, energy utilities and chemicals. Other highlights of the report include:

- Industrial robots' component-type segment is expected to grow fastest with a more than 10% CAGR due to increasing automation, smart factories and digitalization.
- Distributed control system (DCS) segment accounted for the highest market share of more than 30% due to accelerating adoption of the Industrial Internet of Things (IIoT) solutions and components.
- Vertical healthcare segment is expected to grow at the highest rate of more than 10% CAGR due to increasing automation in surgeries and other health applications
- Asia/Pacific is expected to grow at the highest rate of more than 13% CAGR during the 2022-30 forecast period because developing countries are investing in automation, smart manufacturing and digitalization.

For instance, the report adds that ABB secured a contract this past March to automate NatureWork's greenfield plant in Thailand, and provide hardware, software and control room designs. Its report states that more manufacturers are turning to automation to reduce labor and operating costs, as well as minimizing human errors with increased reliability and efficiency.

Likewise, it reports that more industries are rapidly shifting towards smart manufacturing, which is expected to spur and expand the market for industrial control and automation systems, such as different types of robots. For example, ABB also launched it IRB 920T line in September to expand its range of selective compliance assembly robot arm (SCARA) devices. These robots are designed to suit the high-speed production requirements in the electronics sector in increasingly complicated manufacturing processes.

Asia/Pacific players evolve

Research and Markets adds the Asia/Pacific region is also expected to gain strength due to its key players and emerging companies. These include longtime manufacturers Yokogawa Electric, Kawasaki Robotics and Mitsubishi Electric Factory Automation. Much of Asia/Pacific's growth in automation and control can be attributed to increasing demand for better solutions to manage industrial plants in China and India. Also, emerging economies in Indonesia, Vietnam and Thailand have often untapped automation and control markets that are driving investment in manufacturing upgrades. Suppliers can extend their market positions and develop new revenue sources in these areas, according to Research and Markets. Conventional operations are evolving into smart facilities here, too, which is encouraging acceptance of automation.

Turbine flowmeter market keeps growing

Turbine flowmeters—a mainstay in oil and gas, water and industrial liquids markets—are still growing even though they're not growing as fast as newer technologies, according to "The World Market for Turbine Flowmeters," 3rd Edition (www.flowturbine.com) by Flow Research Inc.

The new study found that the worldwide turbine meter market totaled $420 million in 2019, and forecasts that a just over 1% compound annual growth rate (CAGR) through 2024. New-technology flowmeters are growing faster, with an up to 4.8% CAGR. The turbine market is also expected to keep growing due to a large installed base, their ability to measure liquid and gas flows, industry approvals for custody transfers and other technology improvements.

Even though turbine flowmeters are losing ground to some new-technology flowmeters—especially Coriolis, ultrasonic and magnetic flowmeters—they remain an excellent choice for clean, steady, medium to high-speed flows of low-viscosity fluids. Though research and development about turbine meters is less than the R&D for new-technology meters, some turbine meter suppliers are introducing new features and products. Innovations include new bearing types, different rotor designs, dual rotors, and bidirectional capability. They're also introducing wireless technology and more communication protocols.

More specifically, axial flowmeters, widely used for custody transfer of natural gas, are the fastest growing type of turbine flowmeter. Helical turbine meters, which recently found a niche in the petroleum industry for high-viscosity fluids like oil, are benefitting from an upsurge in the oil industry. In general, insertion turbine meters of various types, often used in large line sizes for custody transfer, have been growing slightly faster than inline turbine meters.

Meanwhile, propeller, paddlewheel and Pelton wheel flowmeters, used in water/wastewater, agriculture and other large-scale applications, are growing more slowly. ∞

SIGNALS AND INDICATORS

- **TÜV Rheinland** (tuv.com) agreed Jan. 1 to acquire **ABB**'s (abb.com) U.K.-based technical engineering consultancy that was part of its energy industries division. TÜV Rheinland will integrate this division into its industrial services and cybersecurity business in the U.K. The transaction is expected to close in 2Q23. The consultancy has 160 staffers and includes subcontractors and associates, who help global energy customers improve process safety, equipment and asset integrity.
- **The CC-Link Partner Association**'s (CLPA, www.cc-link.org) partner, **HMS Networks** (www.hms-networks.com), has released an embedded development option for designers of industrial automation devices that's compatible with the CC-Link IE time-sensitive networking (TSN) protocol. The Anybus CompactCom 40 CC-Link IE TSN embedded communication interface provides a gigabit Ethernet connection and TSN functionality in one package.
- **Qognify** (www.qognify.com), a provider of physical security and enterprise incident management software, reported Dec. 19 that it's being acquired by **Hexagon AB** (hexagon.com), a global leader in digital reality solutions combining sensor, software, and autonomous technologies. Qognify's video management (VMS) and incident management (EIM) solutions mitigate risk and reduce the impact of incidents related to security, safety and operations.
- **Schneider Electric** (www.se.com) reported Dec. 14 that it's integrated its EcoStruxure Automation Expert (EAE) software with consultant **Royal HaskoningDHV**'s (www.royalhaskoningdhv.com) process control software for sustainable, cost-effective wastewater treatment. Their collaboration and cloud-ready, cyber secure, flexible and scalable architecture is designed to improve sustainability, resilience and efficiency in water treatment plants.
- **Belden** (www.belden.com) reports it recently acquired **macmon secure GmbH** (www.macmon.eu) and its network access control software, which complement Belden's industrial networking portfolio and will be integrated into its Hirschmann products. Adding macmon will also extend Belden's Customer Innovation Center (CIC) initiatives.

Level measurement levels up

Control's monthly resources guide

GAUGING, ENGINEERING GUIDES

This online library, "Level measurement and tank gauging engineering guides," includes updated, classic publications on level measurement, safe instrumentation and overfill prevention, level for power and steam generation. They're at go.emersonautomation.com/rmt-en-l-level-resources. Also, its 150-page "Bulk solids level measurement application guide" is at go.emersonautomation.com/rmt-en-l-solids-resources-guide

EMERSON
www.emerson.com

LOCATING LAYERS

This blog post, "How to measure the interface between two liquids in a tank" by Gene Henry, shows how to determine the interface levels between two liquids in the same tanks or vessels, detect emulsions or "rag" layers between them, and how all of today's level measurement technologies can participate. It's at blog.isa.org/how-to-measure-interface-two-liquids-tank-level-measurement

ISA
www.isa.org

12 WAYS TO MEASURE

This online guide, "A dozen ways to measure fluid level," traces the field's evolution and covers established and modern sensing technologies. It's at new.abb.com/products/measurement-products/level/a-dozen-ways-to-measure-fluid-level

ABB
www.abb.com

SETTINGS AND SOLUTIONS

This nine-minute video, "Automation basics: level measurement" in Control's Educational Video Series, summarizes covers the settings, materials and challenges faced by users trying to make level measurement and details the most suitable solutions for performing them successfully and accurately. It's at www.youtube.com/watch?v=vdkmXpiu66Q

CONTROL
www.controlglobal.com

SELECTION AND CAPACITANCE

This webpage, "Guide: level measurement instrument selection" includes an Endress+Hauser video about capacitance, slides detailing level measurement technologies, and a link to a selection guide. It's at www.carotek.com/Level-Measurement-Instrumentation-Selection-Guide-Feb2021

CAROTEK
www.carotek.com

INTEGRATE WITH CONTROLLERS

This online tutorial, "The complete guide to industrial level sensors" by Anil Mamillapalli, covers mechanical and electronic sensors, how to connect and wire them to PLCs, and has links to other lessons. It's at www.solisplc.com/tutorials/level-sensor#toc-types-of-level-sensors-

SOLIS PLC
www.solisplc.com

FROM A PIPING PERSPECTIVE

This blog post, "Process instrumentation: level measurement" covers theadvantages and applications of magneto restrictive, laser, magnetic and displacement, bubble tubes and other technologies. It's at www.pipingengineer.org/process-instrumentation-level-measurement

PIPING ENGINEERING
www.pipingengineer.org

MANAGE THE VAPOR SPACE

In this online article, "How to accomplish total tank management," system integrator Novaspect's Jeff Wolendowski shows how users can use vapor space management, tank blanketing and other solutions in conjunction with level measurement to successfully operate their vessels. It's at www.controlglobal.com/manage/asset-management/article/11323063/how-to-accomplish-total-tank-management

CONTROL
www.controlglobal.com

CONTACT AND NON-CONTACT

This online article, "Level measurement technologies in the process industries" categorizes its primary technologies, such as contact and non-contact, and sensing methods such as level sight gauge, RF capacitance, float, resistance tape, displacer, ultrasonics, bubble tube, radar and nuclear. It's at www.predig.com/whitepaper/level-measurement-technologies-process-control-industry

PRECISION DIGITAL
www.predig.com

INTRO TO SENSOR TYPES

This nine-minute video, "What is a level sensor?," covers capacitive, optical, conductivity (resistance), vibrating (tuning fork), float switch, ultrasonic and radar (microwave) level sensors. It's at www.youtube.com/watch?v=EMotg3BQjIl h

REALPARS
realpars.com

STATE OF THE LEVEL ART

This state of technology report, "Innovations in level measurement" by *Control*'s editors covers how instrumentation is transforming water/wastewater operations; automatic tank gauging; how to stabilize a hunting tank level; and best practices in controlling column distillation. It requires a brief registration and is located at www.controlglobal.com/measure/level/whitepaper/21436088/report-innovations-in-level-measurement

CONTROL
www.controlglobal.com ∞

Automation without boundaries

PETER ZORINO
Chief Technology Officer,
Emerson
Emerson.com

It's been some three decades now since the Purdue model first formalized the seven-layer pyramid for "computer-integrated manufacturing" that those of us in the industrial automation space have all come to know (if not love). And while the model's intent was primarily functional, form often follows function and the intervening decades have left us with complex strata and siloes of isolated data that is difficult to integrate and contextualize.

Emerson, a longtime leader in the industrial automation space, has a new vision of a flatter, software-based architecture for automation that democratizes data and enables optimization without all the former hurdles. To learn more, we tracked down Emerson technology leader Peter Zornio at the company's recent Emerson Exchange user conference in Grapevine, Texas, near Dallas. Then chief technology officer for Automation Solutions, Zornio has since been promoted to CTO for the entire Emerson organization.

Q: While many compelling innovations were on display at Exchange, I was particularly intrigued by the future vision of "Boundless Automation" that was presented. Can you take us through the essential aspects of this new architecture and how it's different from the automation systems we've seen up to now?
A: Boundless Automation is our term for the future of operations technology (OT) architecture. That includes everything from intelligent field devices to automation to operational management software—the complete envelope of things that make production operations happen today. We got there pretty simply by looking at the limitations of today's architectures against the technology advances of the IT world in cloud and on what we now call the edge.

The fact that we have very layered, striated architectures with software sometimes tied to very specific hardware, makes it difficult to move data up and down the layers seamlessly. We've built the layers largely as a security construct, or, as you already mentioned, as form follows function. With digital transformation, people went beyond automation into areas like reliability, sustainability and quality, which meant yet more vertical silos of data with their attendant applications.

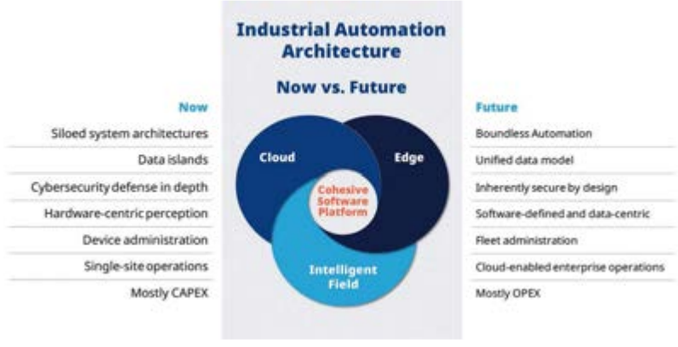
We've decided that this kind of silos or layers doesn't make sense going forward. Instead, think of three integrated computing domains—the intelligent field devices, the edge technologies, and the cloud—combined as peers (rather than layers) with a cohesive software environment that ties the applications in those three environments together. That's really the core concept of Boundless Automation.

Q: You've used the phrase "integrated by design" to describe how the various components and systems that participate in these future systems interact with one another. Is this more than the common communication standards and basic information models that we already use?
A: Each one of these three domains will support software applications that, in order to fulfill their value potential, need to be integrated together much more closely than the lowest common denominator functionality that most standards deliver. Now, standards are absolutely good and essential for some core infrastructure, but they can also limit innovation. So, you need to very selectively decide where you're going to have standards, and it's not always a purely technical problem. A very complex standard might deliver a very high level of functionality, but then you're faced with commercial and testing issues around a multi-vendor environment. Who's going to be in charge of making these more complex pieces of software work together?

What we've seen in the software market over the past 20 or 30 years proves that people want and will pay for a unified software ecosystem that provides greater ease of use and provides for usability of the data, what we call data democratization, inside that software ecosystem. Examples close to home include Microsoft's move to integrated software suites, ecosystems of mobile phones and resident apps, and the original distributed control system (DCS). The DCS has always been an integrated, cohesive suite of automation software that's been designed from the start to work together. The concept has obvious benefits that we've seen people willing to pay for.

Q: Providing more effective and efficient data management and contextualization has been a key push by Emerson for several years now, and the recent controlling interest acquisition of AspenTech and the inmation technology that it acquired promise to advance those capabilities even further. Can you talk to the importance of effective data management in the Boundless Automation systems of the future, and how the inmation and AspenTech technologies help to advance it?
A: If we've learned anything from customers running digital transformation programs, it's that this concept of data democratization or usable data is what's key. Everybody quickly figured out they could use standards, that they could move data back and forth or put it all together in a data lake in the cloud. What was missing was the context provided by a consistent data model around all that data, to make it usable in actual applications.

And that's where inmation comes in: it layers a cohesive, S95-based data model over the disparate data models of various applications. But the Boundless Automation vision goes further, in that applications in this integrated software portfolio will leverage a shared data model right from the start. And of course, now, with the combined portfolios of Emerson and Aspen, we have the broadest suite of OT software in industry. It's a great opportunity to bring them together in the sort of unified software environment that will deliver unparalleled ease of use and data democratization for our customers.



At November's Emerson Exchange conference, the company shared its vision of a new, software-defined automation architecture designed to catalyze the future of modern manufacturing.

Q: The process automation crowd has long been a pretty conservative bunch—and for good reason—when it comes to adopting new technologies. But the pandemic seems to have only accelerated widespread acceptance of the cloud as an important extension of on-prem automation systems.

What advantages does cloud connectivity offer users of Emerson systems, and how does it increase the value you can deliver on their behalf?
A: First off, I'd note that IT has really run to the cloud and embraced it. And frankly, many applications in the OT world are not time critical and could move to the cloud today to take advantage of those same benefits: outsourced infrastructure, no software maintenance, universal access, elastic scalability and pay-as-you-use consumption-based models. The cloud doesn't solve the data integration issues already mentioned but having all the various systems housed together in the cloud is a better starting point.

Q: Just after Exchange, Emerson announced that it had divested a majority stake in the commercial and residential side of its business in a deal that valued the business at $14 billion. Lal Karsanbhai noted that this was "a next step in Emerson's ambitions to become a global automation player." That's a pretty nice nest egg when it comes to investing to increase the footprint and capabilities of what I think of as an already significant force. What can you tell us about what developments we might we expect in the coming months?
A: I think Lal describing it as "a next step" was a little bit of an understatement. Certainly, the deal succeeded in creating the world's largest pure-play automation company. And frankly, we're big in all areas whether it's sensing, final control, and actual control across process, hybrid and discrete manufacturing. And with Aspen, we've set up one of the largest portfolios of OT software. So, you can expect that, yes, we'll take that nest egg and be targeting expansion in all those areas.

It's very clear we're committed to being a pure-play automation company. ∞

BEST IN CONTROL
READERS' CHOICE AWARDS BY
PROCESS AUTOMATION DISCIPLINE

BATCH PROCESS AUTOMATION
Emerson 1
Rockwell Automation 2
Siemens 3
ABB 4
Honeywell 5
Yokogawa 6
Schneider 7

CONTINUOUS REGULATORY CONTROL
Emerson 1
Honeywell 2
Rockwell Automation 3
ABB 4
Yokogawa 5
Schneider 6
Siemens 7

CONTINUOUS SHEET/ WEB MONITORING & CONTROL
Honeywell 1
Emerson 2
Rockwell Automation 3
ABB 4
Siemens 5
Yokogawa 6
Schneider 7

SAFETY/EMERGENCY SHUTDOWN
Schneider 1
Emerson 2
Rockwell Automation 3
Siemens 4
ABB 5
Yokogawa 6
Honeywell 7

SEQUENTIAL LOGIC CONTROL
Rockwell Automation 1
Siemens 2
Emerson 3
Schneider 4
Honeywell 5
Yokogawa 6
ABB 7

SUPERVISORY CONTROL & DATA ACQUISITION
Emerson 1
Rockwell Automation 2
Honeywell 3
AVEVA 4
Schneider 5
Siemens 6
ABB 7

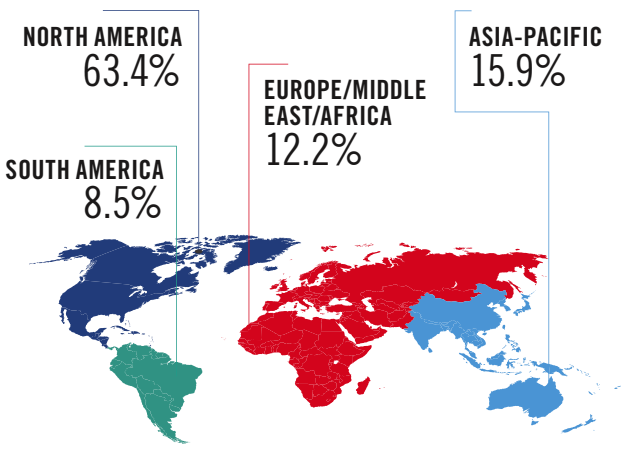
2023 READERS' CHOICE AWARDS

Process automation professionals vote for their favorite suppliers in more than 80 categories

BY CONTROL STAFF

For more than three decades now, the Control Readers' Choice Awards have identified our readers' favorite suppliers across a range of instrumentation and control technologies—from annunciators and batch management to vibration sensors and weighing systems. Over the years, the awards have morphed a bit in line with the times. We no longer have a winner for expert systems software or minicomputers. The number of categories has grown from 50 to more than 80. And leadership by automation discipline was added to acknowledge the all-important application expertise that often transcends a particular product category. Plus, many of the organizations that claimed top honors in 1993 no longer exist—most having been absorbed by acquisition into today's leading solution providers.

VOTERS BY WORLD REGION



VOTERS BY INDUSTRY

Upstream oil & gas	18.3%
Water/wastewater processing	16.9%
Petroleum refining	15.5%
Food & beverage manufacturing	14.1%
Chemicals manufacturing	13.4%
Pharmaceuticals/life sciences	6.8%
Plastics & rubber manufacturing	5.8%
Electric power generation	3.6%
Metals, minerals & mining	3.4%
Pulp & paper manufacturing	2.2%

VOTER DEMOGRAPHICS

Respondents to this year's Readers' Choice Awards survey are an industrially diverse but North America-centric mix of individuals from across the process industries. Process control and instrumentation professionals from end-user and engineering firms made their voices heard, responding to invitations emailed in late 2022. The tables above summarize their industry and geographic demographics. Those individuals who work for systems integration and engineering services firms were asked to choose the end-user industry that most closely represents their work.

But several essential aspects have remained constant. The Readers' Choice Awards is perennially among our most popular feature articles. 2022's version was no exception, ranking as the year's most visited story on ControlGlobal.com. Instrumentation and control professionals refer to the Readers' Choice Awards because they represent the collective wisdom of you, our readers, who have taken the time to share your technology and application expertise.

We sincerely thank all our readers who participated this year, an eclectic group of process automation and instrumentation professionals representing diverse process industry verticals as well as all corners of the U.S. and, increasingly, the world. (For more information on survey respondent demographics, see figures above.)

Leaders by discipline

Our first grouping of Readers' Choice Awards isn't so much a set of product technologies as it is a set of fundamental control domain competencies—ranging from batch automation to SCADA. (See listing of "Process Automation Discipline" winners on the left.) Not unexpectedly, the readers' vote is concentrated among

the global leaders in process automation systems technology: ABB, Emerson, Honeywell, Rockwell Automation, Schneider, Siemens and Yokogawa.

Emerson got the nod in Batch Process Automation, Continuous Regulatory Control and Supervisory Control & Data Acquisition (SCADA), while Rockwell Automation took top honors in Sequential Logic Control. Honeywell took first place in Continuous Sheet Monitoring & Control, and Schneider in Safety/Emergency Shutdown on the strength of its Triconex portfolio.

AVEVA's presence in the listings resulted from Schneider Electric's spin-off of its industrial software businesses into this separate, independent entity that is still majority-owned by Schneider. GE is noticeably absent from our rankings the past few years following the sale of its industrial automation business to Emerson and disinvestment in Baker Hughes.

Applications expertise

Closely aligned with the process automation discipline awards are those in the category of Application Software. Here, again, a significant amount of market presence and customer preference is focused among the global discipline leaders. (See listing of "Application Software" winners on the left.)

Technology specialists that made these ranks included Beamex and Fluke in Calibration Management, Autodesk in Design/Documentation, and Mitsubishi in PLC Programming. AspenTech and AVEVA made the grade in Modeling & Simulation, each now representing a software-focused entity that's majority owned by a systems player—Emerson and Schneider, respectively. In the category of OPC Connectivity, PTC edged out Honeywell-owned Matrikon on the strength of its Kepware acquisition.

APPLICATION SOFTWARE

Advanced Process Control
1. Emerson
2. Honeywell
3. Rockwell Automation
4. Yokogawa
5. ABB

Alarm Management
1. Emerson
2. Honeywell
3. Yokogawa
4. Rockwell Automation
5. ABB

Asset Performance Management
1. Emerson
2. Rockwell Automation
3. Yokogawa
4. ABB
5. Honeywell

Calibration Management
1. Emerson
2. Beamex
3. Fluke
4. Honeywell
5. Yokogawa

Design/Documentation
1. Autodesk
2. Rockwell Automation
3. Honeywell
4. Hexagon
5. Emerson

Human-Machine Interface
1. Rockwell Automation
2. Siemens
3. AVEVA
4. Emerson
5. Honeywell

Loop Tuning
1. Emerson
2. Rockwell Automation
3. Yokogawa
4. Honeywell
5. Siemens

OPC Connectivity
1. PTC
2. Matrikon
3. Siemens
4. Emerson
5. Rockwell Automation

PLC Programming
1. Rockwell Automation
2. Siemens
3. Schneider
4. Emerson
5. Mitsubishi

SCADA
1. Rockwell Automation
2. AVEVA
3. Emerson
4. Siemens
5. ABB

Simulation & Modeling
1. Emerson
2. Rockwell Automation
3. AspenTech
4. Honeywell
5. AVEVA

VISUALIZATION/CONTROL HARDWARE

Annunciator
1. Ametek
2. Rockwell Automation
3. ABB
4. Ronan Engineering
5. Federal Signal

Industrial Computer
1. Dell
2. Rockwell Automation
3. Advantech
4. Siemens
5. Emerson

Operator Interface Terminal
1. Rockwell Automation
2. Siemens
3. Schneider
4. Omega Engineering
5. AutomationDirect

Panel Display
1. Rockwell Automation
2. Siemens
3. Precision Digital
4. Hope Industrial Systems
5. Red Lion

Process Loop Controller
1. Yokogawa
2. Siemens
3. ABB
4. Emerson
5. Honeywell

Recorder
1. Yokogawa
2. ABB
3. Honeywell
4. Siemens
5. Eurotherm

Visualization hardware

A further step adjacent to the core process automation disciplines are the hardware devices that provide a local platform for control, compute and visualization—notably annunciators, panel displays, loop controllers, recorders and industrial PCs. (See listing of "Visualization & Control Hardware" winners on the left.)

As with application software, the global process automation majors earn their share of allegiance in this arena. Notable exceptions include Ametek, whose Panalarm annunciators have long set the standard in the category. Federal Signal and Ronan Engineering also made the list in the Annunciator category.

FLOW INSTRUMENTATION

Coriolis Mass
1. Emerson
2. Endress+Hauser
3. Krohne
4. Yokogawa
5. ABB

Magnetic
1. Emerson
2. Endress+Hauser
3. Krohne
4. ABB
5. Yokogawa

Open Channel
1. Endress+Hauser
2. Emerson
3. Siemens
4. Krohne
5. Yokogawa

Positive Displacement
1. Badger Meter
2. Endress+Hauser
3. TechnipFMC
4. Krohne
5. ABB

Thermal Mass
1. FCI
2. Endress+Hauser
3. ABB
4. Sierra Instruments
5. Kurz Instruments

Turbine
1. Emerson
2. TechnipFMC
3. Badger Meter
4. AW-Lake
5. Hoffer Flow Controls

Ultrasonic (closed pipe)
1. Krohne
2. Emerson
3. Endress+Hauser
4. Baker Hughes
5. Siemens

Variable Area (rotameter)
1. Krohne
2. Brooks Instrument
3. Yokogawa
4. Dwyer Instruments
5. Siemens

Vortex
1. Emerson
2. Endress+Hauser
3. Yokogawa
4. Krohne
5. Siemens

Flow Switch
1. FCI
2. Endress+Hauser
3. Ametek
4. Keyence
5. Dwyer Instruments

LEVEL INSTRUMENTATION

Admittance/Conductance (continuous)
1. Endress+Hauser
2. Ametek
3. VEGA

Float/Displacer
1. Emerson
2. Ametek
3. Omega Engineering
4. Baker Hughes
5. WIKA

Guided-Wave Radar
1. Emerson
2. Endress+Hauser
3. Krohne
4. VEGA
5. Ametek

Radar, Non-contact
1. Emerson
2. Endress+Hauser
3. VEGA
4. Krohne
5. Ametek

Tank Gauge, Inventory-grade
1. Emerson
2. Endress+Hauser
3. Honeywell Enraf
4. Siemens
5. VEGA

Magnetostrictive
1. ABB
2. Emerson
3. Ametek
4. Endress+Hauser
5. WIKA

Radiometric
1. VEGA
2. Endress+Hauser
3. Berthold
4. Tracerco

Ultrasonic
1. Endress+Hauser
2. Krohne
3. Siemens
4. VEGA
5. Ametek

Level Switch, Electrical Property-based
1. Ametek
2. Endress+Hauser
3. Emerson
4. Krohne
5. Siemens

Level Switch, Mechanical
1. Ametek
2. Emerson
3. ABB
4. Endress+Hauser
5. Omega Engineering

Level Switch, Ultrasonic
1. Endress+Hauser
2. Emerson
3. Ametek
4. ABB
5. VEGA

Level Switch, Vibratory
1. Endress+Hauser
2. Emerson
3. Krohne
4. VEGA
5. Ametek

Magnetic Level Indicator
1. ABB
2. Emerson
3. Ametek
4. Krohne
5. WIKA

Laser
1. ABB
2. Keyence
3. Banner Engineering

And in a manifestation of IT/OT convergence, Dell topped our Industrial PC rankings for the first time. In the category of Operator Interface Terminal, Rockwell Automation took top honors, while Yokogawa receives top honors for both its Process Loop Controllers and Recorders. Meanwhile, Advantech, Hope Industrial Systems and Precision Digital earn mentions in the visualization grouping.

Process measurements

Process analyzers, together with devices for measuring the primary process variables of flow, level, pressure and temperature are the workhorse instruments of the process industries. Indeed, the accompanying four award groupings include nearly 40 different technologies for sussing out these important variables in a broad variety of challenging conditions. (See listings of "Flow Instrumentation," "Level Instrumentation," "Pressure & Temperature Instrumentation" and "Process Analyzer" winners on the previous and following pages.)

The leaders here include instrumentation heavyweights Emerson and Endress+Hauser, which win or rank highly in the most categories. But ABB, Krohne, Schneider, Siemens and Yokogawa also show a following in multiple instrumentation categories. Again, a range of specialists have managed to hold out against the majors in this realm, including Badger Meter for its Positive Displacement flowmeters and Fluid Components International (FCI) for its Thermal Mass flowmeters and Flow Switches.

In the level realm, ABB carries the day in Magnetostrictive and Laser technologies as well as Magnetic Level Indicators, while VEGA is top of the charts when it comes to Radiometric (nuclear) gauges. Ametek is tops in Level Switch technologies based on electrical and mechanical principles. Finally, in the realms of pressure and temperature sensing, Emerson ranks highest in most categories, with Endress+Hauser often playing second fiddle. In infrared technologies, however, Fluke reigns supreme.

And in the category of analytical instrumentation (see "Process Analyzers" listing on page 42), Emerson again takes top honors in all but one category, with ABB taking the top spot in Process Spectrometers. Notable second places include MSA in Ambient Gas Detection, Vaisala in Humidity/Moisture and Thermo Fisher in Process Spectrometers. ABB ranks in six of seven analyzer technologies and Yokogawa in five of seven.

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PRESSURE & TEMPERATURE INSTRUMENTATION

Pressure Transmitter
1. Emerson
2. Endress+Hauser
3. Yokogawa
4. Honeywell
5. Siemens

Pressure Switch
1. Emerson
2. Endress+Hauser
3. WIKA
4. United Electric Controls
5. Honeywell

Resistance Temperature Detector
1. Emerson
2. Endress+Hauser
3. Omega Engineering
4. JMS Southeast
5. ABB

Thermocouple
1. Emerson
2. Omega Engineering
3. Endress+Hauser
4. ABB
5. JMS Southeast

Temperature Transmitter
1. Emerson
2. Endress+Hauser
3. Honeywell
4. Yokogawa
5. ABB

Temperature Switch
1. Emerson
2. WIKA
3. Endress+Hauser
4. ITT Neo-Dyn
5. ABB

Infrared Temperature Sensor
1. Fluke
2. Omega Engineering
3. Teledyne FLIR
4. Ametek Land
5. Williamson

Infrared Imaging/ Thermography
1. Fluke
2. Teledyne FLIR

PROCESS ANALYZERS

Ambient Gas Detector
1. Emerson
2. MSA
3. Draeger
4. ABB
5. Thermo Fisher

Density/Concentration
1. Emerson
2. Endress+Hauser
3. Yokogawa
4. ABB
5. Krohne

Humidity/Moisture
1. Emerson
2. Vaisala
3. Baker Hughes
4. Endress+Hauser
5. ABB

pH/ORP/Conductivity
1. Emerson
2. Endress+Hauser
3. ABB
4. Yokogawa
5. Mettler Toledo

Process Chromatograph
1. Emerson
2. ABB
3. Siemens
4. Yokogawa
5. Thermo Fisher

Process Spectrometer
1. ABB
2. Thermo Fisher
3. Emerson
4. Siemens
5. Yokogawa

Stack Gas/Emissions
1. Emerson
2. ABB
3. Siemens
4. Ametek
5. Yokogawa

FINAL CONTROL

Control Valve
1. Emerson
2. Baker Hughes
3. Flowserve
4. Samson
5. Neles

Control Valve Actuator, Pneumatic
1. Emerson
2. Baker Hughes
3. Flowserve
4. Samson
5. Rotork

Control Valve Actuator, Electric
1. Emerson
2. Rotork
3. Flowserve
4. Auma
5. Samson

Valve, On/Off
1. Emerson
2. Flowserve
3. Neles
4. Bray
5. Crane

Electric Motor
1. ABB
2. Siemens
3. Wolong
4. WEG
5. Nidec

Electric Motor Drive
1. Rockwell Automation
2. ABB
3. Siemens
4. Yaskawa
5. Schneider

Final control elements

When it comes to final control elements, Emerson takes top honors in control valves, on/off valves plus pneumatic and electric actuators. Other high-ranking valve-makers include Baker Hughes (Masoneilan), Flowserve, Samson Control and Neles.

In addition to control valves, electric motors and drives increasingly act together as final control elements across the process industries. Here, ABB retains top honors for its Electric Motor technology, while Rockwell Automation ranked highest in the category of Electric Motor Drive.

Infrastructure and essentials

Our final two groups of Readers' Choice Award winners include foundational contributors to the wired and wireless automation infrastructure, as well as role players that serve important process automation functions but frankly just don't fit cleanly in any of the other award groupings. (See "Automation Infrastructure" and "Elsewhere in the Field" listings on the following pages.)

Input/output (I/O) modules, along with terminal blocks, signal conditioners, intrinsic safety barriers and power supplies, work seamlessly together to reliably gather, digitize and distribute the many electronic signals required to run a modern process facility. In this arena, Rockwell Automation ranks highest for its I/O Module offering, while Pepperl+Fuchs receives top votes for its Intrinsic Safety capabilities. Meanwhile, triple threat Phoenix Contact places first in the Terminal Block, Signal Conditioner and Power Supply rankings. Belden is our readers' favorite when it came to Wire & Cable, as is Emerson when it comes to Wireless Infrastructure.

Winners in our last grouping of other essential product technologies (see "Elsewhere in the Field" listings), are primarily specialists in their respective domains. One notable exception is Rockwell Automation, which carries the day in both Data Acquisition Systems and Remote Terminal Units. Leadership in Instrument Fittings goes to Swagelok, Portable Calibrators to Fluke, Weighing Systems/Load Cells to Mettler Toledo and Vibration Instrumentation to Baker Hughes (Bentley Nevada). In the arena of field enclosures, nVent Hoffman edged Rittal, and Pepperl+Fuchs tops the charts in enclosure Purge Systems. ∞

AUTOMATION INFRASTRUCTURE

Input/Output System
1. Rockwell Automation
2. Emerson
3. Siemens
4. Schneider
5. ABB

Intrinsic Safety
1. Pepperl+Fuchs
2. Eaton MTL
3. Rockwell Automation
4. Phoenix Contact
5. ABB

Power Supply
1. Phoenix Contact
2. Emerson
3. Rockwell Automation
4. PULS
5. Acopian

Signal Conditioner
1. Phoenix Contact
2. Pepperl+Fuchs
3. Moore Industries
4. Weidemuller
5. Acromag

Terminal Block
1. Phoenix Contact
2. Weidmuller
3. Rockwell Automation
4. Wago
5. Pepperl+Fuchs

Wire & Cable
1. Belden
2. Prysmian Group
3. Southwire
4. Leoni Kerpen
5. Lapp

Wireless Infrastructure
1. Emerson
2. Cisco
3. Honeywell
4. Moxa
5. Phoenix Contact

ELSEWHERE IN THE FIELD

Data Acquisition System
1. Rockwell Automation
2. Yokogawa
3. Emerson
4. Honeywell
5. Schneider

Enclosure
1. nVent
2. Rittal
3. Saginaw Control & Engineering
4. Hammond Manufacturing
5. ABB

Portable Calibrator
1. Fluke
2. Emerson
3. Beamex
4. PIE
5. Honeywell

Remote Terminal Unit
1. Rockwell Automation
2. Emerson
3. ABB
4. Honeywell
5. Siemens

Vibration Instrumentation
1. Baker Hughes
2. Emerson
3. Metrix
4. Rockwell Automation
5. SKF

Weighing System/Load Cell
1. Mettler Toledo
2. Rice Lake
3. Hardy Instruments
4. Siemens
5. Avery Weigh-Tronix

Instrument Fittings
1. Swagelok
2. Parker Hannifin
3. Hy-Lok
4. Emerson
5. Hoke

Purge System
1. Pepperl+Fuchs
2. Rockwell Automation
3. nVent Hoffman

How power supply design can make for smooth operations

CHRIS HARMAN
Product Marketing Manager
PULS L.P.
pulspower.us

LIKE OTHER ELECTRONIC DEVICES, today's digital control systems rely on a direct current of steady, consistent incoming voltage to operate properly and reliably. But the AC power baseline typical of most industrial environments is neither steady nor consistent, being battered by sudden starts and stops of other electrical loads that propagate voltage dips and surges across the system. It falls then to the industrial power supply to smooth the voltage swings and current inrushes that can take their toll on system operation. To learn more about why it's important to keep AC inrush as low as possible—and the steps that power supply manufacturers take to do so—Control caught up with Chris Harman, product marketing manager for PULS L.P.

Q: What exactly is an AC inrush current, and how are they detrimental to control system operation?
A: We've all experienced the effect of an AC inrush current in our personal lives, for example, when a refrigerator, a power tool, a vacuum cleaner or an air conditioner first turns on. The surrounding lights may dim briefly, a sign that the AC voltage is being drawn down due to the sudden demand for power.

Fortunately, in the home environment, flickering lights are typically as bad as it gets. However, in an industrial environment, inrush current has potential risks. It can have a negative impact on operating systems, with unexpected downtime or even damage to expensive equipment.

In addition, when selecting other system components such as circuit breakers, switches and relays, inrush current effects must be considered. This means that reducing the potential for inrush currents to affect the downstream side of the associated power supply also reduces the need for incremental system design and maintenance efforts.

Q: In what ways can power supplies mitigate the effects of AC inrush currents?
A: A switched-mode power supply (sometimes called a switch-mode power supply, or SMPS) converts the AC supply voltage to DC by way of a bridge rectifier. The voltage is then smoothed using a large electrolytic capacitor. When a DC device that is downstream of the power supply is first turned on, current "rushes in" to the input capacitors.

This inrush current is higher than the nominal or operational current of the power supply. Therefore, the inrush needs to be limited to ensure stable operation and to avoid tripping fuses or circuit breakers, generating voltage dips or welding relay contacts. There are various technological solutions and design techniques that can achieve a low inrush current.

Q: I understand that NTC, for "negative temperature coefficient" thermistors, are the easiest and least expensive way of limiting inrush current. How does this approach work, and what are its limitations?
A: This solution is based on thermally sensitive semiconductor resistors placed upstream of the power supply's input capacitors. When power is first applied, the cold NTC thermistor has a high impedance and effectively limits the charging current to the capacitors. The NTC thermistor heats up very rapidly due to its own losses, so the impedance drops to a low level, allowing the required current to flow.

This simple solution has some disadvantages. If ambient temperature is too cold (e.g., below zero °C), current may not ramp quickly enough, and start-up problems can occur. If ambient temperature is too warm, the thermistor may fail to adequately limit the inrush.

Another weak point in NTC thermistor performance is after a short AC voltage interruption: As soon as the AC voltage is interrupted, the electrolytic capacitors are discharged but the NTC thermistor remains warm and at low impedance. Therefore, it's practically ineffective if AC power is quickly restored. This effect can cause nuisance tripping of fuses or circuit breakers. Also, the very nature of NTC thermistor performance introduces power losses that lower the overall efficiency of the power supply.

Q: Are there other ways to limit inrush current that sidestep the disadvantages of NTC thermistors?
A: The first of three approaches is with a fixed power resistor that is automatically bypassed when the power supply capacitors are fully charged. This approach may rely on relays, TRIACs (for triode for alternating current) or IGBTs (for insulated-gate, bipolar transducers). This approach is significantly more complex and expensive than NTC thermistors, so is primarily used in power supplies with higher power designs (250W and above). The advantages are that fixed resistors are insensitive to ambient temperature effects and incur significantly lower power losses.

Similarly, trailing-edge phase dimming bridges the current to the capacitors with a relay after charging is complete. What makes this solution special is the limiting part itself. An electronic system measures the instantaneous value of the AC voltage and compares it with the voltage of the partly charged capacitors. If the difference is less than a set threshold (e.g., 30V) a MOSFET (for metal-oxide-semiconductor, field-effect transistor) closes. If the difference is greater than 30V, the MOSFET remains opens.

When on (closed) the MOSFET thereby limits the peak charging current. For example, if the on-resistance has a value of 4 ohms, the current is limited to 7.5A (30V/4 ohms). A gentle start for all input voltages is therefore guaranteed. If the input capacitor is fully charged the inrush current limiting circuit is bridged to avoid power losses. PULS uses this technique in many of its Dimension C Series power supplies.

The third method, pulse charging, is a smart and efficient way of softly controlling how much energy is allowed to charge the input capacitor. To achieve this, a small switch-mode power supply is integrated and used as a charging circuit. This enables a very efficient charging of the input capacitor with no losses.

	NTC	Resistor With Bypass	Trailing Edge Phase Dimming	Pulse Charging
Limiting of Inrush on Cold Start	+	+	++	++
Inrush After Short Power Loss	–	+	+	++
Temperature Dependency	–	+	++	++
Input Voltage Dependency	–	–	+	++
Power Loss	–	++	++	++
Good at Low Temps (<10°C)	–	+	++	++
		++ Very Good	+ Good	– Poor

A range of power supply technologies are available to help limit AC current inrush and its negative effects on control system performance.

This method leads to several advantages:

- The inrush current is only slightly higher than the normal operating current.
- The peak current can be defined more accurately, as there are no variables involved.
- A delay on the charging is also incorporated into the design. This means when power is initiated or restored, the supply does not contribute to unnecessary inrush as neighboring equipment is also energized.
- Fuses or circuit breakers can be sized for operating current and not peak current.
- The inrush current limitation is independent of input voltage or temperature.

Pulse charging is highly efficient and is used in many DIN-rail power supplies in the PULS Dimension Q Series.

Q: How can one best decide the optimal choice among these four methods of controlling inrush current?
A: Functionality always comes first. But when faced with alternate solutions that can do the job, total cost of ownership (TCO) is always the rational decision-maker's first tiebreaker. Indeed, devices with lower up-front costs typically penalize their owners in more ways than one. The TCO calculation for a superior design that results in lower energy usage is typically sufficient from an economic justification perspective.

Further, a power supply that produces a very low AC inrush current when it's energized can allow more power supplies to be operated from a single circuit breaker, reducing the number of overall components in an enclosure and possibly resulting in a smaller control cabinet. Lower AC inrush can also help reduce voltage dips on the AC mains if several supplies are turned on at the same time—especially if other AC equipment is being energized at the same time. This also prevents nuisance trips that can cause unnecessary downtime and troubleshooting efforts.

Low inrush current, taken together with other power supply features such as active power factor correction and higher short-term output current can significantly reduce the overall size and rating of the necessary power supply and help reduce mains disturbances. Which one is the right one for you depends on your application and in which environment it is used. You can also consult our team of skilled application engineers to find the best power supply for your application. ∞

Feedwater plant cuts troubleshooting by 60%

EPCM Teng upgrades water supply for boiler at Ontario refinery with PlantPAx controls and HMIs

BY JIM MONTAGUE

IT'S not in the movies, but J.R.R. Tolkien famously wrote that, "Water hot is a noble thing," and the same goes for boilers in refineries. Oil, gas, chemicals and most other modern blessings wouldn't be possible without old-fashioned hot water and steam, which both require clean water.

To keep this crucial resource flowing cleanly and safely at a large refinery in Ontario, Teng Inc. (teng.ca) in Mississauga upgraded its boiler feedwater treatment plant (BFWTP) this past June from a PLC/HMI system to Rockwell Automation's (www.rockwellautomation.com) PlantPAx DCS.

Teng is a 26-year-old, mid-sized engineering, procurement, construction and management (EPCM) firm with more than 145 staffers, who provide project lifecycle services from project development to commissioning/start-up, maintenance services and support such as inspections, optimization and turnaround services, and automation and controls including system integration from concept to commissioning. Glen Rycroft, senior process control engineer at Teng, presented "Upgrade of obsolete boiler feedwater treatment plant PLC/HMI to PlantPAx 5.0" at the recent Rockwell Automation Fair 2022 in Chicago.

Overcoming obsolescence

The BFWTP pretreats water before it goes to the refinery's boilers to make steam. The plant also produces potable water used throughout the plant. As usual, this process is critical to any, overall refinery because losing boiler feed water and steam production would cause a plantwide shutdown.

This refinery also runs 24/7, so there was no feasible way to schedule a full plant shutdown to replace its PLC. Because only a short migration window was available and the plant had to remain online throughout, the new control system would have to be robust and flexible enough to handle it.

The existing BFWTP was controlled by Honeywell's 30-year-old, obsolete IPC-620 PLC with an obsolete version of Intellution's iFix HMI software. The PLC manages more than 500 I/O points, running about 30 pumps and 100 valves, while its programming was heavily sequenced for operations, such as regenerations and backwashes. The PLC was also connected to a legacy Honeywell DCS for control/monitoring (Figure 1).

"The obsolete PLC was no longer supported by the vendor, so it was hard to obtain spares. Meanwhile, PLC component failures

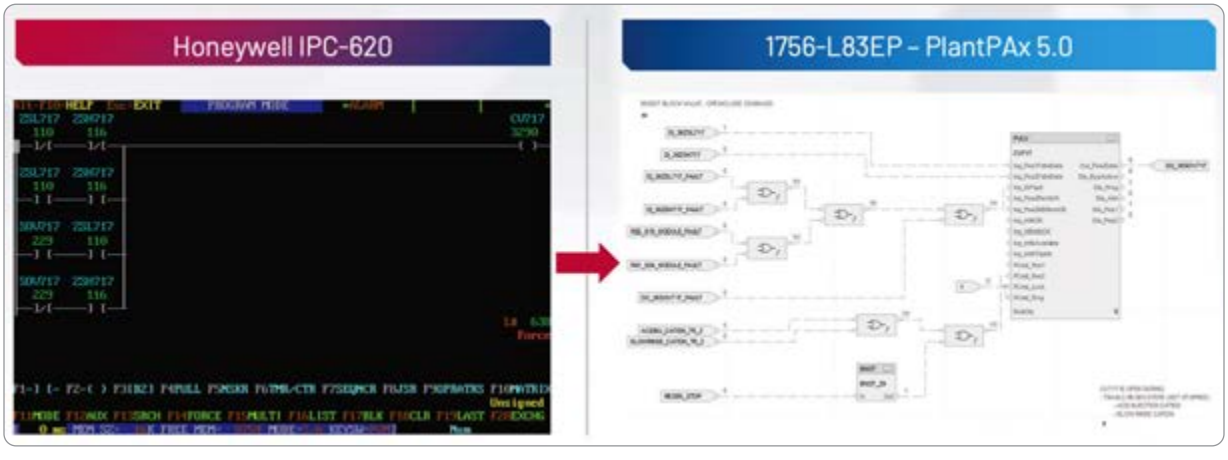

Figure 1: To revamp controls, HMIs and other functions at an Ontario refinery's boiler feedwater treatment plant (BFWTP), Teng migrated it from an obsolete Honeywell IPC-620 PLC with an obsolete version of Intellution iFix HMI software to Rockwell Automation's PlantPAx 5.0 DCS and ControlLogix PLC. The BFWTP manages more than 500 I/O points, running about 30 pumps and 100 valves, while its former programming was heavily sequenced for operations, such as regenerations and backwashes. Source: Teng and Rockwell Automation

were rapidly increasing over the past two or three years. A catastrophic PLC failure would cause a costly plant outage of more than 12 weeks," says Rycroft. "Likewise, the HMI wasn't communicating with the PLC because a custom driver on the HMI workstation wasn't supported and native files weren't available. As a result, control was only available through the Honeywell DCS communications link to the Honeywell PLC. In addition, troubleshooting in the old PLC wasn't intuitive, onsite staff weren't very familiar with the software, and Teng's support was required for detailed troubleshooting or modifications."

Evaluating new controls

To evaluate and implement a new PLC, the BFWTP would need a replacement that was also sequence-based, though this wasn't ideal for the legacy DCS. The refinery eventually settled on Rockwell Automation's PLCs because they were already the site standard outside the feedwater plant's DCS as part of an earlier upgrade. Based on a review by stakeholders, it also adopted PlantPAx due to its ease of operations, enhanced troubleshooting for maintenance, ability to easily complete future modifications, and similar look and feel to the planned, plantwide DCS upgrade.

The refinery and Teng considered converting the IPC-620's program to Studio5000 software via a third party. However, Rycroft reported they rejected this option because this type of conversion wouldn't benefit the site because troubleshooting would still require manual scanning using ladder logic, and it wouldn't provide PlantPAx's enhanced HMI faceplates for operations and maintenance. Plus, the cost difference was negligible compared with migrating to PlantPAx. In addition, converting IPC-630 to Studio5000 would still require:

- Comparable testing to confirm conversion was completed correctly.
- Using an output conversion tool to maintain old PLC's tag naming syntax, and keeping legacy tags and logic, which would make troubleshooting messy.
- Converting tools from ladder to ladder because the BFWTP's site standard is function block where possible, and ladder where function block isn't possible.
- Still having to change process/control loops manually.
- Performing system diagnostics manually.

Likewise, the refinery and Teng also rejected upgrading the feedwater plant's iFix HMI software to its latest version because the supplier reported that mi-

grating would have still been mostly manual due to its age. "With negligible cost difference to reprogram the HMI in PlantPAx, along with multiple benefits of PlantPAx interface, upgrading the old iFix HMI did not make sense for this application," explains Rycroft. "It also would've required about 10-20% more testing without pre-built object libraries."

Picking out the pieces

Based on the BFWTP's 500 I/O and required availability, Teng and the refinery selected redundant 1756-L83EP process controllers and racks, each with a redundant power supply. They estimated CPU utilization at 50% and memory utilization at 44%, though actual performance after commissioning was only 30-40%. Other components and software included:

- I/O modules upgraded in-kind with 25% spare I/O points for expansion;
- Modbus RTU communications to the DCS via Prosoft MVI56E-MCM to replace proprietary Honeywell links between the DCS and the old PLC;
- Device-level ring (DLR) Ethernet/IP communications between racks;
- Stratix 5700 switch for communicating with the HMI workstation and engineering workstation;
- HMI workstation employs Local Station SE application; and
- PlantPAx 5.0 DCS with Studio5000, V.33 and FactoryTalkView SE, V.12.

"Before shipping hardware and software, we took advantage of local distributor Gerrie Electric's value-added service of staging all the hardware at their facility in Burlington, Ontario," says Rycroft. "All firmware was loaded, software and patches were installed on the HMI and engineering workstations, and preliminary switch and network configurations were completed. Processor rack redundancy was also configured and tested. Meanwhile, the factory acceptance test (FAT) was completed at Teng's office, which includes a well-stocked automation lab for testing and training."

Programming the plant

Before migrating the BFWTP's new controls, Rycroft reports Teng performed several standard PLC and HMI upgrades. These consisted of developing the I/O database, developing and reviewing the new control narrative, developing and reviewing static graphics, and conducting more thorough redundancy testing, DLR testing, switch configuration and IP address assignments during the PLC panels and hardware FAT to speed up onsite testing.

"The original IPC-620 PLC program was separated into process areas, which is also an onsite standard, but it was still difficult to read. And, with one rung per page, it was difficult to search through," explains Rycroft. "Other PLC functions were located in separate programs, such as I/O conditioning, DCS communications, diagnostics etc. To program the new PLC, each program was divided by devices containing PlantPAx objects. Sequences were programmed using ladder to interface with PlantPAx objects. Finally, objects were built first, which was done in bulk by using the Process Library Online Configuration Tool."

Likewise, typical function block layouts were developed with a consistent look and feel, which was programmed for each function block diagram (FBD) for maintenance troubleshooting. All commands to actuate devices were located directly in FBD and commented accordingly, instead of using the old program's method of searching and cross-referencing.

"Wherever possible, all previous program functions were moved into PlantPAx objects to remove as much custom programming as we could," says Rycroft. "Complexity of sequences drove them to

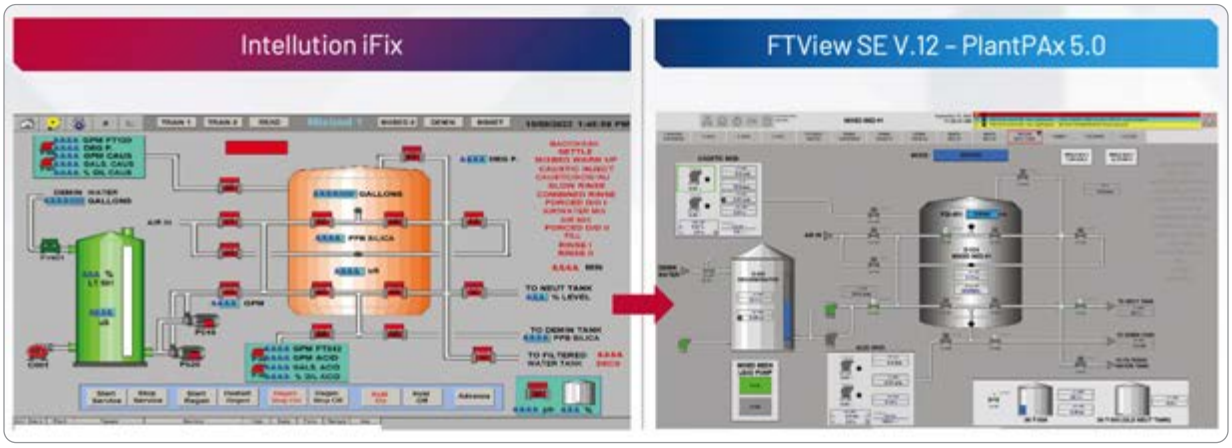

Figure 2: Based on the BFWTP's 500 I/O and required availability, Teng and the refinery implemented PlantPAx's enhanced HMI faceplates for operations and maintenance, as well as redundant 1756-L83EP controllers, upgraded I/O, Modbus RTU networking and device-level ring Ethernet/IP communications, which make it easier to find I/O, and saves 60% on troubleshooting and 20% on development and programming. Source: Teng and Rockwell Automation

be programmed separately, interfacing with PlantPAx objects where required. Each sequence was complex, and generally each interacted with at least one other sequence. We used the Process Library Online Configuration Tool during bulk development for quick modifications to parameters given the I/O points in the system."

In addition, interlocks and permissives were reprogrammed into PlantPAx objects for enhanced operator and maintenance troubleshooting. Also, local Honeywell PID controllers were migrated into the new PLC program as PlantPAx blocks. All loops were retuned by Teng to further improve control. Similarly, storing the alarm database in the PLC and automatically generating it with PlantPAx objects provided benefits, such as speeding up development by 5% and eliminating the need to synchronize and double check the PLC versus the HMI alarm database.

"Integrating local, PID controllers into the PLC gives users control capability from the HMI, and loops are automatically controlled via sequences, reducing operator time in the field," adds Rycroft. "Two loops were previously bad actors that tended to overshoot often and initiate sequence faults/shutdowns, requiring more intervention. Now that they're tied into seeing the rest of the process through the PLC, control is smoother for these loops, which reduces or eliminates sequence faults due to these controllers."

Once this programming was done, the pre-commissioning software FAT was held during two days at Teng, while operations and maintenance training was completed before and after commissioning at the refinery. "Between the BFWTP's DCS and PLC, we also completed a lot of testing because more than 600 tags had to be transferred via the Modbus RTU link for monitoring and control," adds Rycroft. "Testing was accelerated by using virtual/simulation modes of PlantPAx objects rather than manually creating simulation logic/force bits."

Commissioning and benefits

During the six-day migration, approximately 25% of the plant remained online, which required installing temporary facilities required for working seamlessly with the new PLC during the migration. "I/O wiring migrations from IPC-620 to the ControlLogix PLC required I/O power to be segregated from power for the new PLC chassis. This allowed the PLC to stay online, and let us complete any requested last-minute changes and review items with operations," says Rycroft. "We also completed I/O loop checks, which were again sped up by using PlantPAx compared to a typical system. Everything was now well organized, easily visible and manipulated from the HMI with no time wasted on searching for I/O in the old PLC program." (Figure 2)

Benefits gained by migrating the feedwater plant to PlantPAx and ControlLogix included fully supported hardware and software from Rockwell Automation with Gerrie Electric directly involved in assisting system setup and support.

"We're no longer required to obtain third-party parts for an obsolete PLC," said Rycroft. "The feedwater plant reduced the time that operations and maintenance spent on plant troubleshooting by 60% thanks to up-to-date equipment, improved controls, HMIs, alarms and diagnostics.

"We also accelerated the development and programming schedule by 20% by using PlantPAx 5.0 and associated tools, which also reduced expenses to the customer. In short, PlantPAx 5.0 played a major role in ensuring the migration stayed on schedule. Finally, this project's implementation costs were estimated to be very similar to alternatives, while providing a solution with much greater added value." ∞

Global warming and the laws of process control

How process control explains why global warming can cause cooling

This column is moderated by Béla Lipták, who is also the editor of the *Instrument Engineers' Handbook (5th Edition: https://www.isa.org/products/instrument-and-automation-engineers-handbook-proce).* If you have a question concerning measurement, control, optimization or automation, please send it to: liptakbela@aol.com. When you send a question, please include full name, affiliation and title.

Q: Can global warming cause cooling? Can using the laws of process control help to explain why global warming can cause cooling? Is the size of polar vortex events increased by global warming? Do dead times, time constants, capacitance or feedback effects play a role here?

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A: The most basic rule of process control is fully understanding the process in question. In the case of the polar vortex, we must analyze the combined effects of the Earth's rotation around a tilted axis and the albedo effect; travel of heat and the direcions of the winds on the global surface, and the Coriolis effect.

Earth's tilted axis and the albedo effect

If we look at it from the north pole, Earth rotates counter-clockwise (east to west). If it wasn't warmed by the sun, gravity would hold the atmosphere to the planet's surface and would travel with it. There would be no winds. Because the atmosphere is heated by the sun, warm water in insolated regions evaporates, which makes the air even lighter and it rises. In areas that don't receive as much solar energy, colder, heavier air moves in below the warm air and winds evolve. Wind directions vary because air moves to low-pressure areas, usually in warmer regions.

Because the Earth's axis is tilted away from the sun during the winter, the arctic receives very little sunlight that's mostly reflected into outer space by its reflective snow (left side of Figure 1). In the summer, sunlight reaches the arctic and melts most of the reflective snow (right of Figure 1), so most of its surface becomes heat-absorbing water and land (albedo effect). This is why global warming in the arctic is four times faster than the global average.

Travel of heat and wind directions

This second major process involves thermodynamic forces on the atmosphere. As the Earth rotates, warmer and lighter air rises, and heavier, colder air moves in below. The resulting wind carries heat north through three zones or cells:

1. In the tropical zone (between the Equator and 30° latitude), the tradewinds coming from the northeast dominate as they move heat towards the north.

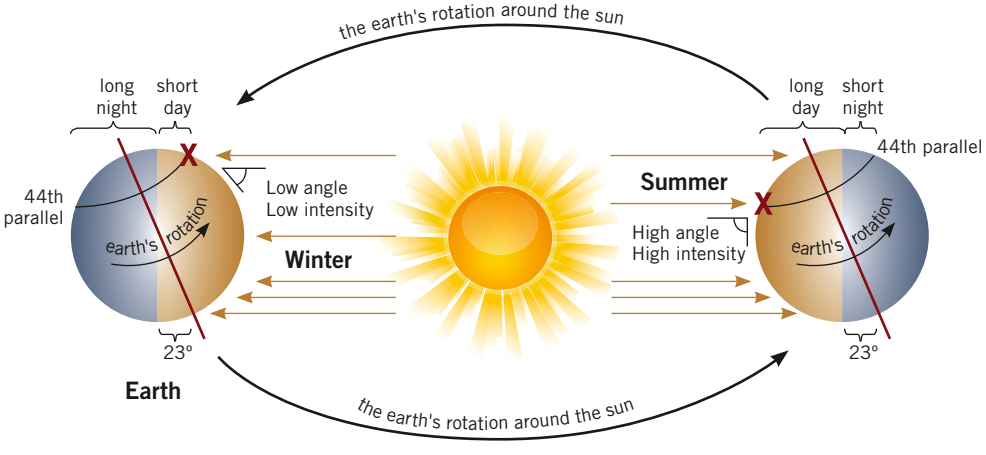

Figure 1: In the winter the Arctic not only receives less solar heat, but also reflects more of it back into space (albedo effect) as it cools and it's ice cover extends to the south.

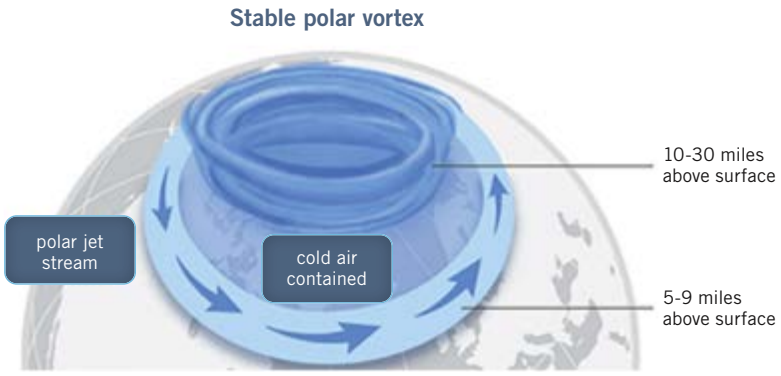

Figure 2: The lower polar vortex is stable in the summer, when the temperature difference (ΔT) between the polar and the mid-latitude zones is high.

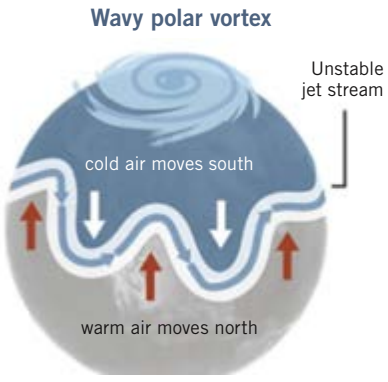

Figure 3: During the winter the polar jet stream can become unstable as the force (ΔT) that holds it to the pole weakens.

2. In the mid-altitude zone (between 30° and 60° latitudes), the dominant winds that carry the heat further north blow from the west.
3. In the polar zone (between 60° latitude and the north pole), easternly winds carry heat towards the north pole.

The Coriolis effect

If there was no Coriolis effect, air would rise at the equator, move to the north pole, and sink there. The Coriolis effect is caused by rotation and the spherical shape of Earth. This is because, as air moves towards the poles, the diameter of the globe shrinks, and therefore a point on its surface moves (rotates) slower and slower as it moves towards the poles. At the equator, a point on Earth's surface rotates at 1,000 miles per hour (1,600 kph), while points near the north or south poles rotate closer and closer to zero. Therefore, the counter-clockwise rotation of the colder air on the northern hemisphere, while moving towards the equator, also picks up speed, as if it was moving downhill. Meanwhile, the rotational speed of the warm air moving north slows down, as if it was moving uphill. As the cold air circulates faster as it moves to the south, it's deflected to the left (west). And, as the warm air above it moves to the north, its path is deflected to the right (east). This is why, in the tropical zone (also called the Headley cell between the equator and latitude 30° north), the tradewinds blow from the northeast.

Global warming and the polar vortex

Having described the three main processes that combine to form the overall weather process, we can discuss the polar vortex. The polar zone is a large, cold, low-pressure area, a wide expanse of swirling, cold air around the poles. The term "vortex" refers to the counter-clockwise flow of air that keeps the colder air close to the poles.

Actually, there are two polar vortexes. One is in the stratophere at an altitude of 10-30 miles above Earth's surface, and operates only in the winter. The second is below in the toposphere at an altitude of five to nine miles from the surface, and operates year round. This second vortex is larger in diameter and it's boundary winds are usually referred to as the "polar jet stream" (Figure 2). This jet stream is stable and strong, and in the summer, it rotates at the "polar front latitude," where the easterly polar winds meet the westerly winds in the mid-latitude zone. In the winter, this path is near the border between the U.S. and Canada.

In the winter, the ΔT that holds the cold air stream to the north pole can drop when in some areas warm and light air moves north, and the polar jet stream rotating west to east becomes blocked by it and becomes unstable (Figure 3).

Role of global warming

Global warning (GW) causes the air in some areas in the mid-latitudes to warm, which reduces the temperature difference (ΔT) that holds the polar jet (polar vortex) to the north pole. A main source of the air getting lighter in some locations is increased ocean temperature, causing increased evaporation and humidity (which is also the cause of hurricanes). Other possible causes can be wildfires sending hot air to the north. Such air movements partly block the stable flow of the polar jet and causes the cold polar air to move south. Therefore, the answer to your question (from the perspective of an average process control engineer) is that the global vortex phenomenon always existed, but GW is amplifying it. In that case, GW can cause cooling. By the way, in the coming years, we'll probably see GW also cause cooling in northwestern Europe and northeastern U.S., when the long dead-time and slow time constant oceanic process caused by the melting of the snow in Greenland starts to slow the Gulf Current, which today transports heat from the south to those areas.

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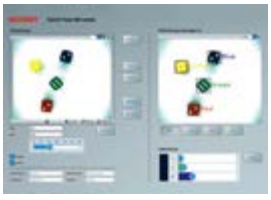

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EQUIPMENT & MATERIALS

AD INDEX

Foray into feedforward control

Many opportunities to preemptively correct for a measured disturbance exist

GREG MCMILLAN

Gregory K. McMillan captures the wisdom of talented leaders in process control, and adds his perspective based on more than 50 years of experience, cartoons by Ted Williams, and (web-only) Top 10 lists. Find more of Greg's conceptual and principle-based knowledge in his Control Talk blog. Greg welcomes comments and column suggestions at ControlTalk@endeavorb2b.com

GREG: We tend have a mindset of PID action to meet our process performance objectives. While we always need feedback control due to imperfect knowledge, the correction is inherently limited to being after the fact in terms of an error. Also, the enemy of deadtime is big time because the appearance of the error and the correction for the error is delayed. There may be many more opportunities to preemptively correct for a measured disturbance via feedforward control than we realize.

Measurements and studies often done to help operations and process engineers better understand what's happening in the process may open opportunities for feedforward control, which offers quick and inexpensive implementation that simply requires the configuring and parameterization of a feedforward controller. Matthew Howard, pulp mill area process systems manager for Sappi North America, gives two examples of fast and effective feedforward control for a paper mill that he presented at the 2022 TAPPI conference.

MATTHEW: In the first case, an SO_2 scrubber sump is used for stack gas emissions leaving a boiler. It's necessary to pump a caustic solution into the sump of the scrubber. This caustic solution neutralizes the SO_2 contained in the stack gas. A pH controller was installed in the DCS. It had pH as its controlled variable (CV) and an equal percentage valve as its manipulated variable (MV). This pH feedback control loop was highly unstable, often oscillating by more than a full pH point above and below the setpoint.

This boiler can burn natural gas as well as woody biomass with a mixture of other fuels and secondary sludge from the waste treatment plant. It was found that the process dynamics of the pH response while burning different fuels was extremely different. The production engineer noted that a caustic flowmeter was installed for accounting purposes years ago. It was also noted that an environmental department inlet SO_2 analyzer was used to measure the SO_2 lb/hr entering the stack. With that information, a stoichiometric equation had been written in the mill historian for troubleshooting purposes to predict the gallons per minute (gpm) of caustic that should be going into the sump. With these measurements installed and calculations verified, a great opportunity was being missed to improve the highly unstable pH feedback control loop.

A stoichiometric calculation of the dry caustic demand based on the inlet SO_2 flow was implemented. This signal was sent to the output of the existing pH controller as an additive feedforward (FF) signal. This controller output was then sent as a setpoint to a new inner flow control loop for the caustic. This flow loop was configured to control caustic delivery on a dry basis instead of a wet basis to minimize pH disturbances caused by caustic quality variation.

The implemented scheme reduced the pH variation by about 90% across all boiler fuels. In this case, there was no lead/lag compensation because the effect of the disturbance variable on pH arrived after the effect of the feedforward variable on pH. However, the greater delay in the disturbance path than the feedforward correction path via pH controller output was not so late to cause a problem. The feedback tuning of the pH controller was tuned with a near integrator model with a relatively slow time constant. This allowed the feedforward correction to take place as the feedback correction was just beginning.

In the second case, the concentrators are the last stage of black liquor (BL) preparation for the recovery boiler. There was a history of poor solids control affecting the recovery boiler operation. This was due to operator manual and automatic control of the BL and steam feeds to the concentrators. The operators had a rule of thumb: “10 kpph of BL and 1 kpph of steam.” It seemed okay at steady state, but the boiling point rise (BPR), a measurement that correlates to product % solids, often varied whenever the operators adjusted the concentrator throughput.

Why couldn't the concentrators be controlled to a target % solids? A scheme for BPR control was found and modified. A BPR controller was built that would supervise the steam flow to the concentrators. BL flow would be used as an FF variable. Bump tests were conducted on the BL flow and the steam flow separately. The dynamics of the BPR response were analyzed. The BPR response was much faster when the steam was changed compared to a change in BL flow. Also, the BL flow measurement is taken much further upstream. Thus, a dead time plus 1st order lead/lag compensator was installed on the FF signal.

The BPR variation was reduced dramatically after the implementation in this scheme. Stabilizing the BPR of the product liquor leaving the concentrator had many benefits, including more stable fuel quality to the recovery boiler and more stable vapor flow to the rest of the evaporator train. This stabilization of the process led to further operational improvements.

GREG: What's your summary and perspective to help motivate automation engineers to do more than replicating feedback control?

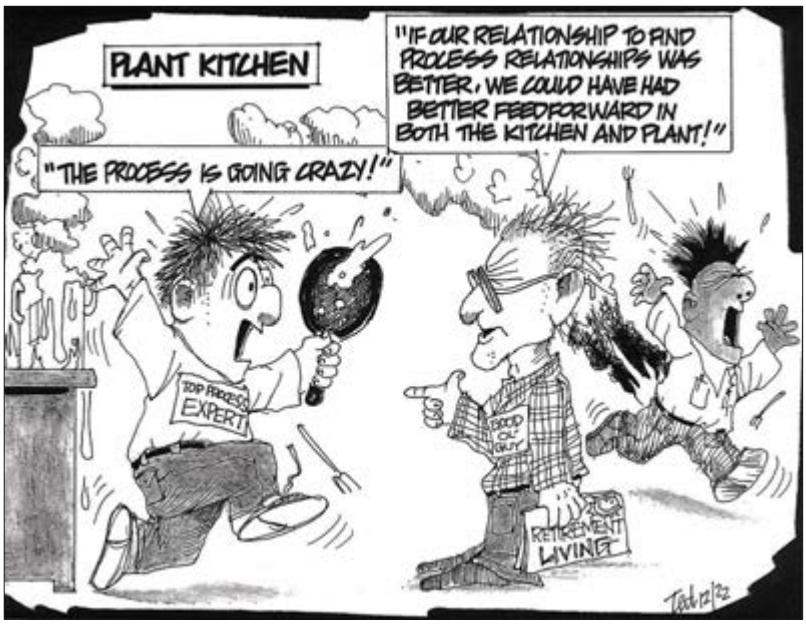
MATTHEW: I've found in the mill that there are often transmitters installed for reasons such as accounting or process monitoring that could be further used for more advanced and robust control schemes. This is especially true around heat exchangers installed for energy reduction projects. When attempting to optimize a process, the plant engineer shouldn't be afraid to look for temperature and flow transmitters that are already installed. The necessary instruments and valves may be found, already calibrated, and maintained. The above projects required no additional capital. It's not possible to implement effective feedforward controls without first being able to implement effective feedback controls. Dynamic modeling is a must for optimization. Remember, complicated schemes are not the goal. Controls that work all the time is the goal.

GREG: For much more on feedforward control, see the Mentor Q&A post started by Matthew, "What are some ways to improve and prioritize feedforward and fast feedback control?" and the Control Talk column with Peter Morgan "A straightforward explanation of feedforward."

Here's some guidance on how to make sure the feedforward doesn't do more harm than good.

First, let's consider the situations where the FF arrives way too soon, creating inverse response, or way too late, creating a second disturbance. You can prevent it from arriving too soon by simply inserting a deadtime in series with the lead/lag in the dynamic compensation of the FF. Since there's no compensation for too much deadtime like there is with a lead for a lag in the FF, the best thing you can do is, if possible, start the FF before a setpoint is changed that creates the disturbance. In other words, when the culprit setpoint change is requested, the FF starts and the actual culprit setpoint change is delayed, so that FF isn't too late.

Second, let's see what we can do if an unmeasured disturbance is driving the PV in the same direction that the FF would do in its response to the measured disturbance. We can compute the current rate of change of the PV and the rate of change of the PV requested by the FF. The feedforward gain is multiplied by the fraction that's the expected PV rate of change from FF minus the current PV rate of change divided by the expected PV rate of change from FF. A future-value block can be used to quickly compute with good signal to noise ratio the current rate of change observed and the expected PV rate of change from FF by a dynamic model of FF effect on PV developed from tests for dynamic compensation of the FF. ∞



See the online version for more general guidance on feedforward implementation and the Top 10 signs feedforward is too little or too late."

Willing to bug

Fresh details and innovations are out there. We just have to ask—and likely ask again

JIM MONTAGUE
Executive Editor
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"Doing the dishes or other chores, or writing a police blotter, products section or magazine story may not be as fancy as the Japanese tea ceremony. However, I've been told that any activity can be a form of meditation."

MORE than 40 years ago, I attended a college lecture by the editor of a big-time, mainstream magazine. I think it was Seventeen, and I remember she advised against covering any beat for more than two years. I didn't know what she meant until I started attending and writing about heritage days or whatever other local festivals for several years in a row.

As you might guess, the prospect of covering more of the same for years into the future could be more than a little frightening. And later, it was beyond scary to realize that switching beats was no solution because most local events and issues are basically the same. I'm sure it's the main reason most reporters are young and most editors are old.

Likewise, I once asked a veteran French teacher how he could stand going over the same material year after year? He said it was the students and their responses that were always different, and kept his curriculum new and interesting. Later, I interviewed a high school principal, who looked like he was in his mid-40s, but turned out to be in his late 70s. He too said it was the kids who kept him young. This is no doubt the same as holidays and other wonders that are best experienced by young eyes or at least as nearby parents or grandparents.

Consequently, when I'm faced with another year of covering Control's mostly identical editorial topics, it's very useful to recall these and many other predecessors. Granted, I'm researching and reporting on sustainability, edge computing, Industrial Internet of Things (IIoT), data analytics, cybersecurity and wireless yet again. However, I'm always reminded that most of the people I interview and their responses and innovations are new and different as these overall topics evolve.

I know I'm just a conduit for whatever readers want to know about what's going on in their geographic backyards or professional communities. I merely enable the essential discussions and information exchange that needs to happen between my sources and their readers. Everyone wants to know whose bike got stolen, what their neighbor's house sold for, how to setup a wireless network, or how to achieve and maintain cybersecurity. Their interest and collective focus is what keeps everything fresh.

So how can we breathe new life into old topics and other projects? Well, the first task is finding and talking to as many new sources as possible. Long-established experts have useful know-how, but it's the newer players that have the hunger and incentive to innovate.

Either way, it can be daunting to talk to new people. I remember having a terrible crisis of confidence before my first person-on-the-street interview in the about 1985 outside a supermarket in a small town. Who was I to pester anyone with silly questions? But the job had to get done, so I did it. Even after more than 10,000 interviews since then, I still get that guilty twinge about bugging people. However, as always, the job still has to get done.

The good news is, after the first dozen or more people refuse to be interviewed, their reluctance is more than made up for by the few individuals who are open, willing to talk, and almost always provide useful input. It never fails and it's always a good investment. Whether we're fishing or researching a topic, we just have to patient and cast a wide net.

Secondly, seeking useful details and serving as the information exchange for any community becomes routine over time, and can take on a ritual quality. Doing the dishes or other chores, or writing a police blotter, products section or magazine story may not be as fancy as the Japanese tea ceremony. However, I've been told that any activity can be a form of meditation.

The other good news is that seeking useful details eventually reveals deeper layers in topics we thought were familiar and pretty much exhausted. Just like a good interview, some unanticipated innovation or other surprise will show up when we least expect it. All that's required is just a teaspoon of desire and bravery to go look for it. ∞

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