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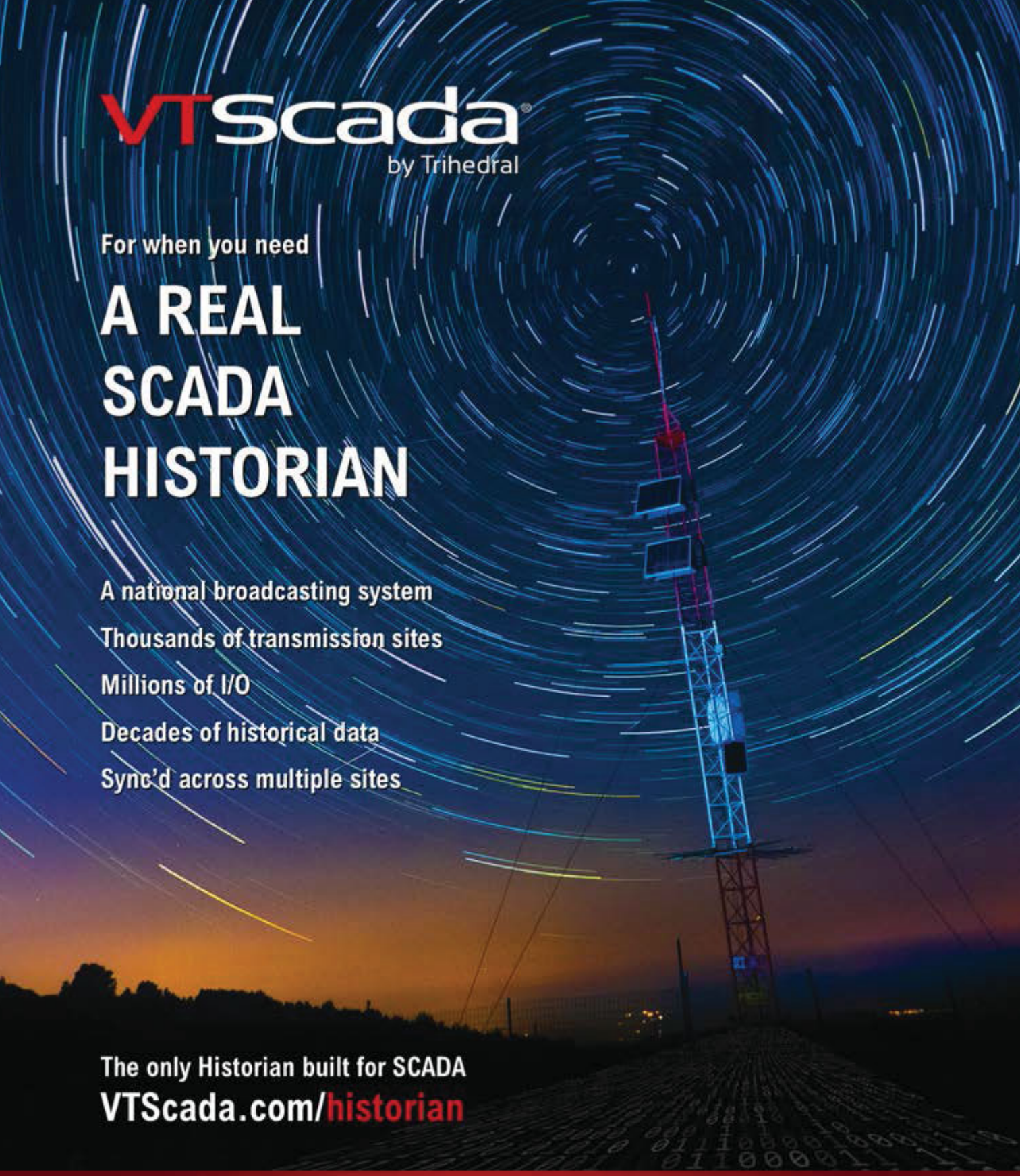

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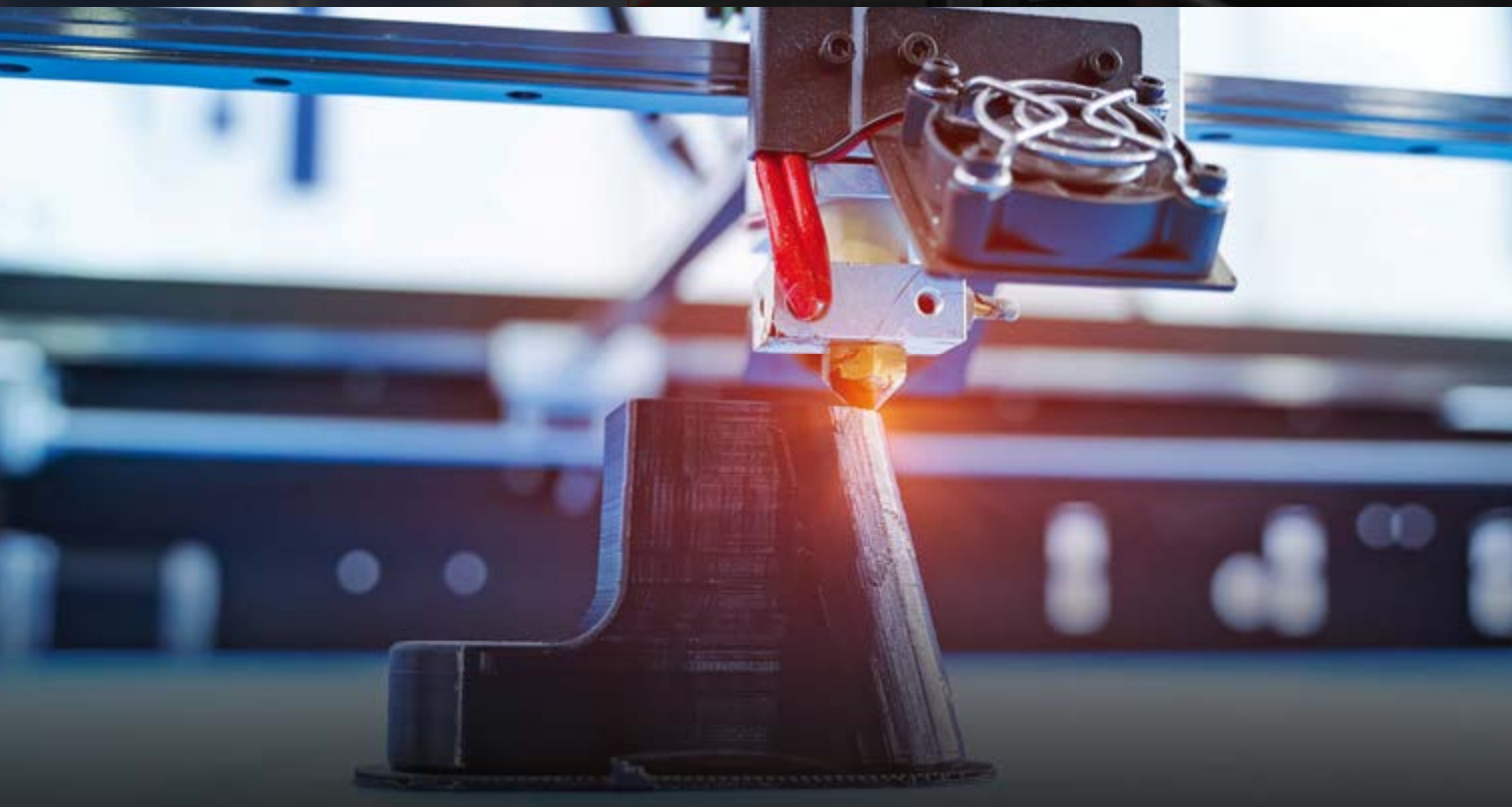

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Control® is published 10 times by Endeavor Business Media, LLC. 1233 Janesville Ave., Fort Atkinson, WI 53538. POSTMASTER: Send address changes to: Control, PO Box 3257, Northbrook, IL 60065-3257. SUBSCRIPTIONS: Publisher reserves the right to reject non-qualified subscriptions. Subscription prices: U.S. $120 per year; Canada/Mexico $250 per year; All other countries $ 250 per year. All subscriptions payable in U.S. funds.

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In pursuit of leadership

There aren't born leaders, only lifelong learners

A funny thing about leadership: when the worst of times are upon us, the best leaders tend to shine brightest. While I wouldn't label these days as the worst business environment we've ever seen—far from it—the post-pandemic processing industries certainly face their share of turbulence ahead. Those challenges come in the form of tighter standards and expectations for sustainability, workforce shortages and supply disruptions, to name a few.

The motivation to do great things is alive and well as we hear enthusiastic plans and new innovations to address each of those challenges. However, without great leadership, motivated executives, investors and workers—as well as their best laid plans—tend to become a mass of malaise with no real progress in sight.

Leading through turbulent times takes experience and practice. That was the theme of the recent Measurement, Control and Automation Association's (MCAA) recent Industry Forum in Arlington, Texas. Shane Filer, general manager, Neal Systems Inc., and an MCAA board member, opened the multiday gathering by saying, "There's something different when leaders come together. Leadership asks things in a different way." And many of the industry's leaders were interested in picking the brains of their peers, as more than 300 attendees, including representatives from 137 member companies, made this year's gathering the group's largest event ever.

While there, they heard from Capt. Mike Abrashoff, former commander of the *USS Benfold*—once considered one of the worst run ships in the U.S. Navy before he famously turned it into one the best. Abrashoff made some important points about what it takes to be a great leader, the first being that no one is a born leader, and it takes a lifelong pursuit to be good at it. This is exactly why the heads of so many measurement and control companies came to Texas—to find out what it takes to be and to produce quality leaders.

They will need those leaders as economic turbulence will hang around for a bit longer. Alan Beaulieu president and principal, ITR Economics, said during the conference's final presentation, the U.S. economy will still be slowing as we go through the remainder of this year until the end of 2024. However, he points out, the GDP will increase—a sign of a healthy economy— before taking two separate dips from that growth. He added that while the press will howl during a presidential election year about recession, it's nothing good leadership can't handle to get companies through the muck.

Now, aren't you glad you kept up your pursuit of becoming a productive leader? ∞

LEN VERMILLION
Editor-in-Chief
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"Without great leadership, motivated executives, investors, and workers—as well as their best laid plans—tend to become a mass of malaise with no real progress in sight."

Powering up lithium-ion battery production

by Len Vermillion

WHILE the automotive industry has taken the first steps in establishing lithium-ion battery manufacturing in North America, a new venture is coming online in Arizona, and it's one of the first independently operated cell manufacturing facilities in the U.S. Called KorePlex, the gigafactory developed by Kore Power, a developer of lithium-ion battery cells and modules for the e-mobility and energy storage sectors, is getting an efficiency and production assist from Honeywell's end-to-end, integrated Battery Manufacturing Excellence Platform (MXP).

KorePlex is set to open in Maricopa County, Ariz.

The facility promises to apply robust automation and digital technology to battery manufacturing, which has been largely manual. The new facility isn't tied to a joint venture and will manufacture cells for customers in several industries. "I think that's the big difference, and that's going to, hopefully, give them the competitive advantage to be successful in the market," says Frederick Westerberg, vertical customer marketing director at Honeywell.

According to a National Renewable Energy Lab (NREL) report, traditional lithium-ion cell manufacturing has many inefficient, manual operations, leading facilities to commonly operate at a 70% production yield at steady-state. "KorePlex will be a new state-of-the-art, lithium-ion battery facility, that uses end-to-end connectivity, digitizing the entire process for a more sustainable and novel approach to cell production," adds Alec Falzone, lithium-ion battery initiative leader at Honeywell.

KorePlex will be the first fully digitized and integrated lithium-ion cell manufacturing facility using MXP. With continuous closed-loop control, Honeywell's Battery MXP will enable Kore Power to visualize and control its entire lithium-ion battery production process in real-time, from mixing, coating and assembly to its formation-finishing area. This centralized approach will allow Kore Power to reach target capacity faster, while improving production yields and improving safety.

Meanwhile, the digital Honeywell MXP platform lets users scale their enterprise and achieve operations with superior yields starting from the first day of operations. Coupled with production optimization and improved efficiencies, the technology can reduce energy consumption. Also, the platform provides online quality management with complete production traceability/genealogy of the cells produced.

Efficiency is vital in cell production because battery cost is often the main driver of high prices for products utilizing lithium-ion. For example, electric vehicles are expensive because their batteries are expensive. The first step to solving that market conundrum is to reduce production costs, according to Westerberg.

"We're dealing with lithium, nickel, cobalt, different oxides of metals, oils. You can't scrap these things easily. They're extremely expensive," he says. "Getting efficiencies up is extremely important to reduce production costs to the point where EVs and energy storage are more affordable."

That's especially true as the competition heats up. KorePlex may be one of the first to come online, but there's a laundry list of others soon to follow. All the new gigafactories will be competing for those expensive materials. "It's critical to use what [materials] you have efficiently, so using this new state-of-the-art automation and connectivity, these companies are going to be ahead of the game," Falzone says.

They'll also be ahead of the game when it comes to sustainability. "Sustainability and efficiency, these things go hand-in-hand. You can't have one without the other," Westerberg says.

An operation can't be sustainable without high yields and high throughput. So, addressing the efficiency of the operation by integrating individual machines into a holistic system, and then optimizing the operation is the one major area of sustainability that MXP can impact, according to Westerberg.

Falzone adds traceability and genealogy insights can pinpoint where something occurred. "So instead of shipping a million cells to your recycling partner, which have to be shipped to the recycling facility because it's not on the same site, you would ship a fraction of that," he says. "The visibility into the process piece by piece gives you that insight to make intelligent decisions." ∞

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The principles of success

Dr. Klaus Endress has seen his family's company grow by leaps and bounds, and he's excited for the future

For Dr. Klaus Endress, leading Endress+Hauser after taking over from his father Dr. Georg H. Endress, who founded the company in 1953 with Ludwig Hauser, is a great honor and a great responsibility. On the Group's 70th Anniversary and as he prepares to move on from heading the Supervisory Board, the man who served 45 years with the company discusses his father's legacy, the Group's success and its future.

Q: What did it mean for you to take over responsibility for the Endress+Hauser Group from your father and continue his work?

A: Please allow me to elaborate a bit on this answer, for I assumed responsibility much earlier. My father asked me when I was 16 years old if I would like to become his successor. I said, "Yes." But, of course, this was associated with many expectations.

I finished high school in Switzerland, studied industrial engineering at the Technical University in Berlin, then went to the U.S. for two-and-a-half years for my first professional experience. Back in Europe, I worked my way up at Endress+Hauser: starting in industrial engineering, then in sales in Frankfurt, head of controlling and finally managing director of our German subsidiary based in Maulburg, Germany, which, at the time, was a combined sales and production company. In 1992, I took over responsibility for production at the corporate level, and in 1995 I became CEO of the Endress+Hauser Group. So, when I was finally entrusted with the company, I already had quite a bit of experience under my belt.

The Group had a turnover of around 420 million euros with some 4,300 employees and a sufficient result. Becoming CEO of such a company was a great honor and an equally great responsibility. Of course, I didn't want to disappoint my father, but to continue developing his life's work. He was the pioneer who founded the company together with Ludwig Hauser. He created something out of nothing—and I set out to make something even more beautiful out of it! I could never have done what my father did because I was not and am not a pioneer. But vice versa, he would never have been able to do what I achieved. So, it was a timely handover, just as the handover 19 years later to my successor, Matthias Altendorf.

The cooperation between Matthias and myself as Supervisory Board president further boosted the company over the past 10 years. Every successor stands on the shoulders of their predecessors. I think my father and Mr. Hauser, who also dedicated almost 20 years to the company, would both be extremely proud to see Endress+Hauser today. We have a shareholder family of more than 75 members and a family charter with established institutions that keep the family close and connected. We meet six times a year in larger groups to cultivate our commonalities and strengthen our collaboration. We live up to our common rules and values. That's the whole secret. Of course, it's a lot of work, but it's also a pleasure to see it work!

The Endress family continues to grow.

Q: Endress+Hauser has continued to thrive, even after 70 years. What do you think was crucial for this success—and what is needed to succeed in the future?

A: When I started as the Group's CEO in 1995, I asked myself where I could get inspiration, what was right and what would remain right over time, and who could support me in my deliberations and decisions. My father was no longer available. Of course, there are many books, consultants, even real gurus in this field. But I found inspiration in nature. Living nature has evolved very successfully over more than three billion years; its sustainable principles are my model for entrepreneurial action.

I like to compare our company to a tree: the crown with its leaves stands for sales as the surface to the market and customers, the roots for anchoring production and development in technology and the procurement markets. Lean but sustainable structures connect these two surfaces.

In the company, these are the innovation and logistics processes and supporting functions such as finance and controlling, human resources, IT, legal or communications. A large tree has taken many years to grow. It evolved every day, and no part has been neglected. This is perhaps the most important insight: for the company to thrive, you must develop all its parts. That's what we've always done at Endress+Hauser.

We have enlarged our interface with the market and customers worldwide, opened new regions and industries for sales, expanded our portfolio, built global production capacity, and strengthened our innovative powers. And we have developed efficient management and support structures for the Group. Even in the past few years, which were marked by a lot of uncertainty, first with the pandemic and with the war in Europe, Endress+Hauser was always able to deliver. So, as we go into the future, we can build on many things we have done well in the past. As long as we maintain our focus on the market and customers and keep improving, we won't run out of work even one hundred years from now!

Q: What is your fondest memory growing up with your father being the organization's founder?

A. My father was quite strict; performance was important to him. But he always supported us eight children in our development. He attached great importance to a good education. He made many things possible for us, even when money was tight in the family. He always said, "Your education is the only thing no one can take away from you!"

Reflecting change

Endress+Hauser's logo design has evolved to include new colors and symbols of the growing business.

1953 1980 1987 1995 2004 2012

Q: Is there a company milestone you remember your father being very excited about?
A: As the company's founder, sales milestones were always important. In my father's eyes, they were proof that he had achieved something, a sign of success. So, he was very pleased when Endress+Hauser exceeded the one billion euros threshold in the year before his death.

Q: What do you think your father and Mr. Hauser would say to you today about the company?
A: I am sure they would be extremely proud of what their company has become and what we, their successors, have made of it. I think they would say, "Well done!"

Q: What are the most important values and skills your father had that you've .continued to carry on through his legacy?
A: Many of his thoughts and values are still very much alive in our family and the company. One of his favorite phrases was, "We serve our customers and learn from them." So, not to look at what's in it for you, but what you can do by putting customers first. This keen focus is paramount to our success. Customers are any company's driving force. Without ours, we wouldn't be where we are today. Because of our customers, we can thrive.

Q: The Group announced a generational change. As you prepare to move on from your current role as President of the Supervisory Board, what does the next chapter of your life hold?
A: From next year on, I will no longer have an active role in the company after almost 45 years of working for Endress+Hauser. But I remain chairman of the Family Council, in some sense, the CEO of the shareholder family. The Family Council is the most essential link between the family and the company. Its task is to decide on important issues in the relationship between the family and the company, to accompany members in their careers, and to inspire the younger generation. Only if the family functions well can the company also function well.

Additionally, I'm an enthusiastic horseman. I have kept horses for decades, but for a long time, I didn't have much time for this hobby. Now, I ride almost every day. Since I was 19, we have had dogs. I'm often out and about with our family dog, Maya, biking in nature. That is quality of life for me. Finally, I look forward to spending more time with my wife and grown children.

Q: What advice do you share with your children, grandchildren, nephews and nieces—the next generation of family members—coming up in the company?
A: The same I tell all young people: use the opportunities you have for a good education, gain experience, go out into the world at a young age and acquire all the skills you need to realize your goals and dreams. You must always support young people in their development.

You must give them wings and not tell them where to fly. They must figure out for themselves where to go. We can only keep the doors open for them; they need to enter them on their own. And we also must remember that our family's younger generation is essential not only when working at Endress+Hauser, but also as responsible company shareholders.


Georg H. Endress with son, Klaus Endress

Conquering the digital frontier

Digitalization and IIoT have opened a new world of efficiency and safety

The world continues to become more digitalized to such an extent that companies globally categorize it as essential rather than optional. That includes process automation industry experts, Endress+Hauser.

There are two main reasons for the push toward digitalization in the industrial sector: customer expectations and market forces. Endress+Hauser has not only taken notice of its customers' digitalization needs and expectations, but also set forth on its own transformation.

The company's digitalization journey began quite some time ago, mainly when the benefits of digitalization started to become very apparent not only in how the company's products sent their variables and information to control and host systems, but also within its own ERP, CRM and service management systems. The journey's results have helped make the company's focus on end-to-end service and solutions even more possible.

"It has provided us a means to digitally connect our products to customers in a way that we never could before," says Jason Pennington, director of digital solutions for Endress+Hauser.

Successful digital transformation

These days, instruments can create help desk tickets on their own. In addition, the devices can produce alarms and recommend possible remedies. They provide a secure means from a remote desktop into a device to help solve a customer's challenge before they might even know they have one. These are just a few examples of the capability digitalization has brought to the table, according to Pennington.

As digitalization has flourished and the Industrial Internet of Things (IIoT) has emerged, three core areas of process control have seen the most changes. The first and most apparent involves what one can see and feel: miniaturization, power consumption, connectivity, HMIs and how people interact with devices.

ASICs were infused with microprocessors and pressure-to-current transducers became microprocessors and current-to-pressure transducers became 4-20mA transmitters. Meanwhile, a myriad of field buses emerged. Pennington says it's been a pursuit to simplify, if not eliminate, wiring.

"So, combined with the idea of what more powerful microprocessors can support, our devices have evolved into process analysis tools for our customers that also happen to measure process variables," he points out.

He adds that the evolution of multivariable measurement and bringing more quality aspects and diagnostics, in addition to the overall core measurement, have impacted the industrial sector.

Additionally, changes in the supply chain, particularly regarding sourcing "greener" and safer materials, whether for consumption or the good of the environment, have been just as impactful. For example, Endress+Hauser vetted its suppliers to be more inclusive, reputable and sustainable. As a result, it's become part of the overall product picture. Another change is the growing importance of cybersecurity.

"It's a very real thing for us today that maybe 25 years ago didn't exist," Pennington says of the importance of cybersecurity in an increasingly digital world.

Cybersecurity is part of how instruments and systems are now designed and built.

"It's about digging down into the components as they become more connected in the world today," he adds.

Journey and breakthroughs

One of the significant milestones in Endress+Hauser's digital journey happened when the company connected its internal processes and production systems to benefit its customers.

One of the significant milestones in Endress+Hauser's digital journey happened when the company connected its internal processes and production systems to benefit its customers.

Throughout every production step, from the time a piece arrives on the Greenwood campus, it's scanned and logged. "We know who touched it, where it came from, how it got here and if it's authentic."

A QR code on each prouct helps digitize processes, allowing data-minded customers to get all the necessary information to check on reliability, build a Pareto analysis, or track alarm trends over time. Those are only some of the capabilities available to customers.

The process also guards against counterfeit parts.

There have been other breakthroughs in the digitalization journey for Endress+Hauser. Pennington points to flow as an area that has seen a digital evolution of products.

Over time, flow devices became more advanced on the power management front. In addition, the evolution of Safety by Design meant devices provided a safer environment, both electrically in hazardous areas and their operations.

In addition, printed circuit boards have allowed for the creation of traceable and highly reliable diagnostics.

End-user expectations

Manufacturers and representatives have an opportunity now with tools such as Heartbeat Technology® as well as other remote diagnostics, to support their end-users through the product lifecycle. Such support on an ongoing basis is another frontier in digitalization: moving from being connected to using connectivity to solve challenges or to advance business objectives.

"Sourcing data through this connectivity is the easy part. It's how you do it and more importantly, what you do with it that matters," Pennington says.

He points out that staying ahead of the evolution comes from dialog with customers. It helps create a broader enterprise view of some of the products. In fact, Endress+Hauser has been able to use Heartbeat Technology and Netilion Connect, an API platform, to provide customers the capability to create a calendar in their system and the devices know if they're safety-important, safety-critical, fiscally-critical or regulatory. For devices that are not on the calendar within the customer system, they can have Netilion run Heartbeat verifications on the devices. When they pass verification, they're able to produce a certificate with that ISO stamp and close the work order. Connected devices can have Netilion run Heartbeat verifications either by calendar scheduling or on-demand. This process delivers insightful information to the user but can also be automated to effectively perform its own maintenance and work order management. The ISO recognized verification results are stored within the Netilion Library and presented to the user.

The process lets customers autonomously maintain their systems, and if there's a failure in the functionality of the verification, Endress+Hauser can provide diagnostics, remedies and even the spare parts information. Pennington says such systems represent the devices' "connected spirit."

Endress+Hauser and the entire industrial sector are continuing the digitalization journey. The more digitized the industry becomes, safely integrating data can help create more reliable, safe and efficient systems and processes. ■

Cultivating tomorrow's workforce

From a Design and Innovation Studio to internships, building the next generation of process control engineers

As future generations of engineers enter the workforce, they're discovering opportunities in the industrial sector, even if they hadn't previously known what all it has to offer. Thanks to efforts to increase awareness of science, technology, engineering and math (STEM) opportunities at many schools and universities, more students are learning about careers in the industrial sector. Moreover, those efforts are strengthened by the efforts within the industry itself, where budding engineers are learning even more about the alluring opportunities in process control and automation.

Many aspiring engineers know about fields such as construction, welding, machining and other areas of need that we often hear about. Many aren't thinking or know about what can be done with process control. Consequently, the lack of exposure to process control contributes to the growing need to cultivate future talent, according to Nicole Otte, director of workforce development for Endress+Hauser USA in Greenwood, Ind.

Otte, along with Devina Fernandez, workforce development specialist in the company's Houston, Texas, location, spearhead the company's efforts to make the up-and-coming generations of workers aware of all that process control careers have to offer.

"Process control is at the foundation of every product we use, everything that we encounter daily," Otte explains. "I was just speaking to a group of middle schoolers and telling them that our instrumentation is what is being used so they can safely consume the food and beverages they like to eat and drink. They were really excited about it."

Endress+Hauser has built a full continuum of workforce development programs to reach students from kindergarten to college. In addition, the programs reach beyond schools to non-traditional paths such as military personnel re-entering the workforce or career adults simply looking for a change.

Building awareness

One of the most significant initiatives of the past year has been the development of the Design and Innovation Studio in Greenwood, which extended its programs to younger minds.

Their experience is more than simple show-and-tell. The students actively engage with instrumentation and other tasks usually done by engineers for the company. They work with robotics and coding, and activities are usually done in the context of fun. For example, they'll engage in a PTU® (Process Training Unit) scavenger hunt, 3D printing, or assembling a building blocks Coriolis flowmeter.

"There are lots of fun, engaging ways that they can learn about STEM and our industry," Otte says.

The studio is a collaborative effort between Endress+Hauser and Purdue University's Indiana Manufacturing Competitiveness Center (IN-MaC). Purdue established a series of Design and Innovation Studios through grant funding at several schools and three at other manufacturers in Indiana, but those three were automotive. Endress+Hauser inquired about establishing a studio for a different manufacturing and STEM-focused strand and was awarded a grant.

From these schools, eight are local school districts in the Southern Marion and Johnson County area from rural Indian Creek to suburban Greenwood, including the most urban and diverse school in the area.

The company also hosts classroom visits, organizes advisory boards for high school teachers and high school interns, and offers job shadowing. Meanwhile, they are engaging colleges where Endress+Hauser executives and personnel help with senior capstone designs and serve on advisory boards.

"Sometimes you get a request for 450 students, so we try to design an experience that breaks them down into smaller groups so they can see the PTU, and they can

see the space here and go into the other areas, to be exposed to multiple STEM activities," Otte says.

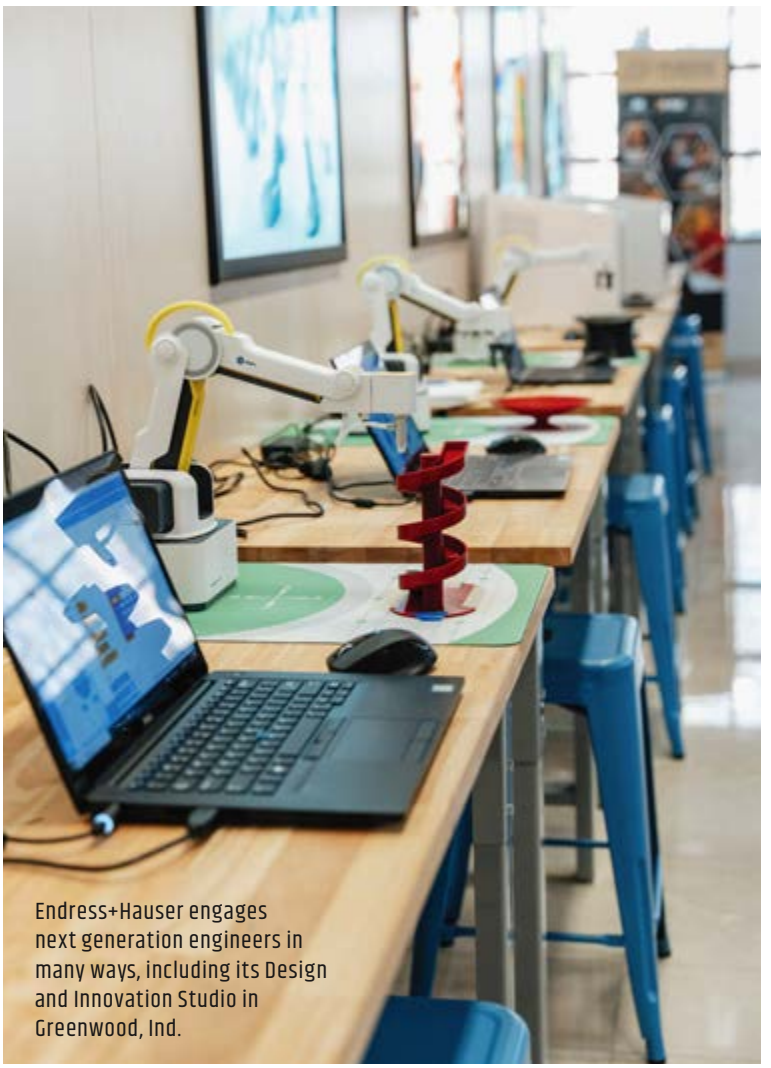
Meaningful experience

Another one of the company's exciting workforce development initiatives is the evolution of its college and high school internship programs.

Endress+Hauser has a 20-year history of internships. The program has interns from engineering to the business side and covers the full spectrum of all the different areas in the company, according to Fernandez.

Fernandez says Endress+Hauser is building a very robust learning experience for its interns, intending to build a future workforce.

"We look at how rigorous the projects are and the skills the interns should expect to have at the end of the summer," she adds.



Endress+Hauser engages next generation engineers in many ways, including its Design and Innovation Studio in Greenwood, Ind.

The company's internship program focuses on meaningful experiences that ultimately helps build its talent pipeline. The goal is for interns to move toward working in the process control industry, with the company, its representative partners or customers.

"We had two interns who interned with us twice, one of which had an international internship in Spain," Otte said. "The other one interned after his freshman year, and then did a co-op with us during his junior and senior years. They're both coming back as full-time employees into the rotational program in June. Very, very powerful."

Some of those interns get an early start as seniors in high school. The new program sees high school students spend about 10-15 hours a week with the company.

Fernandez also mentioned the company's Community Career+Education Forum where students, parents, educators and manufacturing professionals gather to learn about STEM and career opportunities in advanced manufacturing today.

This event takes place in both Greenwood and Houston with plans for several of Endress+Hauser's local representative partners committing to host their own event.

Today, there are a variety of opportunities for each member of the education and workforce ecosystem to get involved. Cultivating the workforce of tomorrow starts with inspiring and educating the youth of today. With its various programs and on-site opportunities, at Endress+Hauser, the future is now.

THROUGH THE YEARS

With funding of 2,000 Deutsche Marks, 'L Hauser KG' was established in 1953. The company's name came from Ludwig Hauser's wife, Luise.

Endress+Hauser USA relocates from Beverly, Mass., to Greenwood, Ind. Seven acres of land were purchased from a local farmer and a 5,000 sq.-ft. facility is built with 11 employees and sales reach $490,000. Twenty-three years later, in 1997, the company invests in an expansion of the Greenwood campus, building a 60,000 sq.-ft. sales center for the growing team.

In 1961, Endress+Hauser moves to a new, modern site in Maulburg, Germany.

Endress+Hauser launches Liquiphant, its first level switch for vibronic point level detection. Today, the Liquiphant product line measures reliably and is not affected by changing media properties, flow, turbulences, gas bubbles, foam, vibrations or build-up. The device is easy to use, has a digital connection and gives real-time data at hand.

1953 | 1955 | 1961 | 1971 | 1974 | 1977 | 1983

The early years for Georg H. Endress (right) and Ludwig Hauser (left) were pivotal. Georg H. Endress files his first patent at the Swiss Federal Office for Intellectual Property in 1955. Innovation is a cornerstone of Endress+Hauser's success and continues to fuel the spirit of growth and creativity. Today, the company has a total of 8,900 active patent and patent applications.

Ludwig Hauser retires. Production starts in the U.S. in the same year.

Endress+Hauser starts to produce flowmeters with just three employees in a former military barracks in Reinach, Switzerland (Basel-Landschaft). Further acquisitions add liquid analysis, temperature measurement technology, pressure measurement technology and system products to the portfolio in the following years.

Endress+Hauser releases its new generation of Coriolis and Electromagnetic flowmeters, Proline 300/500. The launch of the new generation continues its legacy of exceptional measurement quality and unmatched accuracy of mass flow, volume flow and density.

In 2021, Endress+Hauser launched a new generation of liquid analysis sensors. Memosens 2.0 digital technology provides simple, safe, and connected liquid analysis.

Production expands in Greenwood with a 95,000 sq.-ft. flow manufacturing facility. In 2013, an additional 83,500 sq. ft. is added to the facility. The expansion of production allowed for more technologies to be produced in the U.S., including thermal mass flow.

Endress+Hauser releases the first self-calibrating thermometer, the iTHERM TrustSens®. The iTHERM TrustSens stands out from other thermometers with fully automated inline self-calibration. This results in high product safety and increased plant availability.

In 2021 Endress+Hauser introduced the new generation of the Deltabar. The Deltabar PMD78B differential pressure transmitter minimizes ambient and process temperature effects on measurement thanks to the TempC membrane.

1984 2006 2013 2017 2019 2021 2023

Endress+Hauser USA acquires early expertise in calibration. Calibration ensures that instrument measurement is accurate and within the limits required to produce a quality product. Today, Endress+Hauser helps customers stay in compliance while reducing their costs and increasing process up-time.

Endress+Hauser strengthens its analysis portfolio. The Group acquires Analytik Jena, which opens the door for laboratory business. Investments in optical analysis technologies, including TDLAS and Raman spectroscopy, strengthen Endress+Hauser's advanced analytical portfolio and underscore the strategic goal of supporting the customer from laboratory to process.

In 2023—and 70 years later—Endress+Hauser continues to march forward as the People for Process Automation. The company celebrated the seven-decade milestone at each location across the globe in February 2023.

While a groundbreaking ceremony was held in 2019 for the Houston campus, doors opened with a ceremonial ribbon cutting in 2021. The $38.5 million LEED-certified facility houses a state-of-the-art PTU® Process Training Unit, an office space for the Endress+Hauser team, an office space and warehouse for Vector Controls and Automation Group, and an office space and lab for Analytik Jena.

Writing a North American success story

From humble beginnings Endress+Hauser USA grows with the help of its customers and partners

Seventy years ago, the ideas and strategies developed in a small, private apartment in Lörrach, Germany, set the building blocks of an eventual multibillion-dollar company. Swiss engineer Dr. Georg H. Endress, only 29 years old then, and German bank manager Ludwig Hauser, 58, launched the company on the back of 2,000 Deutschemarks and a knack for electronic level measurement technology.

Endress's instrumentation expertise and Hauser's business savviness proved to be the perfect match. For 40 years, Endress led the company across new markets and fields of application. After Endress's tenure, his son, Dr. Klaus Endress, led the company along with strong involvement from the Endress family. In 2014, Matthias Altendorf would fill those shoes.

Today, Endress+Hauser employs 16,000 and generates more than $3.6 billion in yearly sales. The company now owns sales centers in more than 50 countries and production centers on four continents.

In 1970, as Endress+Hauser continued its growth as a global player, the company started its US operations. This move has proven to be a vital part of the organization's overall success.

One important philosophy of the company is to manufacture for each region of the world in the region. And, this is true for the North American region and the US specifically. Because of that, 85%-90% of everything the company sells to its US customers is built in the US. It's an important piece of the value we offer our customers in the US, according to Todd Lucey, general manager of Endress+Hauser USA.

Enduring partnerships

As the US business continues to grow—it currently stands at more than $600 million in revenue—company executives such as Lucey are quick to credit the enduring relationships they've established with customers and representative partners as the keys to the evolution of the business. "The company has evolved over the years to meet the ever-changing needs of its customers which has included more and new services and solutions based on and customized to our customers' specific needs for their own growth and success. That is especially true as many companies are experiencing challenges to keep the same numbers of people and thus the capabilities of subject matter experts at the plant level. Moreover, those pressures continue to mount as more workers retire and new generations opt for other industries.

"Experts [at the plant] are harder to find," Lucey says. And that's where Endress+Hauser can be of service to its customers.

As a family-owned group, Endress+Hauser has always focused on people and maintaining and building relationships with its customers over its 70 years of existence. While that's not always easy, considering the ups and downs of the market and the occasional super-disrupter such as the pandemic, the ability to continue investing even during difficult situations has been an advantage. More importantly, having stable, family-owned leadership has helped keep the focus on people, especially the workforce and Endress+Hauser's domain expertise. Lucey says not having to reduce the workforce under challenging times has prepared the Group to offer its customers added value support with specific applications, instrumentation, services and solutions and retain knowledgeable talent in the organization.

That includes recent endeavors into becoming what the company terms "a main instrument vendor" (MIV). The project-oriented concept focuses on services from front-end engineering design to procurement, warehousing, receipt verification, startup and commissioning. Lucey says the company has done "more than 20 MIV contracts with customers in recent years."

Endress+Hauser USA's customer center in Greenwood, Ind.

Regional relationships

Endress+Hauser USA works completely with representatives as its sales channel and has continued to refine its partnerships with its representatives over the past two decades. The critical part of success in this model is finding representative organizations with leadership and ownership that have the same culture as Endress+Hauser. That culture includes reinvestment into the business, growing the business, and willingness, for example, to take a 25-person representative organization and grow it to 100 people. According to Lucey, those are the types of commitments that Endress+Hauser USA has from all its representatives.

"We see them just as Endress+Hauser and they see themselves as Endress+Hauser," Lucey says. "I always tell people that a typical representative-principal relationship has a lot of dynamics to it. We have different dynamics in the model that we've chosen with our representatives, but the resolution to the dynamics is that we're all one team, and one team is strong enough to withstand individual dynamics that you might have with one representative versus another.

"We had an inflection point when we brought on our representative partner, TriNova, in 2002. This fundamentally changed how we viewed our channel partners."

Some representative organizations were formed from the ground up to partner with Endress+Hauser USA. One of those representatives, Vector Controls and Automation Group, recently celebrated its 10th anniversary. Endress+Hauser was the driver behind the creation of Vector Controls and Automation Group formed from merging six smaller organizations together. "I think that was significant just because we were trying to find the right representative organizations and we didn't have a good way to do that," Lucey says. "Bringing those organizations together was something most people said couldn't be done and wouldn't work. It was very complicated, with many owners and different thoughts. It took a long time, but we all stuck with it. Jared Boudreaux [president and managing director] and the leadership at Vector made that happen."

Vector Controls and Automation Group shares Endress+Hauser USA's facility in Houston, Texas, which was inaugurated in 2021. In addition, Endress+Hauser continues to make investments in new projects and buildings.

"Family leadership sees the growth of the North American market as critical," Lucey says. "We're 12% to 15% market share [in the U.S.]. We want to be at 25%, 30% market share. So, the growth opportunity is still here."

In its 70-year history, Endress+Hauser has always been in the business of doing good business. And just as history does, it repeats itself. ■

Continuing the Journey

Endress+Hauser's next Supervisory Board leader is ready to take on the future

The first 70 years for Endress+Hauser were filled with successes and achievements. The company grew from a small, family-owned business in Europe to a global enterprise and leader in the process control and automation space. But its story still has more to be written, and CEO Matthias Altendorf expects the journey to continue while upholding Endress+Hauser's spirit, quality and power of innovation.

Endress+Hauser has a history of outperforming the markets and has never given in to the temptation to strive solely for low costs, even during challenging times such as the recent global pandemic. Altendorf says that will stay the same, even as new challenges, such as increasing globalization, emerge over the coming years.

Its strategic approach: "From the region, for the region," has enabled Endress+Hauser to gain market share over the past two decades. Still, globalization has made it essential to strike a new balance between proximity to customers, the resilience of supply chains and the ability to innovate.

"We must meet the changing needs of our customers while maintaining our operational performance," Altendorf says.

Globalization is one of many disrupters posing challenges to companies these days. Like its peers, Endress+Hauser has experienced fundamental changes in the process industry, particularly over the past two decades. Those changes are marked by an increasing level of digitalization and the push for automation to increase productivity. Meanwhile, the advent of the Industrial Internet of Things (IIoT) has added new domains such as mobile applications, cloud computing, Software as a Service (SaaS), Infrastructure as a Service (IaaS), Analytics as a Service (AaaS), digital twins, and augmented and virtual reality.

Altendorf says those changes can be a positive for the industry, provided they are met with the right course of action. He says it is inspiring to see how Endress+Hauser has developed as a company on a global scale while maintaining its focus on doing right by people and their futures.

"It is encouraging to know that we can contribute with our work to make the world a better place," he says. "Through process and lab instrumentation and automation, we enable companies, communities and countries to enhance the lives of countless individuals."


Klaus Endress and Matthias Altendorf

The company's guiding principle has always been to remain open to the world and actively engage and learn from it. To continue doing so, Altendorf says they must maintain the freedom to move and operate unencumbered. This requires financial stability beyond the mere maximization of shareholder value. It requires a human-centric business approach.

"We believe that our customers, employees, shareholders and the communities we serve are all vital components of this approach. To this end, we have cultivated a culture that dispels fear and fosters stability, which becomes the fertile ground for creativity," he says. "Such a culture empowers and enables people to give their best."

The company's direct link to its customers and ability to design a value stream to cater to customers' needs is a unique proposition that Endress+Hauser prides itself upon. The goal is always to remain innovative, relevant and valuable to customers. The best way to maintain that success is to seek a "deeper understanding of their challenges," according to Altendorf.

Endress+Hauser can look to the future with confidence and to the past with pride.

"The world needs process automation to improve in every aspect, and we are glad to be part of that journey," Altendorf said. ■

From apprentice to CEO

Having served as CEO of Endress+Hauser since 2014, Matthias Altendorf is set to become the president of the Supervisory Board next year. At the same time, Peter Selders will take over the reins as CEO. It's been a long journey for Altendorf, who started his career at 16 years old. He's quick to point out that becoming CEO was the furthest thing from his mind at that time.

In those early days, his motivation was much simpler: It was to start a learning journey while earning an income that would provide him with some form of independence in life.

"I've always been a very responsible person, hungry to learn and grow, but also humble enough to realize that I've also been very lucky in my life," he says.

Altendorf credits the good advice he received that helped him improve. He says the values Endress+Hauser holds are the same that helped him grow with the company.

"Our brand values of commitment, excellence, sustainability and friendliness aptly describe what you need to embody to be successful in our business," he says. "When you combine these values with curiosity, openness and a willingness to continue learning, they carry you a long way."

Today, he enjoys doing something for people, developing them in the social system that Endress+Hauser represents. In addition, he likes proving that the company's entrepreneurial approach and his own leadership style are more sustainable and successful than pure shareholder value thinking.

The journey hasn't always been easy, but he knows the most significant challenge he'll ever face as a leader is himself.

"You have to overcome your own biases, personal limitations and the constraints of your own socialization while at the same time ensuring that you don't become an obstacle to the development of the social system that you are entrusted to lead," he says.

Still, he has made lasting memories over his three decades at the company. What stands out the most, he says, is how the company has navigated crises, coupled with seeing the joy in the faces of people in the company.

He took over an already well-run company and further developed it successfully, and he's happy to be able to look back on a decade of excellent results. In that time, the company gained market share year after year and became a global leader in process instrumentation. He believes that success is because of customers' trust in Endress+Hauser.

"It's never a single action or decision by a CEO; it's always the 'we' that matters, not the me," he says. "My greatest achievement will be that we have found a good successor who will do an even better job than I did."

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Endress+Hauser

Heat balance of our planet

Detection of global temperatures over past millennia requires outstanding technology

THE temperature of any object is a function of the balance between the quantities of the incoming and outgoing energies. Temperature rises if the incoming energy is greater, and drops if the outgoing is greater. In the case of Earth—a warm object surrounded by cold outer space—the incoming energy comes from the sun and the outgoing energy is the sum of the energy emitted and energy radiated back into outer space (Figure 1).

Earth rotates as it travels around the sun, and if there was no atmosphere, its surface facing the sun would be hot and the other side would be cold. The conditions would be the same as on the moon, where the surface facing the sun reaches more than 100 °C, while the dark side cools to about -150 °C during the lunar night. It's our atmosphere that protects our planet from such a temperature cycle because it absorbs some of the solar heat during the day and transmits some of that heat back to the planet's surface during the night. It, in effect, provides Earth with thermal insulation.

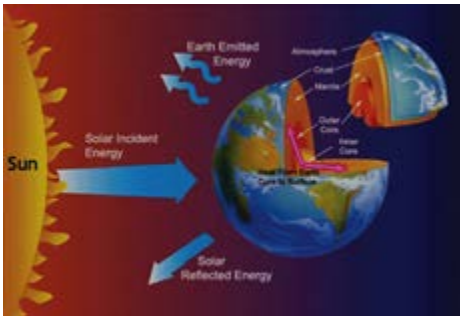

Figure 1: When incoming and outgoing energies are the same, Earth's temperature is constant.

Under steady-state conditions, 70% of the total incoming solar radiation is absorbed (19% by the atmosphere and 51% by Earth's surface), while 30% is reflected into outer space. The cooling effect of outer space is the same as the incoming (absorbed) energy, amounting to 70% of the total solar radiation as it leaves our planet as heat (infrared radiation) (Figure 2).

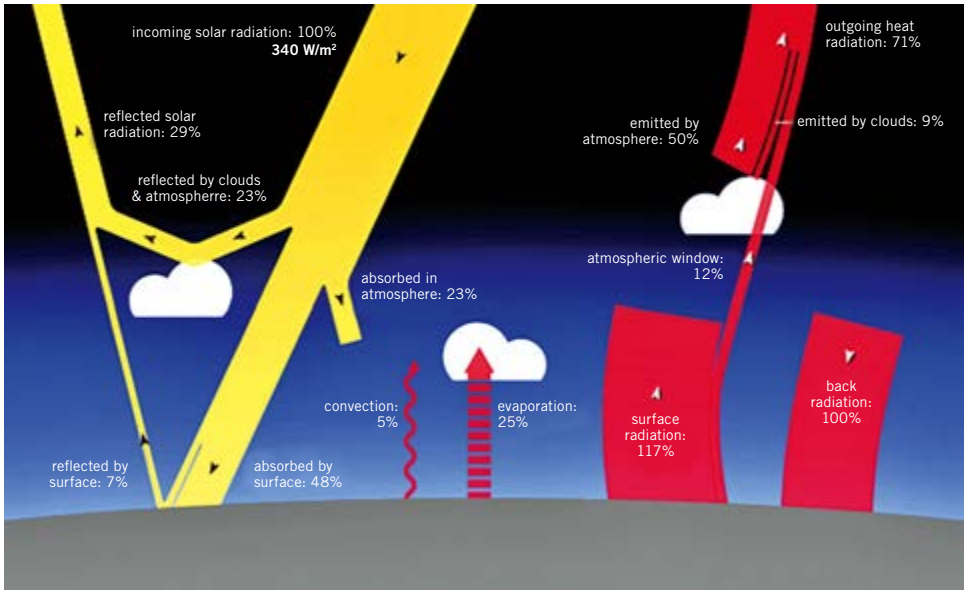

Figure 2: Heat balance exists when solar energy absorbed by the atmosphere and the planet surface equals (19% + 51%) the cooling effect (infrared (IR) loss of 70%) of outer space.

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"Under steady-state conditions, 70% of the total incoming solar radiation is absorbed (19% by the atmosphere and 51% by Earth's surface), while 30% is reflected into outer space."

The average temperature of Earth's surface during the pre-industrial period of 1880-1900 was 13.9 °C. By 2022, it had increased to 14.97 °C and is still rising. The media usually reports the present value of global warming as 1.1 °C. However, the zero reference of these reports isn't always between 1880 and 1900. Also, it's not usually, clearly stated from what segment of the planet's surface the measurements were collected.

This sgment should always be the area between the latitudes 45° N to 90° N in the northern hemisphere. To illustrate this, the zero reference for the data in Figure 3 is the average temperature for the period between 1960 and 1990, and it's between 1951 to 1980 in Figure 4. In Figure 3, the blue lines show global temperature and the red lines show atmospheric CO_2 concentration during the last half-million years.

We can see that during the last half-million years Earth's average global temperature cycled between 3 °C and -10 °C as the distance between its surface and the sun cycled. The time periods between major ice ages were somewhat more than 100,000 years. During that period, the temperature decreased about 1 °C

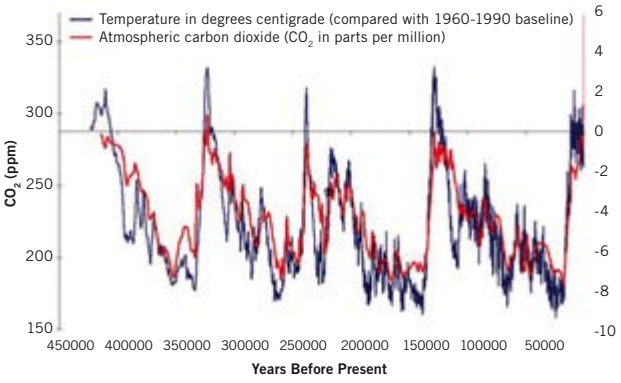

Figure 3: Global values of atmospheric CO_2 concentration (red) and temperature difference from the 1960 to 1990 average (blue).

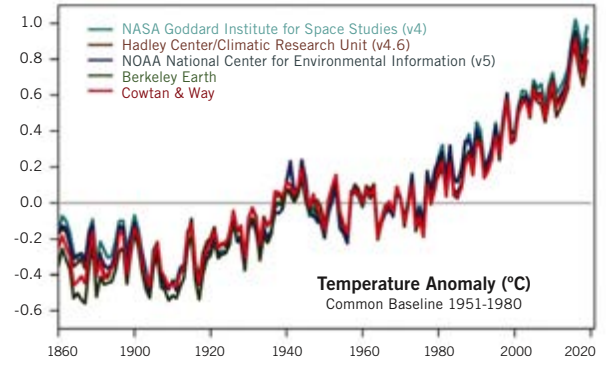

Figure 4: Human activity is not only preventing the end of the current interglacial period, which would have started cooling, but is accelerating the rise of global warming.

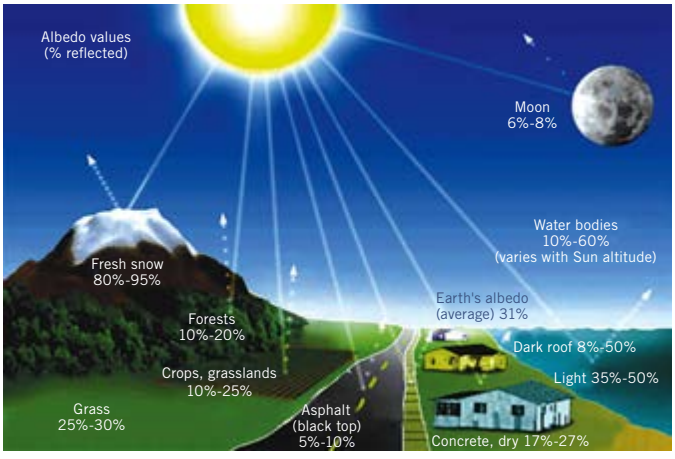

Figure 5: Melting reduces the area of highly reflective snow (~80%) with low-reflectivity land or water (~20%). If all ice on the planet melted, sea levels would rise by 60 m (220 ft)

per 10,000 years. It has since risen about 1 °C per 1,000 years. The last ice age ended about 12,000 years ago, so during the last half-million years, Earth's average temperature never rose above 3 °C or dropped below -10 °C.

What does this tell us about the heat balance of our planet? It tells us that global temperature follows the cyclic change in its distance to the sun. It also tells us this effect is amplified by the variation in the highly reflective ice cover of the planet. That's because, as the area of the ice cover shrinks, heat absorption rises and global temperature rises as well.

Right now, we'd be at the end of the last interglacial period, when global temperature sually starts to drop. However, this is prevented by (what's never occurred during the last half-million years)—recent warming caused by human activity. Global temperature increased about 1 °C during the last 60 years (Figure 4). This speed of temperature rise is much faster than the rate of temperature changes, which the combined Milankovitch cycles can produce (Figure 3). This is added proof that global warming is (and can only be) caused by human activity.

The quantity of solar heat reflected into outer space is dropping because of the melting of the ice, which reflects much more heat than does either land or water (Figure 5). This self-accelerating process can, not only bring global warming to the tipping point, but also be reversed by "whitening" the human footprint by using lighter colored roofs, roads, agriculture, etc.

Accurate measurement of the yearly rise of global warming that amounts to only 0.02 °C/year or the detection of global temperatures over past millennia requires outstanding technology. For more, see my column, "Can we reliably measure the rate of rise of global warming at 0.01 °C/year" in *Control*, June '20 (www.controlglobal.com/home/article/11296663/can-we-reliably-measure-the-rate-of-rise-of-global-warming-at-001c-yr). ∞

The cost of getting it wrong

Identifying uncertainty and errors up front can help avoid catastrophes later

AN adage called Segal's Law states, "a man with one watch knows the time, but a man with two watches may never be sure." But the fellow with two watches has something the former doesn't: a measure of uncertainty. While both might be in error, the degree to which his instruments differ can support a judgement of "good enough."

Accuracy to the millisecond might be critical for a rendezvous in orbit, but not for catching the L train. We can say for all measurements, the value of accuracy depends on the consequences of getting it wrong.

Sometimes we learn this lesson by trial-and-error. In the 1980s, a chemical facility was required to reduce its volatile organic compound (VOC) emissions and constructed a waste heat boiler/incinerator to combust the VOCs in the stream. A service provider specializing in emissions measurements was contracted to monitor the stack of the new apparatus. Their extractive analytical equipment determined the minimum temperature to achieve the 99.99% destruction target.

Inadvertently, they adopted the unchallenged certainty of the man with a single watch. When a sister facility 1,000 miles away faced the same task, they used the results from the first measurement to make many design choices. But when the second incinerator was commissioned, it proved incapable of achieving the target destruction of VOCs. The combustion specialists were stumped. How could they miss by so much?

It was revealed the culprit—a "Type K" thermocouple—was configured in the original installation as a "Type J," making it appear that 99.99% destruction was achieved at hundreds of degrees cooler. Delays and costly upgrades of burners, control valves and fuel pipelines followed. The designers were diligent about not overdesigning the incinerator, but their reliance on an inaccurate measurement cost millions of dollars.

In today's lean staffing environment, advice to validate the accuracy of a measurement can be scarce. This was true for a mechanical engineer specifying a new economizer (a preheater for incoming boiler feedwater), who loaded years of history for an incoming waste gas stream. Averaging a pitot tube/differential pressure flowmeter's output in the site's historian didn't announce that it was using the uncompensated measurement. Standard cubic feet (SCF) or pounds per hour (PPH) are, in essence, mass flow measurements, and any D/P flowmeter only indicates a mass flow accurately (with a typical uncertainty of ±2%) at its "sizing conditions." This is the temperature, pressure and composition (specific gravity) at one selected operating point. There was a compensated measurement in the system, but there wasn't anyone around who may have asked, "What tag are you using again?"

After startup, the new economizer was a smashing success, demonstrating improved energy recovery from the boiler flue gas, thanks to increased surface area. But in a few months, the flow across the somewhat fouled economizer was moving it off its mounting, stressing connections enough to create leaks. Eventually, entire sections of the economizer had to be bypassed, costing many thousands of dollars in daily energy losses, as well as increasing greenhouse gas emissions.

Even tighter tolerances were haunting a small batch brewer, who was befuddled by the rapid attenuation and undesired off-flavors in his flagship lager. The Braumeister really wants to "drive the car," that is, use his kit without assiduous or nerdy insights into the nuts and bolts of the brewery. What wasn't obvious was the installation details of the temperature sensors in his fermenters. All were installed through the glycol (coolant media) jacket, without any isolation or insulation. Consequently, the actual temperature was consistently higher than what was indicated, with the error growing as the fermenter cooled.

When operating a processing plant, it's not unusual that "two watch" situations confront us. Instrumentation and control professionals are valuable when we identify uncertainty and errors, and work with our process counterparts to confront the costs of getting it wrong. ∞

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"Accuracy to the millisecond might be critical for a rendezvous in orbit, but not for catching the L train. We can say for all measurements, the value of accuracy depends on the consequences of getting it wrong."

I/O systems get smarter, simpler

Often overlooked, I/O systems remain critical to any control loop

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"The traditional multi-conductor cable to the central control room is rapidly becoming a thing of the past."

SENSORS, and by extension associated input/output (I/O) cards, are often overlooked but critical parts of any control loop. Like all parts of control systems, the capabilities of I/O systems continue to evolve. Enhanced capabilities and Ethernet/packet-based communications to connect various control system nodes have a significant impact on that evolution.

Several DCS manufacturers have distributed I/O, claiming to increase design flexibility and save cabling costs by supporting installation of I/O "in the field" or at least closer to it. PLC suppliers have the same idea, offering remote I/O that can be installed in a cabinet close to field devices and communicate back to the controller via Internet protocol (IP)-based communications. Other control systems reduce hardware dependence by making I/O software configurable.

Intelligent terminal manufacturers also offer slice I/O, in which each terminal block sits on a backplane, connected to either a PLC or communications card. This is like the PLC model, but with the advantage of supporting almost any protocol and the flexibility of only buying I/O the user requires, which has a smaller footprint than the DCS or PLC options. This option appears closest to the Open Process Automation Forum's (OPAF) distributed control node (DCN) concept.

All of these solutions require local, normally UPS, power. Fortunately, manufacturers of power supplies offer a range of rail-mounted, redundant power supplies with local battery backups suitable for installation in Class 1 Division 2 (Zone 2) environments.

Ethernet-Advance Physical Layer (Ethernet-APL) offers the opportunity to make another step change in how we connect to field devices. APL can supply power and Ethernet signals over one twisted-pair cable. One cable goes to each cabinet. Or, if redundancy is needed, it can use two cables or maybe a ring, which is just two cables going to different places.

One fortuitous aspect of Relcom's legacy fieldbus, Megablock, is that it was the same length as the equivalent number of terminal blocks (positive, negative, ground) that it replaced. It had four fieldbus devices in the same space on a terminal strip as 12 terminal blocks. In my project, I also had to change my field devices to Foundation Fieldbus, which wasn't trivial. However, it would have been easier if I'd built an APL-connected gateway converted my existing protocol to its packet-based equivalent (i.e. HART to HART/IP). Even so, it wouldn't have been much harder to have the gateway also change to a different protocol such as Profinet or EtherNet/IP. ∞

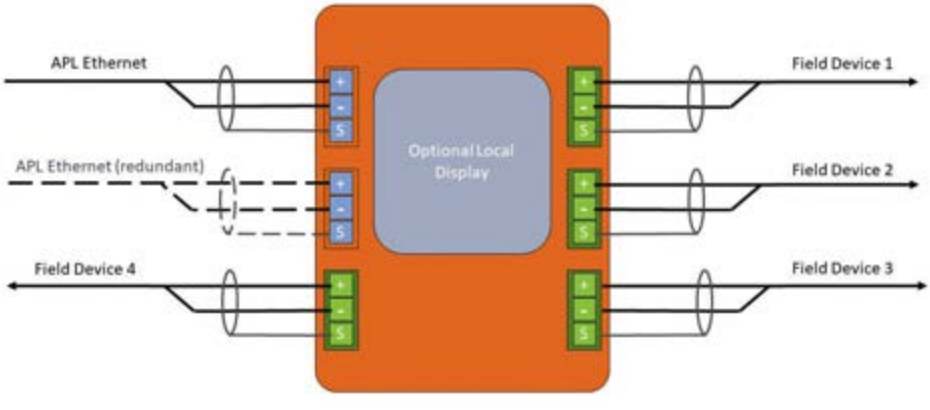

Figure 1: From a real estate standpoint, developing something so it's "backwards compatible" has the potential to make the Open Process Automation Forum's (OPAF) distributed control node (DCN) a reality.

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Why modularization matters for today's industrial PCs

There are benefits to using thin client technology for applications in the process industries

MARC SEISSLER
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Pepper+Fuchs

AARON SEVERA
Regional Product Manager and Level 2 Technical Support, Americas,
Pepperl+Fuchs

IN today's industry, the trend is to move away from standalone PCs. Why? Many end-users in the process industries find benefits in modularization. Marc Seissler and Aaron Severa, both of Pepperl+Fuchs, recently talked to *Control* editor-in-chief Len Vermillion about industrial PC trends and process automation to provide some answers. Seissler is head of product management for HMI and based in the Manheim, Germany, headquarters of Pepperl+Fuchs. Severa is a regional product manager and Level 2 technical support for the Americas region.

Q: Let's talk about technology trends, specifically the trends you see in the industrial PC market.

Seissler: In general, when we talk about industrial PCs, there are basic requirements that are known by the industry. Typically, we talk about rugged devices that give long-term support for end users. This becomes more important, particularly when there are transitions from operating systems and shorter lifecycles at the software and hardware levels. We also try to have a platform that offers long-term availability to customers with operating system migrations.

The big trends that we see today are all-around modularization. What does this mean for HMIs? It typically means that you split the display from the computing technology. The computer is typically a rugged, box PC, and this is now an exchangeable component. In case of an upgrade, or even in case of a failure of the display or the computer, you can migrate or replace these components in the field. That's something we've seen becoming more important in recent years.

What we also see from the overall control system perspective is a strong trend away from standalone industrial PCs to more distributed infrastructure, where you have a thin client in hazardous areas or on the shop floor. You also have a host server somewhere in a more protected area, which runs the software and the applications, while the thin client in the field connects to the host server where the software is executed.

Q: What are the benefits of using thin clients instead of industrial PCs?

Severa: First, I'd say cost savings is a very big benefit to using thin clients. There are some up-front costs and some are long-term costs.Initial costs could be due to some of the lesser-grade hardware that's required in thin clients. For example, a low-power processor has less RAM and there's typically smaller hard drives, which means cost savings can be realized.

Long-term savings can come from a couple of different avenues. The first is from energy consumption. Thin clients use low-power processors. They also use significantly less power than traditional PCs, so you can save on energy costs. Second, thin clients typically have a longer useful lifecycle than traditional PCs, so they're typically replaced much less often. This reduces maintenance and qualification costs. In our experience, thin clients are replaced about half as frequently as PCs.

Another big benefit is security. Within client installations, in most cases, there's no really critical data that's stored locally on the thin client. All that data is stored on the central, IT-implemented server. Other features, such as blocking USB storage devices, as well as right filters and application whitelisting, are things that help keep thin client installations safe and secure.

Another benefit is software management. If you think of a very large installation with many thin clients spread around a big facility, any sort of patch or update you might need to do could become really tedious. This is especially true if you had to add these patches one by one locally at every single thin client in the field.

Luckily, with these thin clients, there are usually great management tools. For example, the Pepperl+Fuchs VisuNet control center allows you to perform these types of updates completely remotely from one central location. This is especially critical in large-scale process automation applications, where facilities may span many acres, and may include hazardous locations or even clean room facilities with restricted areas. So, having the ability to easily access these thin clients from the safety of your office, your desk or the control room is an important time saver that creates a much more efficient maintenance and support structure at the plant.

Q: What do you offer in this area, knowing Pepperl+Fuchs has a seamless portfolio?

Severa: We have a very wide-reaching portfolio that covers an extensive list of area classifications and installation scenarios—from simple things like a small, form factor-boxed thin client, which is a unit without a display to panel mount products, to standalone, pedestal-mounted workstations. Pepperl+Fuchs, especially in process automation, is known for our hazardous location products, and with our HMI portfolio, it's really no different. We cover the complete range of hazardous locations, and we have an HMI product for every one of them—from Zone 2 and Zone 1 products with ATEX and IECEX certifications for Asia and Europe's markets to Division 2 and Division 1 products that comply with the North American certifications, such as UL or Intertek.

On top of that, we have solutions engineering centers (SEC). These are located around the world, and they're fully capable of working with applications that involve any type of customizations or tweaks to our standard products to fit the needs of end-customer installations. This could include tasks like creating a mobile cart-type product that users can wheel around to different areas of the process. Or, it could be something like adding heaters or coolers to a design, or other things like adding pushbuttons or emergency stops to an HMI. The SECs can kind of do a little bit of everything to make products fit perfectly into customers' applications.

Pepperl+Fuchs offers a seamless portfolio of industrial PCs covering an extensive list of classifications and installation scenarios.

Q: What are some of the solutions for different verticals?

Seissler: We are set up very broadly, and we work from the life sciences industry to the chemical industry to oil and gas applications with our products. Each of those verticals has different types of applications, which differ in how the end-users operate their plant or their system. When you look at the traditional chemical industry, where continuous production processes (e.g. steam crackers) are implemented, you will hardly find any HMIs on the shop-floor level. Most of those plants are typically controlled from a control room, and in those applications, we see a demand for thin clients but in a form factor-boxed thin client. These devices are typically installed under the tables, etc.

Our users benefit from having the same software and long-term availability on those devices. Since they're rated for higher operating temperature ranges, you can even install them where standard IT equipment might face problems, even due to increased heat under a table.

When you go into a biopharma plants, you may find no control room at all. Their processes are typically batch oriented. Their operators work at the shop-floor level with an HMI system that they use to connect a decentralized control system (DCS), which is often in parallel to a manufacturing execution system (MES) to monitor production tasks they need to execute.

Typically, HMIs are used that are mobile. For these applications, we use mobile cards, which can even be in a setup with a duplex monitor system with one screen having the DCS picture and the other screen having the MES system, which are typically, completely separated from each other. You also find customers or applications that are in between, where there's a control room and operators on the shop-floor level. Those customers benefit from that seamless portfolio, where we have the same software solutions and management capabilities, just in different packaging of the hardware. This is a seamless solution for the process industries, when it comes to thin client solutions. ∞

Trihedral traces SCADA evolution

Fifth VTScadaFest event features training, education and networking

A record-setting number of visitors attended the fifth VTScadaFest (www.vtscada.com/vtscadafest) on March 27-30 in Orlando, and were treated to a 50-year tour of supervisory control and data acquisition (SCADA) technology and a peek at its future by Glenn Wadden, president of VTScada by Trihedral, a Delta Group company.

The modern SCADA era began in 1971 with the introduction of Intel's microprocessor; took off in the mid-1980s with the introduction of Microsoft Windows 3.1 in 1992; and continued with the popularization of TCP/IP networking technologies that allowed SCADA systems to span multiple computers and synchronize their operations.

"Moore's law lowered the cost of what could be monitored, and we saw soaring I/O counts, ultimately spawning the Industrial IoT," said Wadden. "Lots of cheap I/O meant booming volumes of data, with tag counts regularly numbering in the tens and hundreds of thousands."

Today, Wadden sees control rooms fading in importance, with alarms providing a primary means of managing operations. Meanwhile, virtual machines and cloud environments allow SCADA users to create new apps quickly, even on remote hardware, even cyber-threats, intrusions and attacks multiply. Wadden adds another issue in SCADA development is removing "configuration bottlenecks," which led Trihedral to pioneer online application development by multiple concurrent editors, and use templates, import tools and modular code.

Glenn Wadden, president of VTScada

To confront these challenges, VTScada software has a built-in, application-version control utility that manages changes by recording what system edits were made when and by whom, and allow users to rewind systems to any previous version. Also, Trihedral continues to update versions of VT Scada every two weeks, reflecting the company's sprint development process and commitment to cybersecurity, while maintaining backward compatibility. This gives users a routine update cycle to ensure they benefit from new features, bug fixes, and security enhancements.

For full coverage, visit www.controlglobal.com/events/vtscadafest-2023/article/33004489/vtscadafest-2023

OSIsoft founder Kennedy dies

Dr. J. Patrick Kennedy, 79, founder and CEO of OSIsoft and its PI System real-time data management software, died on April 9 after a 10-month battle with interstitial lung disease. He established OSIsoft in 1980 as Oil Services Inc., and ran it for just over 40 years in San Leandro, Calif., before it was acquired by AVEVA (aveva.com) on 2021 for about $5 billion.

Dr. J. Patrick Kennedy, founder and CEO of OSIsoft

Close to ubiquitous in all the process industries, "OSI PI" long performed data acquisition, historizing, analysis, delivery and visualization, and continues to serve as an enterprise infrastructure for managing real-time data and events.

It automatically collects from multiple sources, such as sensors, instruments, analyzers, I/O, controllers and software; organizes it using OSIsoft and third-party PI Interface software; and gives users access via common formats including PI ProcessBook software, Microsoft Excel and web browsers.

Kennedy was born in 1943 in Portland, Oregon, and was raised on a farm south of Lawrence, Kansas. He earned B.S. and Ph.D degrees in chemical engineering from the University of Kansas.

Kennedy is survived by his wife of 56 years, Patty, three children and their spouses and grandchildren, as well as his brother in San Diego. No memorial ceremony is presently planned. His family requests privacy, and suggests donations to UNICEF (unicefusa.org) in his name in lieu of flowers.

Ethernet and wireless grow, fieldbuses shrink

The industrial network market is expected to grow by 7% in 2023, according to the latest study by HMS Networks (hms-networks.com). Each year, the company analyzes the industrial network market to estimate the distribution of new connected nodes in factory automation worldwide. HMS defines a node as a machine or device connected to an industrial field network.

The study found that industrial Ethernet still shows the highest growth, and now accounts for 68% of all new installed nodes, compared to 66% last year. Fieldbuses declined to 24%, while wireless grew to a 7% market share.

Engineers Without Borders partners with Bentley

Engineers Without Borders International (www.ewb-international.org) reported Apr. 20 that it's partnering with Bentley Systems (www.bentley.com) to bring together the global EWB movement and unite the engineering sector, so millions more people can benefit from addressing today's most pressing challenges. The partnership includes five years of core funding and executive insights, and will strengthens the capacity of EWB International to drive collaboration and cooperation within the movement, deliver better results, and unlock its global impact.

EtherNet/IP gains device profiles

ODVA (www.odva.org) reported at Hannover Messe on Apr. 17 that process device profiles have been added to the EtherNet/IP specification to give users another tool to optimize plant operations. These profiles are reported to provide a standard format for process variables and diagnostics across many devices for smoother vendor interoperability and easier DCS and PLC data integration from EtherNet/IP-enabled field devices.

EtherNet/IP process device profiles are available for Coriolis, electromagnetic and vortex flowmeters, and standard and scaled pressure devices. This lets users take advantage of EtherNet/IP devices with better communication of critical diagnostics, such as NAMUR NE 107 status signals and improved alignment with the Process Automation Device Information Model (PA-DIM). "The introduction of process device profiles to EtherNet/IP is another step in meeting the requirements of the process industries," says Dr. Al Beydoun, president and executive director of ODVA. "EtherNet/IP process device profiles will help end users operate plants with superior yields, minimal downtime and reduced costs. ∞

SIGNALS AND INDICATORS

- **The OPC Foundation**, (www.opcfoundation.org) reported Apr. 17 that it's expanding the OPC UA networking standard with a representational state transfer (RESTful) API to allow worldwide access to data made available by implementations of more than 90 standardized information models by IT applications.
- **ABB** (go.abb/processautomation) reported Apr. 20 that it's collaborating with three partners, **Skovgaard Energy, Topsoe and Vestas**, to build the world's first dynamic, green, power-to-ammonia (PtA) plant. Located in Lemvig, Denmark, this demonstration plant will run on energy from its own wind turbines, and avoid using electricity from the grid. This project is already under construction, and is expected to start production in early 2024.
- **Rockwell Automation Inc.** (www.rockwellautomation.com) reported Apr. 18 that it's partnering with the non-profit **Water Council** (thewatercouncil.com) to promote corporate water stewardship worldwide. This will be accomplished with TWC's Wave verified, corporate water stewardship program and Rockwell's water-related sustainability products and services.
- Indiana-based **Lebanon Utilities** (lebanon-utilities.com) reported Apr. 19 that it's improving its wastewater treatment infrastructure by upgrading a lift station with two of **Tsurumi Pump**'s (www.tsurumipump.com) FM-rated Avant MQC Chopper pumps that operate smoothly and reduce callouts. These FM-rated pumps offer impeller options and horsepower ratings from 4 hp to 215 hp, while the Avant line can handle flows up to 14,000 gpm.
- To help decarbonize its operations by 2030, **Danfoss North America** (www.danfoss.com) announced May 2 that it's agreed to buy about 75 megawatts of solar power starting in 2025 from a solar farm that **CIG Capital** is building in the Texas panhandle. The six-square-mile solar farm is scheduled to start up spring 2025, and have a capacity of 509 MW.
- **United Flow Technologies** (www.uft.com) reported Apr.10 that it acquired **Kodru-Mooney** (www.kodru-equipment.com) last October and **Macaulay Controls Co.** (www.macaulaycontrols.com) this past March. The two acquisitions are expected to accelerate UFT's strategic position into the Midwest and Texas regions, add product categories to the platform, and strengthen OEM partnerships.

Understanding Ethernet-APL

Control's monthly resources guide

APL ORGANIZATION ESSENTIALS

This website, "Ethernet-APL," is ground zero for everything about the emerging single-pair Ethernet (SPE) networking technology for hazardous areas. It includes a 90-second introductory video, FAQs, 18-page whitepaper, 120-page engineering guide, progress reports, blog, library and details about the four standards development organizations (SDO) and 12 suppliers that maintain it.

ETHERNET-APL
www.ethernet-apl.org

INTRO VIDEO FROM FIELDCOMM

This 40-minute video, "Ethernet-APL" by the FieldComm Group, covers all the basics, such as definitions, layered model, Internet connectivity, ISO OSI model, registration and others. It's at www.youtube.com/watch?v=Lm88SjCV0og

FIELDCOMM GROUP
www.fieldcommgroup.org

CONNECTIONS, PROTECTIONS

This online article, "The Ethernet-APL engineering process" by Dr. Karl-Heinz Niemann, covers its context in the ISO/OSI protocol stack, design needs, differences from regular Ethernet, cabling and connection technologies, network structures, explosion protection, network traffic and shielding concepts. It's located at r-stahl.com/en/global/blog/post-detail/the-ethernet-apl-engineering-process

R. STAHL
www.r-stahl.com

EXPERT PANEL DISCUSSION

This 65-minute video, "Networking Lounge about Ethernet-APL," presents a roundtable discussion hosted by Pepperl+Fuchs at its Online Summit event in July 2020. The session features Gerd Niedermayer of BASF, who details its test installation of Ethernet-APL. The panelists also compare APL to existing technologies, suppliers' progress on solutions, and rail field switches. It's at www.youtube.com/watch?v=dsNls9kGyKQ

PEPPERL+FUCHS
www.pepperl-fuchs.com/apl

STANDARDS, NETWORK, POWER

This six-page article, "Ethernet-APL for evolving field devices and the future of industrial Ethernet" by Taro Endoh, Shuji Kuwahara and Seiichiro Takahashi, explains how APL can meet the requirements of process automation (PA) plants, shows what benefits it will bring and what challenges are expected to emerge, and describes the prospects and expectations of Yokogawa's contribution. It's at web-material3.yokogawa.com/1/32505/files/rd-te-r06402-005.pdf

YOKOGAWA
www.yokogawa.com

TWO SHORT VIDEOS FROM E+H

These 2.5-minute videos, "What is Ethernet-APL?" and "Ethernet-APL: simple, fast digital" from Endress+Hauser, trace its history and development by the four SDOs and their supplier partners; shows how it's supported by other protocols like Profinet, EtherNet/IP, OPC UA and HART IP; and details how it gives users loop-powered communications with straightforward and reliable networking. They're at www.youtube.com/watch?v=OYCkTptlViY and at www.youtube.com/watch?v=x6WGadify2E

ENDRESS+HAUSER
www.endress.com

COSTS AND TOPOLOGIES

The first of two blog posts, "Ethernet-APL—the new gold standard for process automation" covers technical fundamentals, shows how Ethernet-APL can make networking cost-effective, and previews two modules Softing is developing. The second post, "Ethernet-APL—network topologies," details three variants, including connecting directly using regular Ethernet, or using truck technology and APL switches with autonomous power or an added energy source. The first is at industrial.softing.com/news/blog/ethernet-apl-the-new-gold-standard-for-process-automation.html and the second is at industrial.softing.com/news/blog/ethernet-apl-network-topologies.html

SOFTING
industrial.softing.com

HIGH-AVAILABILITY SAFETY

This 13-page whitepaper, "Ethernet-APL in the field for high-availability safety applications," shows how it can be applied consistently to enable functional safety. It covers benefits such as applications up to SIL 3, increased accuracy and flexibility, and challenges such as device requirements. It's at files.pepperl-fuchs.com/webcat/navi/productInfo/doct/tdoct7122__eng.pdf

PEPPERL+FUCHS
www.pepperl-fuchs.com/apl

PROFILE OF P&G'S TESTBED

This online article, "P&G gets simpler, smarter with Ethernet-APL," shows how Procter & Gamble developed an Ethernet-APL demonstration project at its Corporate Engineering Technology Lab (CETL) in West Chester, Ohio. The demo was implemented on the lab's Smart Process Cell (SPC), and showed that Ethernet-APL wiring was easy and robust, and that devices on the network looked like any other Ethernet components. It's at www.controlglobal.com/network/industrial-networks/article/11287467/pg-gets-simpler-smarter-with-ethernet-apl

CONTROL
www.controlglobal.com

Non-contacting radar technology's growing application landscape

Product evolution and industry-specific innovation create emerging opportunities in new markets

CHRISTOFFER WIDAHL
Director, Solutions Management, Radar New Markets
Emerson

FIFTY years ago, Emerson began utilizing a new method for measuring tank levels: non-contacting radar technology. Taking a technology originally designed for military aircraft, the company became a leader in using radar technology for maritime and land-based tank level applications. Technology has evolved over those five decades and, these days, new opportunities are emerging for several industries to use the non-contacting radar thanks to the continual evolution of the products available on the market. Christoffer Widahl, director of solutions management for radar new markets at Emerson, talked with *Control*'s editor-in-chief, Len Vermillion, about the transformation, benefits and emerging opportunities for non-contacting radar level measurement.

Q: The footprint for non-contacting radar technology is becoming broader across the application landscape. What created these opportunities?

A: When we started 50 years ago, the products were very big, bulky and expensive. Over the years, technology has evolved from discrete components on large boards that were very power hungry and inefficeint. Everything has become much smaller and less power hungry. Also, the cost has gone down. Now, with our sixth generation of frequency-modulated continuous wave radar transmitters, we're able to make them very compact and power efficient.

Q: The transformation radar technology has gone through is fascinating. Why is radar technology superior to other technologies, such as ultrasonic level measurement, and what are the advantages that non-contacting radar offers?

A: Legacy technologies, such as ultrasonic level transmitters, are sensitive to environmental changes that typically happen when a device is installed, especially outdoors. Ultrasonic level transmitters are affected, not only by moisture, temperature, condensation on the antenna, but also by dust and wind. And, they're prone to delivering inaccurate measurements, and require more maintenance and manual checks.

Q: There are applications in water and wastewater, metals and mining, food and beverage, life sciences and chemical industries. Explain why they're fits for non-contacting radar transmitters relative to other level measurement technologies?

A: In many of these applications, for example, the chemical industry, the media in some cases are very aggressive and corrosive. As the name stipulates, it's a non-contacting technology. So, nothing of the radar sensor is in contact with the liquid or the fluid it's measuring, so you don't have to worry about corrosion.

The same applies to metals and mining, where you're using a lot of chemicals, but it's also quite rough. You have solids applications with rocks, cement or other things that are very abrasive. Having non-contacting, top-down technology that's far away from the media is an advantage. The lifetime of the product will increase. It won't break down as easily.

In food and beverage, the radar is also always mounted on top of the tank, measuring top-down and without contact with the media, thus minimizing contamination risk. In life science, we still comply with all the hygienic requirements and hygienic certifications, but it's easier to put it on top. You don't have to dismount the entire system to do the cleaning.

One good thing about non-contacting radar in the water and wastewater industry is that you can do open-channel flow measurement with a non-contacting radar by measuring the level.

Q: Can you talk about some of the different non-contacting radar transmitters that are in the level portfolio for Emerson?

A: We can start with the Rosemount™ 5408 Level Transmitter. It's the radar with the most advanced capabilities. It's designed to cope with any application or condition. It's proven to be efficient in chemical applications, as well as petrochemical and oil and gas applications. It's rated for safety-instrumented applications. In this case, we developed our own radar front-end to get better signal output, better efficiency, and more power that we can use to do our level measurements.

The next is the Rosemount™ 1408 Level Transmitter, where we saw a need for hygienic, cost-effective transmitters for the food and beverage industry. We recognized there were legacy products or technologies that were only partially fulfilling our customers' needs, and we had transmitters that were originally developed for other industries, such as oil and gas or chemical, which were adapted with hygienic approvals and used in food and beverage or the life sciences.

But none of these were really developed specifically for these industries, and we saw the opportunity to make something that really addresses our customers' needs and what they're really asking for in these industries. When we did our first trials with the 1408, we realized there could be an issue when you're cleaning the tanks with a steam-in-place (SIP) or clean-in-place (CIP) process. We developed a specific algorithm that detects when the spray ball is starting to move, so the transmitter won't generate any alarms.

The Rosemount™ 3408 Level Transmitter was specifically designed for the chemical industry. We added our Smart Meter Verification diagnostics that have been leveraged by other Emerson product lines. This is also available in our radar portfolio, which helps our customers verify the performance and the health of the radar transmitter. You don't have to do anything to take it out of process or service. You can just take action while it's still operating, and you can get a good verification that everything is still working according to its certification or standards.

Emerson's Rosemount non-contacting radar technologies are used in industries such as oil and gas, chemical processing, food and beverage, metals and mining, water and wastewater and process industry utilities.

The Rosemount™ 1208 Level and Flow Transmitter is a new addition to our portfolio. We tailored it specifically for water, wastewater and process industry utilities. With the 1208, we really focused on making it even more compact, smaller, and more efficient in terms of power management. Also, we developed the plastic housing that's common in those industries.

One thing that differentiates the 1208 from many of its competitors, especially in the water and wastewater industries, is the M12 connector. Many of the products for this industry have cables that are molded into the plastics, which means that if, you would have a problem with a cable, you have to replace your entire instrument. That is not sustainable. So, for the 1208, we added an M12 connector that makes it more sustainable. If it has any issues, it's easy to replace the hardware on the transmitter. If the cable breaks down, it's easy to replace the cable without having to replace the entire unit.

Q: Every industry values different things, but besides non-contacting features, what does non-contacting radar bring to the table that you don't see from many other technologies?

A: The trend is that you add more and more diagnostics. But to have reliable diagnostics, you need reliable information. And you must have a lot of raw data, or it's difficult to build those diagnostics and have reliable results.

That's one thing that differentiates our transmitters. The latest generation of radar products feature our Fast Sweep Technology, which allows them to send more sweeps to the media surface. With Fast Sweep, we send more sweeps and get more data, which in turn increases reliability and leads to better diagnostics. ∞

Ethernet-APL gears up

BY JIM MONTAGUE

The two-wire, single-pair Ethernet (SPE) network prepares to work in intrinsically safe (IS) and other hazardous areas

MORE often than anyone likes to think, optimizing process applications is a lonely business. Users must often deploy sensors, instruments, I/O, controls and networks with far less precedence than they'd prefer about how well they'll work together to fulfill the requirements of individual applications. This know-how is even more important in safety processes, so even innovations like Ethernet-Advanced Physical Layer (APL, www.ethernet-apl.org) must be thoroughly evaluated before it can deliver on its promise of allowing Ethernet networking into intrinsically safe (IS) and other hazardous areas.

"It's very important for us to test any new production technologies. We can't simply trust they'll work as expected because many applications are pioneering topics," says Gerd Niedermayer, senior E&I engineering manager at BASF for its chemical plants and new plants in Europe. "We need to know if they'll work properly or not, if they deliver the advantages they claim, and if they solve our problems."

In the case of Ethernet-APL, BASF researched it in 2017-18, and built its field test lab in 2019-20 at its headquarters in Ludwigshafen, Germany, to evaluate communications using Profinet protocol over Ethernet-APL (Figure 1). To test how Ethernet-APL would work with its applications, Niedermayer reports that BASF worked closely with several suppliers, including ABB, Emerson, Endress+Hauser, HIMA, Krone, Samson, Siemens and Yokogawa. They provided the lab with mass and magnetic inductive flowmeters, level, pressure and temperature transmitters, three to five valve positioners for each application, full sensor sets, and other components needed to equip a process plant.

Figure 1: To evaluate Ethernet-APL networking, communications and devices via Profinet protocol, BASF built a field test lab in 2019-20 at its headquarters in Ludwigshafen, Germany. The lab tests flowmeters, level, pressure and temperature transmitters, valve positioners, sensor sets, and other components, which is helping its supplier partners develop Ethernet-APL products. Source: BASF

"Ethernet-APL is attractive because it lets us easily connect all these devices, download data from them, and exchange data with their DCSs," explains Niedermayer. "Where we previously had to deal with polarity requirements and if we were connecting the right green or red wire, we no longer have to care about many of these connection issues or which direction they're going. Plus, using Ethernet-APL gives us 10 Mbps, which is a lot faster than Profibus PA's 31.25 kbps."

Faster for wider reach

Thanks to its greater speed, Ethernet-APL can connect to more sensors, transmitters and other devices, depending on what their DCS interfaces can handle.

"Anything that moves over Ethernet wiring and uses its protocols can also use Ethernet-APL, so it's not limited to simple communication and control. It can relay alerts and alarms, perform equipment monitoring, provide motion data, deliver video, and network into hazardous areas with an eight-port switch," says Paul Sereiko, marketing and product strategy director at the FieldComm Group (www.fieldcommgroup.org). "Traditional instruments have one network trunk for dumping aggregated data and another for sending images from cameras watching vats or other equipment, and each needs its own dedicated wire bundle. Ethernet-APL can connect to all of these using the same network it uses for switches, and save all the time, money and labor required to set up and maintain separate networks.

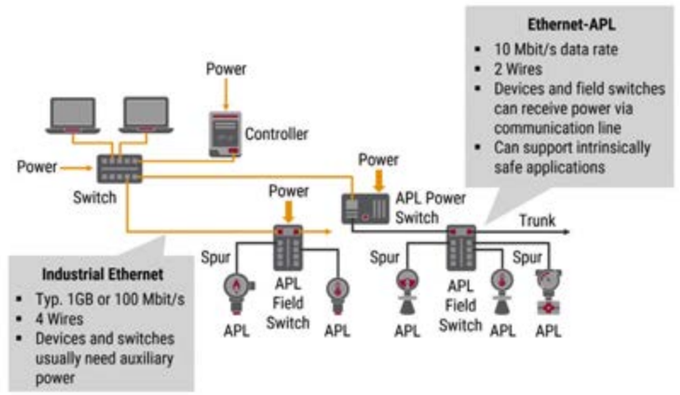

Figure 2: The FieldComm Group reports that Ethernet-APL field devices will connect to Ethernet switches, which in turn will connect to controllers and servers. Source: FieldComm Group

Ethernet-APL will be dominant in the process industries because it provides all the speed and benefits that different applications need, but users only have to run wire once, and can also reconfigure and rearchitect for new designs over time."

Because it can run on existing Ethernet cabling, Ethernet-APL needs that infrastructure to reach in-place instruments. If they have Ethernet, users can test and deploy Ethernet-APL. If not, they have to work with their usual patchwork of networks, and should expect to add an adapter card to let older devices use Ethernet-APL, according to Sean Vincent, technology programs director at the FieldComm Group (Figure 2).

"There are two sides to consider in any automation decision. The first is asset management, and Ethernet-APL can provide many benefits here. The other is controls and operations, and users adopting Ethernet-APL are beginning to report on what it's doing for them," says Vincent. "Ethernet-APL is like the new kid replacing 4-20 mA and HART. It's exciting because Ethernet-APL also gives users the opportunity to replace traditional current loops, even if it takes a while to overcome some infrastructure hurdles."

Likewise, at BASF's field test lab, Ethernet-APL connects via Profinet to redundant controllers via field switches with eight, 16 or 24 ports. These two controllers include Honeywell's Experion DCS and ABB's 800 xA DCS, which are connected to 238 field devices in a Profinet ring/loop topology via 24-port field switches that can handle 24 devices each. Of course, one of Ethernet-APL's main advantages is its two-wire loop can run up to 200 meters in IS settings with Ex ia potentially explosive atmospheres, where Ethernet couldn't go before.

"Because we work with so many motor control centers (MCC) and variable frequency drives (VFD), one of BASF's primary goals for the field test lab was having at least two interfaces for each of the two controllers, which would also let us manage electrical equipment over Ethernet with Profinet protocol," adds Niedermayer. "We also wanted our ring network to standardize on Profinet to reach all these devices, and use Ethernet-APL in the intrinsically safe areas."

Development and testing

To test Ethernet-based equipment and models, the field lab at BASF implements new components in its field devices or switches, which is helping its supplier partners develop Ethernet-APL products. For example, in mid-2022, it installed

and beta tested several Endress+Hauser items with standardized Ethernet-APL chips and two-wire Ethernet communications. This is expected to let Endress+Hauser release Ethernet-APL products in 2Q23, with other vendors project to follow shortly after.

More recently, Niedermayer reports BASF and its partners conducted a scalability test of the field lab in mid-March. The team tested 40 criteria and scenarios using its standard devices and full ring network's communications stack and memory, and found their operations were very stable. The ring was examined with communications tracking software from Indu-Sol and Procentec, which can monitor network traffic performance and identify problems.

"We're helping develop Ethernet-APL products because BASF is very interested in it. We believe it has big advantages for three new plants we're doing detailed engineering for now, which are scheduled to start up in 2025," says Niedermayer. "These advantages are that it's simpler, enables plug-and-play, and makes it easier exchange field devices, along with allowing two-wire Ethernet to serve in intrinsically safe areas."

Andrew Kravitz, product management director instrument connectivity at Emerson (emerson.com), adds, "Ethernet-APL is the latest step in Ethernet's transition down the ISA-95 enterprise-control integration stack from Level 3's manufacturing operations management to Level 0's production processes. Many users tried to work with Foundation Fieldbus and other protocols, but they're often too complex. This is where Ethernet-APL can help because it's simpler, much like familiar 4-20 mA, and can provide power and intrinsic safety along with communications using two-wire, twisted, shielded-pair cable."

However, even though everyone uses Ethernet in their daily lives, Kravitz reports it poses some added challenges in industry. "It's easy enough to set up Ethernet and use web browsers to manage individual components and gain access to their data and diagnostics. However, this process doesn't scale well for configuring and maintaining hundreds or thousands of devices in industrial settings," explains Kravitz. "We already use Emerson's AMS Device Manager software for bulk configurations and diagnostics, and we believe that Ethernet-APL users will leverage the same tools for automating maintenance work practices faster and without having to do as much retraining."

What's Behind FCG's Testing and Registration?

Testing and registration is key to interoperability and ensures specific devices and systems conform to the same standard. FieldComm Group is one of the few automation industry organizations with a registration program requiring mandatory testing of critical elements of its technology.

Today, our testing and registration program encompasses HART®, WirelessHART®, FDI™, FOUNDATION™ Fieldbus and Ethernet-APL products as well as physical layer components such as power supplies, cables and device couplers. There are over 2,300 product registrations completed to date.

One of the founding principles of FieldComm Group is the support of interoperability – the ability to operate multiple devices from multiple manufacturers, in the same system, without loss of functionality.

Check our Product Registry for listings of REGISTERED products

www.fieldcommgroup.org/registered-products

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Connecting the World of Process Automation

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Kravitz reports that traditional 4-20 mA networking has relatively higher latencies because it must go through the usual I/O infrastructure, while Ethernet-APL is faster because it can talk directly to sensors, instruments and other device-level items. These reduced touchpoints and simpler network path also let Ethernet-APL capitalize on its 10 Mbps, compared to fieldbuses like HART that runs far slower at 1.2 kbps. For instance, processes that can benefit from quicker data delivery include radar gauges that take 15 minutes to provide an echo curve with HART can relay one in less than 5 seconds with Ethernet-APL.

Simplicity saves time—and inspires

Niedermayer adds that BASF's prior networking efforts usually started at the field device with 4-20 mA, and most still do. However, this traditional networking requires analog-to-digital (A/D) conversion, digital-to-analog (D/A) conversion, voltage and power, signal marshalling and conversion, and A/D conversion again to reach the DCS.

"With Ethernet-APL in the field, we make one A/D conversion to reach a field switch, and that's all! These Ethernet-APL switches, such as those that Pepperl+Fuchs, Phoenix Contact and R. Stahl are making, can connect via the ring right to a controller, and again, that's all!" says Niedermayer. "This is a lot simpler, which is especially helpful when we're starting a plant because we can see all the loops when we connect to the asset management station. We also don't need to do as many field tests and measurements to do loop checks to measure ranges in the DCS, which means we don't need to go into the field as much because the process values are fully digital. This reduces our loop check times by about 80%, which is our present expectation, and also lets us start plants sooner."

Beyond its speed and reach, Niedermayer adds that Ethernet-APL also has more bandwidth than typical networking methods, so participating devices can easily transmit and receive data in parallel to asset management systems and redundant controllers on the same wire and at the same time. This is possible with other protocols like Foundation Fieldbus and Profibus PA, but their bandwidth is comparatively limited.

"Previously, we couldn't do what we wanted with our networks due to 4-20 mA's limited bandwidth," adds Niedermayer. "With Ethernet-APL, we can do

what's needed, just as we can get Ethernet into hazardous areas. In fact, Ethernet-APL also allows us to bring in ProfiSafe protocol for safety applications along with Profinet in future safety applications. This lets users communicate with safety PLCs via Ethernet-APL and the ProfiSafe stack. Of course, safety applications will likely continue to maintain separate networks and redundant devices, but the advantage now is that they can employ the same network structure and topology, and use the same field devices."

Al Beydoun, president and executive director of ODVA (www.odva.org), adds that, "The inspiration for Ethernet-APL comes from seeing digital transformation elsewhere and the increasing need to connect devices in the process industries at higher speeds and greater bandwidth, as well as reach to edge devices and hazardous areas where Ethernet hasn't gone before. However, there have been some challenges along the way, such as shifting from four or eight wires to using only two to reach field devices. Likewise, getting Ethernet into hazardous locations meant complying with the process industries' requirements for intrinsic safety by defining specifications for appropriate power classes, and developing conformance tests based on common process operations."

This is why Ethernet-APL had to be a specific application of the IEEE 802.3cg single-pair Ethernet (SPE), which is defined as 10Base-T1L for 10 Mbps at up to 1,000 meters. "Previously, we had long cable runs iand faced hazardous conditions when trying to deliver power to the field, and this led to many complex wiring schemes," explains Beydoun. "Now, with Ethernet-APL, we have two wires that can go up to 1,000 meters, and run at speeds up to 10 Mbps, which allows seamless data loading."

While different devices and protocols can run on the same physical network with Ethernet-APL as they do with regular Ethernet, Beydoun acknowledges they don't provide immediate, plug-and-play interoperability. However, he adds that protocols like EtherNet/IP, Profinet, Foundation Fieldbus and others can talk to each other via gateways and converters that can translate their conversations and data.

"Users no longer need to run multiple networks, and they can benefit from testing to ensure that Ethernet-APL is safe," says Beydoun. "To learn about and begin implementing Ethernet-APL, we recommend visiting the Ethernet-APL.org website, and reading its 'Ethernet to the field' whitepaper and engineering guidelines. Us-

ers can also work with the Ethernet-APL organization's four standards development organizations (SDO) on how to implement it safely in their IS processes. Ethernet-APL will let them perform remote commissioning and digital troubleshooting, diagnostics and analytics, so they can detect upcoming failures and maintenance issues earlier, but without all the old, complex networking."

Beydoun adds that Ethernet-APL's speed will also let users reduce device configuration times from several minutes each to just a few seconds, and monitor out-of-range operations and premature failures that could impact end-product quality or increase unplanned downtime. "Overall, Ethernet-APL will emerge as vendors implement its physical layer on their products, and then work with system integrators and end users to reach all the components in their processes and plants. With EtherNet/IP sitting on top of this physical layer, Ethernet-APL gives user the full capabilities of EtherNet/IP, including its CIP Security and CIP Safety network extensions. It's also nice that Ethernet-APL allows potential reuse of Type A fieldbus cables, but users should retest them to verify they have the 100 ohms of resistance (± 20 ohms tolerance) that the standard requires."

Historical needs, removing limits

Just like any multi-year, overnight success, Ethernet-APL's present innovations and momentum are just the latest news in a longer and older story. "Ethernet-APL is the holy grail of bringing Ethernet to instruments in explosive and hazardous areas," says Michael Bowne, executive director of Profibus & Profinet International (PI) North America. "With typical four-wire Ethernet, installations in hazardous areas often require specialized equipment such as Ex-d housings, so Ethernet wasn't used in these areas. This is because Ethernet simply carries too much power."

Bowne reports this is why PI, the three other standards organizations and a dozen manufacturers spent several years building Ethernet-APL on top of the IEEE's existing 802.3cg 10BASE-T1L single-pair Ethernet (SPE) standard. It adds power restrictions defined by IEC TS 60079-47 technical specification for two-wire IS Ethernet (2-WISE) for trunks up to 1,000 meters and spurs up to 200 meters. Ethernet-APL also follows power guidelines for spurs, so users don't need to worry about possible ignitions or loss of performance.

"One of the most essential tasks for implementing Ethernet-APL is getting rid of the attitude that 'we can't do Ethernet,'" says Bowne. "It's important to get an Ethernet infrastructure in place because there are soon going to be many Ethernet-APL devices available from a variety of manufacturers. Likewise, if you already have Profibus-PA, Ethernet-APL is designed to run on the same Fieldbus Type A cable, so you won't need to remove those wires."

"The beauty of Ethernet-APL is that it's just Ethernet, so users can utilize its 10 Mbps to do things like access to an instrument's embedded webserver," adds Bowne. "When employing HART, for example during configuration, its 1.2 kbps means long commissioning times. Using Ethernet-APL for configuration will save hours

on commissioning time alone, and enable users to access, gather, and transmit parameters much more quickly."

Andre Fritsch, senior product manager for remote I/O, fieldbus and Ethernet at R. Stahl (r-stahl.com), adds that, "In the past, Ethernet for hazardous areas typically used fiber-optic lines, which had the advantage of speed, data capacity in the hundreds of megabytes to gigabyte range, and protection against electromagnetic interference (EMI). However, it also had disadvantages due to installation difficulties, costly cabling, and the inability to provide power, which meant it had to come from elsewhere. This is why the four SDOs and their 12 industry partners sought to globally standardize a copper-based Ethernet for hazardous areas, established the Ethernet-APL organization in 2018-19. Its original core requirements were: providing electricity via Ethernet, though different than the Power over Ethernet (PoE) method; connectivity with two-wire copper; longer distance of 1,000 meters; and enabling process automation in hazardous location with the support of intrinsic safety (IS) in accordance with the IEC 60079-11 standard. Ethernet-APL is just two-wire Ethernet with explosion protection on top."

How to DIY on the physical layer

To implement Ethernet-APL, R. Stahl's Fritsch reports there are several questions users need to ask. First, if they're implementing a greenfield application, they can go with any suitable Ethernet-APL option because they're buying new cable. However, if it's a brownfield application, they need to determine if they can reuse their existing cable, and if so, how much?

"If the user already has Profibus or Foundation Fieldbus in place, they can likely reuse it for Ethernet-APL. However, if they have 4-20 mA, then they have to be very careful, and test it, check with the manufacturer, and determine its quality before trying to reuse it," says Fritsch. "If their cable is 20 years old, they may need to replace it."

If a user already has an Ethernet infrastructure, Fritsch reports they have two main options for connecting with Ethernet-APL:

- Standard Ethernet in a star topology that uses switches with eight to 24 ports to reach Ethernet-APL devices. Two disadvantages are that field switches need 24 VDC power, and network length is limited to 200-300 meters without repeaters. One advantage is that a ring topology at the switch level improves availability.

• Trunk-and-spur topology similar to Foundation Fieldbus, which can deliver power from the trunk's supply and couplings, including IS switches. While trunk-and-spur doesn't allow a ring network at the field-switch level, users can implement a daisy chain, which Ethernet-APL calls "cascade mode."

"A star topology is simple because it mainly involves connecting switches to field switches and production devices, even though it's limited to 200-300 meters," says Fritsch. "It's classic Ethernet that's well understood. However, it's still important to check cable capacity and measure resistance because Ethernet-APL spurs use Type A fieldbus cable that isn't always common in the Ethernet world. Where they probably used lower-quality, unshielded 4-20 mA wire before, they may now need better-quality shielded, twisted-pair cable or higher-quality Type A. It's not cheap, but more and less costly cable will likely be certified Ethernet-APL-compliant as demand increases."

Fristch advises potential Ethernet-APL users to determine what cable, parameters and other data they'll need by consulting the 118-page "Ethernet-APL engineer guide" at https://www.ethernet-apl.org/wp-content/uploads/APL-Engineering-Guideline-V114_1.14.pdf.

To transition to Ethernet-APL once switches and other components that support it are available, Emerson's Kravitz recommends that users develop a thorough plan that lets Ethernet-APL convey both the traditional process signals they are used to originating via 4-20 mA, as well as the rich datasets from devices that have been traditionally underutilized in smart process devices. However, if a process application or facility doesn't already have a regular Ethernet network, it will be necessary to install one before Ethernet-APL devices are deployed in brownfield applications.

"The key is to have one solution that supports both Ethernet-APL and traditional protocols and signals simultaneously," adds Kravitz. "Pepperl+Fuchs, Phoenix Contact, R. Stahl and Softing are testing Ethernet-APL switches, and we're updating our CHARMS modules with a distributed carrier backplane that allows an Ethernet-APL I/O channel alongside the other traditional I/O signals it supports. This Ethernet-APL capable CHARMs solution will be available in the upcom-

ETHERNET-APL AT A GLANCE

Here are some vital statistics for Ethernet Advanced Physical Layer (Ethernet-APL) networking technology:

- Two-wire Ethernet physical layer (IEEE 800.2.3) for trunks up to 1,000 meters and spurs up to 200 meters
- Provides high-speed communications of 10 megabits per second (Mbits/sec) down to field-level devices
- Speed and distance designated as 10Base0T1L
- Communicates using Ethernet protocols, such as TCP/IP, Profinet, EtherNet/IP, HART IP, Modbus TCP/IP and others
- Based on existing IEEE 802.3CG single-pair Ethernet (SPE) standard, and added power restrictions defined by IEC TS 60079-47 technical specification for two-wire IS Ethernet (2-WISE).
- Administered by the Ethernet-APL organization at www.ethernet-apl.org
- Developed over seven years and launched in April 2021 and August 2022 by the Ethernet-APL organization's four standards development organizations (SDO), including the FieldComm Group, Profibus/Profinet Intenrational, ODVA and the OPC Foundation
- The Ethernet-APL organization's 12 supplier members include ABB, Emerson, Endress+Hauser, Krohne, Pepperl+Fuchs, Phoenix Contact, Samson, Rockwell Automation, Siemens, R. Stahl, VEGA and Yokogawa

ing DeltaV version 16 release timeframe. Today, we have a DeltaV PK controller than can communicate with Ethernet-APL devices through available Ethernet-APL switches. Beyond this, we're allowing devices to communicate with more than the DCS they usually talk to. This will let intelligent field devices more effectively communicate their own health and maintenance information. Ethernet-APL is better at pulling in this kind of intelligence, which helps users know when to act before faults happen."

Endress+Hauser sets a good example

In a further boost to applying Ethernet in IS locations, Endress+Hauser (eh.digital/launch-ethernet-apl) reported March 30 that it just conducted two successful load tests of a realistic Ethernet-APL setup at its headquarters in Reinach, Switzerland. The tests were designed with end-user specifications from BASF and hardware from ABB, Endress+Hauser, Honeywell and Pepperl+Fuchs. Together, they report the tests demonstrated that components from different manufacturers can combine to create a reliable, robust Ethernet-APL system.

The first test involved nearly 240 Endress+Hauser measuring devices, including flow, pressure, temperature and level sensors. They were networked via Ethernet-APL and Profinet with Pepperl+Fuchs' field switches and Honeywell's control system. The second test used ABB's control system, and

tested it along with the field switches and measuring devices used in the first test (Figure 3).

Endress+Hauser reports the result of both tests showed that Ethernet-APL could be used in realistic circumstances. This is because the tests were carried out with a maximum-sized network layout, and Endress+Hauser adds the scalability and fault tolerance of the devices, controllers and network were successfully verified. It also states that all relevant requirements, such as total netload or redundancy switchover times, were met or exceeded.

"The load tests proved that Ethernet-APL can be used for real. The components from various manufacturers work together smoothly, and the systems run reliably," says Jörg Reinkensmeier, head of the Open Integration partner program at Endress+Hauser, whose supplier members supported the tests. "We're proud that the close cooperation with our Open Integration partners made it possible to validate this technology. We've reached the milestone of bringing Ethernet to the field level of process automation."

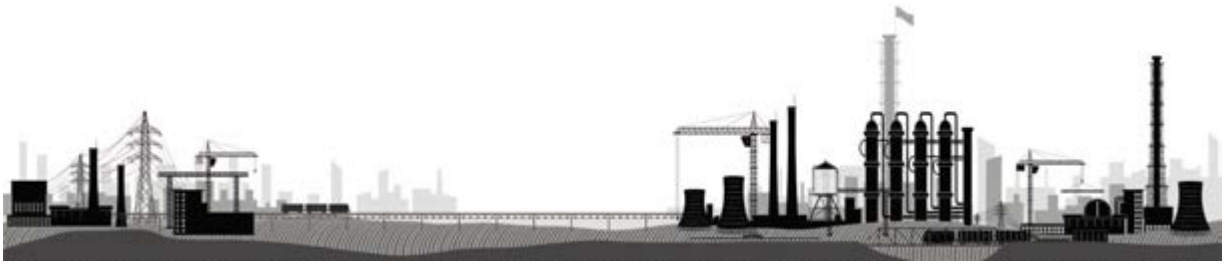
Tim Shope, VP of digital transformation solutions at Endress+Hauser, adds, "Ethernet-APL will be an enabler to the Open Process Automation Standard's (O-PAS) vision of connecting field devices and getting more data than is available via 4-20 mA and HART. It also extends and builds on the physical Ethernet architecture via protocols like Profinet, Modbus-TCP and EtherNet/IP," says Shope. "Once we get these protocols on Ethernet-APL, we'll be able to communicate and interoperate via switches."

Figure 3: Endress+Hauser load tested an Ethernet-APL network and components by integrating 238 field devices into an Ethernet-APL system at its headquarters in Reinach, Switzerland. It deployed field switches from Pepperl+Fuchs and controls from Honeywell and ABB. The two tests found that Ethernet-APL provided increased bandwidth and speed for easier data access and improved transmission from the field. Source: Endress+Hauser

Shope reports that Endress+Hauser plans to roll out three protocols on Ethernet-APL over the next two years. These include Profinet, Modbus TCP/IP and EtherNet/IP. These connections and Ethernet-APL's extended reach will allow process industry users to take advantage of Ethernet's pervasiveness as its experienced in the mainstream IT, business and consumer realms.

"Many people use Ethernet via the Internet frequently for tasks like shopping online. Ethernet-APL gets us closer to that level, so instruments can have a better chance of telling us what's wrong," says Shope. "For example, we tied our Netilion Health condition monitor via a REST API to cloud-based CMMS data, which allowed the device order parts and services to fix them. As Ethernet-APL gets more prevalent, users will be able to access production data in their field instruments and check the health of those devices without going through the usual I/O and control system."

"Ethernet-APL also opens a lot of potential opportunities for interoperability between intelligent field devices with a common interface. If one device talks EtherNet/IP and another talks Profinet, they'll still need a gateway to translate, which could mean added time and labor for configuration and programming. However, even these tasks are getting easier because organizations like ODVA are working on templates to unify the integration that harmonizes Profibus, EtherNet/IP and other protocols. These profiles enable an Endress+Hauser flowmeter to appear the same on the network as another manufacturer's flowmeter and gives us the interoperability we need." ∞



NWR REFINERY AUTOMATES PIPELINE MAINTENANCE

New refinery streamlines CO_2 contribution to the Alberta Carbon Trunk Line and saves $6 million

BY JIM MONTAGUE

YOU may have started up the first major refinery in North America in 35 years, but what have you done for me lately?

This was the not-so-subtle challenge faced by Northwest Redwater (NWR) Partnership and its NWR Sturgeon Refinery (nwrsturgeonrefinery.com) shortly after it completed the first of three design phases and went fully operational in 2020. However, the same spirit that drove NWR and partners including Spartan Controls (www.spartancontrols.com) to design and build the refinery in Redwater, Alberta, Canada, continues to fuel their efforts to use automation to increase efficiency, reliability and sustainability, too.

Figure 1: Located 60 km north of Edmonton, NWR Sturgeon Refinery processes 79,000 bpd of diluted bitumen into several products, but it also contributes 1.2-1.4 MMt/y of CO_2 as a feedstock to the 240-km Alberta Carbon Trunk Line (ACTL). ACTL works with partners Nutrien, Wolf and Enhance to transport and inject CO_2 in wells to improve oil recovery operations, and captures CO_2 for permanent storage. NWR is predicting equipment failures and catching issues earlier with Emerson's AMS Device Manager software and AMS Snap-On software. Source: NWR

"The mission of this early stage was developing a maintenance and reliability program to increase the efficiency of field technology resources, spares management, maintenance scheduling and uptime," said Jamin Hrebeniuk, instrument asset specialist at Spartan Controls. "However, maintaining uptime means reducing some hidden risks beyond the usual maintenance costs. These include environmental regulations, monitoring asset health, having parts available to avoid supply chain issues and using labor resources efficiently."

Hrebeniuk and Harmandeep Sangha, maintenance specialist at NWR, presented "Leveraging predictive maintenance for efficiency and reliability at a world-class refinery" at the Emerson Exchange event last October.

Sustainability and finding failures

Located 60 kilometers north of Edmonton, NWR Sturgeon turns bitumen from northern Alberta's oil sands region into diesel fuel for a variety of automotive and other uses. It completed the first of three design phases before starting up, and presently processes 79,000 barrels per day (bpd) of diluted bitumen into ultra-low-sulfur diesel, low-sulfur vacuum gas oil, diluent and naphtha, and butane and propane.

However, the refinery also supports sustainability by producing CO_2 as a key feedstock for the 240-kilometer Alberta Carbon Trunk Line (ACTL), which injects CO_2 in wells to improve oil recovery operations and captures CO_2 for permanent storage. ACTL is reported to be the world's largest pipeline for manmade CO_2 and has a capacity of 14.6 million metric tons per year (MMt/y) to which NWR Sturgeon contributes 1.2-1.4 MMt/y (Figure 1).

To maintain efficiency and reliability, predict failures and reduce downtime, Hrebeniuk reported that NWR Sturgeon is seeking to predict failures closer to the points where they can start to be detected. This is done by catching issues early with Emerson AMS Device Manager software, and by performing 24/7 asset monitoring with Emerson's AMS Snap-On software and other best practices.

NWR Sturgeon monitors and collects data from more than 8,700 smart instruments, 261 wireless transmitters, 1,261 control valves with smart positioners and 7,324 smart transmitters. They're networked via Emerson's CHARMS electronic I/O, WirelessHART protocol and wireless I/O cards to DeltaV distributed control system (DCS) and AMS Device Manager.

Streamline commission and startup

NWR Sturgeon and Spartan Controls also collaborated during Phase 1 to develop support functions for the refinery based on:

- Using a range of asset criticality levels and AMS Alert Templates for determining required diagnostics levels by criticality and establishing a baseline.
- Conducting failure-mode analyses that are application-specific by using AMS diagnostics and alerts to find problems.
- Developing job plans, procedures and application-specific maintenance strategies, and finding efficiencies with AMS best practices.
- Covering more assets with less inventory by developing a spare parts optimization plan and making it part of the overall inventory management process.

Hrebeniuk reported that NWR Sturgeon benefitted by using several labor-saving, digitalized technologies during commissioning and startup:

- Where technicians could typically only examine one device at a time in various locations, AMS users could access thousands

of devices from a remote location and view multiple plant points at once.
- Without digital links, managers have limited access to technicians, and communications, questions and progress updates are a challenge. However, AMS users can easily interface with operations and engineering colleagues.
- With data on paper, information accuracy depends on possibly years-old documentation by prior technicians, and questions often remain about who made what changes and when. With AMS, changes are logged digitally in its audit trail, and setups and other actions can be compared to digital project documentation.

Because the more than 8,700 smart instruments at NWR Sturgeon had diagnostics configured, they could also show items like "valve installed" signatures and performance tests indicating who touched them last before servicing. They could also support on-the-fly operational support, troubleshooting and audit configurations. Finally, device groups were organized based on asset criticality, and as an initial baseline, alerts were enabled according to criticality and application-specific maintenance strategies. AMS Alert Monitor and ValveLink were configured, and devices were set up for documentation. This allowed live operations to begin.

"It's important to have valve assembly baselines because of whatever may happen in the future. You want to be the last one to touch a device, so it's ready in OEM condition," said Hrebeniuk. "We ran ours in 2018, and during a small outage in 2019, we noticed some friction in a valve at the top end of its travel. This let us examine it during a planned outage in 2022, and schedule and budget for a repair."

Other problems and fixes identified during commissioning and baseline testing included:
- Air supply root valve not fully opening, which could have caused startup delays.
- After passing a stoke test, a low CV solenoid was discovered by an updated ValveLink diagnostics test, which includes the valve signature and performance/step test.
- A loose valve stem coupling block was found and had "play" in the connection with the valve stroking after both the travel Hi-Hi and the travel Lo-Lo alerts became active in the alert monitor.

Indicators raise awareness

Once the NWR Sturgeon refinery started normal operations in 2020, AMS Device Manager continued to play a big role, according to Sangha. For instance, AMS Specialist detects and validates alerts, performs initial investigations to determine causes and severity, and corrects minor issues or enters a detailed work order (WO) into Maximo software. These WOs are approved or rejected by decision makers, and corrective jobs are planned as short-order opportunities or deferred to a future outage.

"We have to prioritize because sometimes we can't bring a process down, or there's a long lead time to make a repair," said Sangha. "If a boiler or other super-critical process needs to be fixed, then it's often deferred, though we try to correct them before they became major reliability issues. If any of these problems are recurring bad actors, we also work with our reliability improvement team (RIT) to decide what to do."

For example, to prevent a boiler feedwater (BFW) trip, NWR's staff ran a valve signature for the BFW valve and found that a piston ring was damaged. So, it was repaired during an outage, "as found" and "as left" signatures were recorded, and it returned to satisfactory performance. The "as found" section of the Maximo WO system is where friction was reported on the upper end of the BFW valve's travel, and recommendation section is where the inspection and failed seal ring were documented.

Similarly, wear to valve seats and plugs can be captured and monitored with ValveLink software's travel Lo-Lo alert. In a BFW pump valve, potential wear to a seat or plug can be indicated when a valve continues traveling negatively at 0% setpoint. Sangha reported this notification can give users more time to proactively order parts and schedule repairs before complete failures (Figure 2).

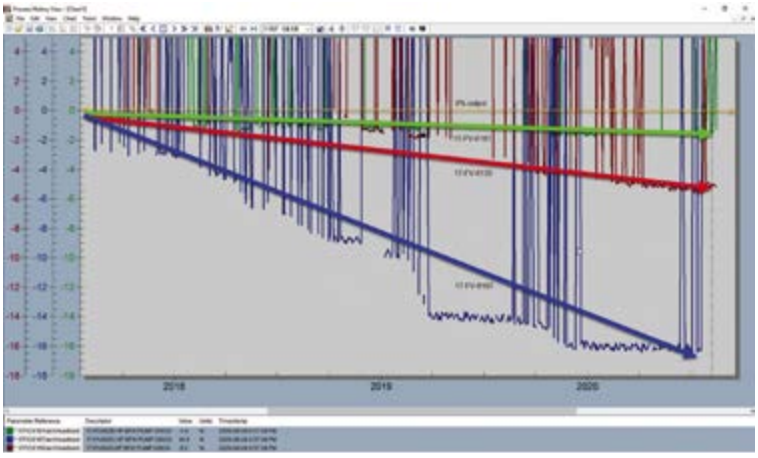


Figure 2: NWR Sturgeon refinery also uses Emerson's ValveLink software to capture and monitor wear to valve seats and plugs. In a BFW pump valve, for example, potential wear to a seat or plug can be indicated when a valve continues traveling negatively at 0% setpoint. This notification can give users more time to proactively order parts and schedule repairs before complete failures occur. Source: NWR

"We also got a low air supply alert that was captured by a status monitor doing a baseline test for steady-state supply pressure," added Sangha. "The supply pressure was low-active, and because poor valve control can equal a boiler trip risk, a work order was submitted. We found that a gauge on a regulator was leaking; the leak was repaired and pressure returned to the expected value."

Regulations and results

Hrebeniuk added that testing and baselining NWR Sturgeon's valves and other systems also help it comply with Alberta's regulatory and reporting requirements. These include the Alberta Energy Regulator (AER), which covers the development of hydrocarbon resources, and the province's Technology Innovation and Emissions Reduction (TIER) rules on greenhouses gases. For instance, AMS Smart Meter Verification Snap-On software verifies inline and in-service performances with 90-second online tests.

"This is more efficient than traditional methods that are risky due to removing, transporting, testing and reinstalling devices," added Hrebeniuk. "Likewise, AMS QuickCheck Snap-On software and its check sheets eliminate human errors because we're using live data with a date/time stamp. It also flags configuration error that may have been introduced at some point and gives us a digital report."

Sangha estimates that NWR Sturgeon's implementation of AMS Device Manager and AMS Snap-On have saved the refinery more than $6 million, which is largely attributable to maintenance efficiencies because the software is leveraged sustainably and saves on labor. "Our present maintenance program produces AMS-generated WOs, which drives consistent value for NWR," said Sandha. "More than 600 predictive and proactive AMS Alert Monitor WOs have been generated and executed. Plus, the data feedback we get provides high value to operations and our RIT for turnaround planning. And, third-party, auditor-approved regulatory compliance is easy to manage with AMS-focused work processes." ∞

"Our maintenance program produces AMS-generated work orders (WO) that drive value for NWR. More than 600 predictive and proactive AMS Alert Monitor WOs have been executed."

BY R. RUSSELL RHINEHART

Why ratio control may be right for the job

YOU FIRST NEED TO WEIGH THE PROS AND CONS OF THE VARIABLES IN PLAY

THERE are several techniques that enhance PID controllers, termed advanced regulatory control. These were developed in the 1930s and 1940s, and include reset feedback to prevent windup, override to prevent excessive or unsafe conditions, and feedforward to correct an anticipated upset. Also, they include ratio, cascade, decouplers, gain scheduling, output characterization and various forms of model-based adjustment. These techniques remain very useful today.

Ratio control bottom line

If you notice that one process variable should be a ratio of (proportional to, a fraction of, scaled to or a similarly named relation) another influence variable (or to a calculated load or demand), consider ratio control. In ratio control, the output of the primary (supervisory) controller is the desired ratio, which is multiplied by the wild variable/demand/load value to become the setpoint for a secondary controller.

The wild variable is usually a flow rate, but it could be a compound variable calculated from material and energy balances such as a heat load. For example, the required steam flow rate to heat something to a target temperature depends on the process inflow rate as well as its temperature. The steam flow rate is proportional to the composite calculated value of the load, Q? = F?C_p (T_SP-T_inflow).

The secondary (inner) loop needs to be faster than the primary loop for this method to offer an advantage. Some engineers use the rule of (?+3?)_secondary < ?1/5 (?+3?)?_primary.

Tune the secondary controller in the inner loop first, then tune the primary controller with the inner in AUTO. To the primary controller, the inner loop is just part of the process. If you tune the secondary after the primary, this changes the primary's view of the process dynamics.

Ideally, you could calculate the ratio from first principles thinking, and not need the primary outer-loop controller. However, reality requires feedback from the primary controller to compensate for calibration errors of secondary sensors, as well as unmodeled and non-ideal effects.

In ratio control, compensation happens as soon as the input change is detected, which is nearly as soon as the variable changes (given lags in sensors, controllers and valves).

If the input change won't affect the process for a while (perhaps because load calculations are based on far upstream measurements), then the ratio will cause compensation to happen too soon, creating an upset. If dynamic compensation is needed to match the timing of the control action to the process response to the disturbance, then use feedforward.

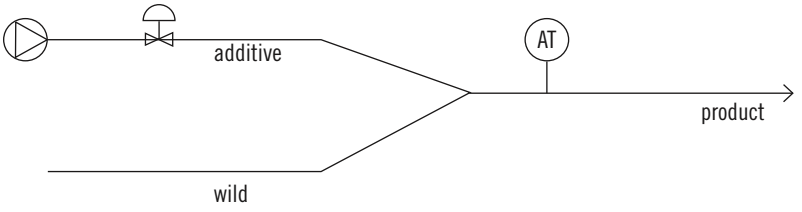


Figure 1: Illustration of a blending process

Blending example of ratio

Figure 1 illustrates a blending process as an example. The wild flow is process stream. The additive, which may be called a titrant, is added. The additive may be to adjust composition, pH or temperature, for example. Here it's considered composition, and the analyzer transmitter (AT) measures and reports the mixed-stream composition.

Figure 2 illustrates a primitive control strategy. If the reported composition is off-target, the analysis recording controller (ARC) adjusts the valve in the additive line to return the product to the correct composition. This primitive strategy works.

It's worth noting that, if the ARC were talking to the valve in English and using engineering units, it would be saying, "Valve, go to 53% open." If the valve is air-to-open (fail-closed), abbreviated as ATO or FC, then the ARC needs to act in reverse. If the analysis of additive composition goes down, the controller output must increase to open the valve to compensate.

Here's a problem: if the wild flow rate increases, control action is delayed. The AT won't detect the change until after the transport delay from the mix point to the sample point. Then, lags or delays in the AT won't instantly report the full deviation. As the composition deviation is reported, the controller begins to respond, but the integral has a time-constant and will create a second lag. Finally, as the controller instructs the valve to change position, the valve will create an additional lag due to actuator dynamics. Eventually, the controller will return the composition to the setpoint, but not until the delay(s) and several dynamic lags have passed. During this time, there will be a persistent composition deviation.

Consider ratio. If the wild flow rate doubles, then the additive flow rate should also double. Rather than waiting for feedback correction, double the additive flow rate as soon as the new wild flow rate is detected.

Figure 3 illustrates a ratio strategy. Here, the wild flow rate is measured, and the ARC determines a flow-rate ratio. This ratio multiplies the wild flow rate, which becomes the flow rate setpoint for the lower-level (secondary, inner) controller. The secondary controller is within a standard, flow-control loop.

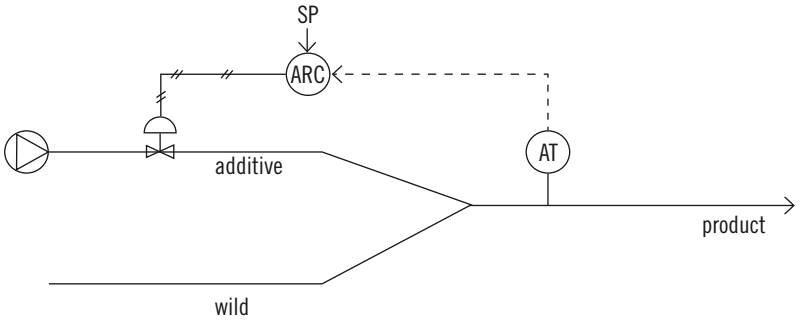


Figure 2: A primitive control strategy

The analyzer may be relatively noiseless, and the ARC may be PID. But the flow loop is probably a bit noisy and fast-acting, so the secondary should be PID.

It could be that the ARC isn't in control for any number of reasons, such as the valve getting stuck or reaching a limit. FIC may be in manual. Instrument techs may have the valve on bypass. If so, the ARC will wind up to its limit of 0% or 100%. To keep its bias at the right value, use the actual flow rate ratio as an external reset feedback (ERF) signal.

The ratio strategy creates a role change for the ARC. The ARC is now talking to the multiplication block, and now it might be saying, "Hey, x-function, use 0.125 as the ratio." The x-operation will also hear the wild FT say, "Hey, x-block, the wild flow rate is 220 gpm." The x-block will multiply the two numbers, then tell the secondary flow controller, "Hey, FT, your setpoint is 27.5 gpm."

In this case, the ARC continues to be reverse-acting. If the analysis value goes down, the ARC needs to increase its output, the ratio, to raise the flow rate setpoint to correct the deviation. In some ratio applications, the primary controller might change direction, for example, if the valve were air-to-close.

The ERF signal must be the same as what the controller would be saying if it were in charge. It's the actual flow rate ratio that might not be what the ARC wants (an operator could be adjusting the valve, the valve may be at a limit, the

secondary controller could be in MAN mode). Use the lowest level transmitters in the control hierarchy to determine the ERF signal value.

There's a strong similarity of the inner- and outer-loop structure between ratio and cascade. But the difference is that, in cascade, the primary controller sends a setpoint to the secondary controller. Meanwhile, in ratio, the primary sends a ratio to a multiplication operation, which sends the setpoint to the secondary.

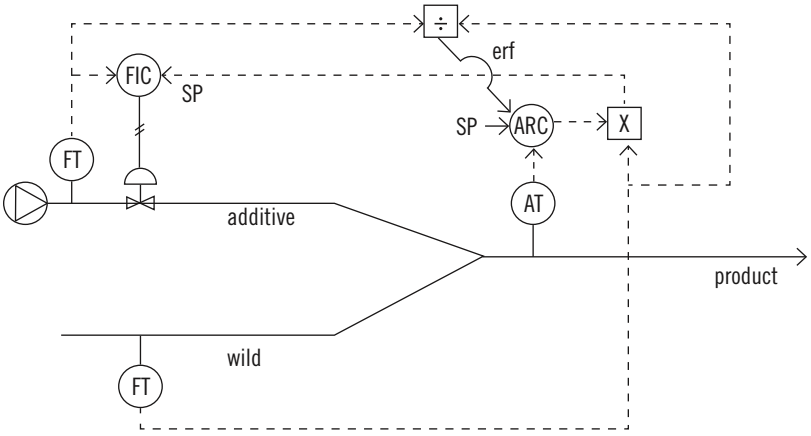


Figure 3: A ratio strategy with ERF

Scaled signal calculations

If the signals and messaging between devices were in engineering units representing flow rates in gpm and temperatures in oF, it would be easy for a process engineer to understand the ratio strategy. But, of course, all these values are scaled values in the 0% to 100% range. As a result, the x-block needs to have an operation that keeps variable values consistent with the mechanistic meaning. For example, if the flow transmitter is scaled so that 0% to 100% matches the 0 to 500 gpm range, its output isn't 220 gpm, but it is:

FT = (220-0) gpm / (500-0) gpm (100-0)% = 44% (1)

If the ARC output is scaled so its full range of 0% to 100% matches a ratio range of 0 to 0.2, then its output is:

ARC = ((0.125-0) gpmA / gpmW) / ((0.2-0) gpmA / gpmW) (100-0)% = 62.5% (2)

The x-operation shouldn't multiply 44% times 62.5%, obtaining 2,750%^2. What it must do is reconvert the 44% to the wild flow rate value and the 62.5% to the desired ratio, using the inverse of Equations (1) and (2).

Fwild = ((44-0)) / ((100-0)) (500-0) = 220 gpmW
Ratio = ((62.5-0)) / (100-0)) (0.2-0) = 0.125 gpmA / gpmW

Then multiply:
Product = 220 gpmW?0.125 gpmA / gpmW = 27.5 gpmA

Then convert the product to the 0-100% range that matches the additive flow range for the secondary controller. If this is 0 to 125 gpm, then:

xBlock = (27.5-0) gpmA / (125-0) gpmA (100-0)% = 22%

Similarly, the divide block needs to first convert scaled signals to their process units. So, do the division and convert the ratio to the appropriate scaled signal range for the ARC. If the wild flow rate is zero, then the divide operation will encounter an execution error. If so, it needs a calculation override, and a reportable default value, perhaps the last prior executable value.

If you choose ratio in your control devices, it might ask for the ranges and do the scaled signal conversions for you. But it might not.

Notes about Ratio

- The ratio control action happens immediately (as far as possible considering lags in sensors and final elements and delays in scan times) when the demand/load is detected. This prevents demand/load changes from upsetting the controlled variable.
- Ratio is easy to understand from a process engineer's viewpoint, using values and units of the process variables. However, it probably needs to be implemented in scaled signal calculations.
- Relative to a more primitive control strategy, ratio required two new flow transmitters and a new controller. The cost of installation and maintenance of these devices needs to be considered when the control benefit of adding ratio is being considered.
- The inner loop needs to be about five times faster than the outer loop for ratio to provide a substantial benefit.
- If the load is based on far upstream measurements, the delay in needing to change the additive may require a delay in the ratio implementation. Feedforward might be a better solution.
- ERF is not a requirement for ratio. It's a complication to implement, and it may only solve a brief issue after some infrequent situations. I like it, but others may weigh the performance pros and implementation cons differently, and choose not to include ERF. ∞

Russ Rhinehart started his career in the process industry. After 13 years and rising to engineering supervisor, he transferred to a 31-year academic career. Now "retired," he enjoys coaching professionals through books, articles, short courses and postings on his website at www.r3eda.com.

Configuring feedforward control of heat transfer

Feedforward control can anticipate the error that's likely to occur as soon as the load starts to change

Q: We have a large heat exchanger under feedback control. When the load changes, we experience a temporary but substantial error in the controlled outlet temperature. The heating medium is steam. I'm told that feedforward control could reduce the upset in the outlet temperature. How should we configure a feedforward loop? What options do we have for configuring it?

Z. FRIEDMANN
control engineer

A1: When controlling the outlet temperature of a heat exchanger by using feedback control, you should realize that, even if the PID loop is tuned correctly, corrective action can only start when an error has already developed. By comparison, feedforward control can anticipate the error that's likely to occur as soon as the load (incoming process fluid flow or temperature) starts to change. If correctly "modeled," it can cancel or reduce the upset that the load change would cause in the outlet temperature.

While feedforward models can be steady-state, changes in the system dynamics or errors in temperature measurement or the control models upon an upset will still cause the loops to allow some error to occur. If you want to minimize this error, you should add cascade trimming to the feedforward model to provide dynamic compensation. In general, static feedforward control can cut the PID error by approximately half, while dynamic feedforward loops reduce the error to about 10% of the feedback error (Figure 1).

The heat balance of a steam-heated heat exchanger can be stated as: $F1Cp(T2-T1) = Ws\lambda s$
Where:
F1 = flow of the incoming process fluid
CP = heat capacity of the process fluid
T2 = controlled outlet temperature of the process fluid
T1 = incoming temperature of the process fluid
WS = heating media (steam) flow
λS = latent heat given up by the condensing steam

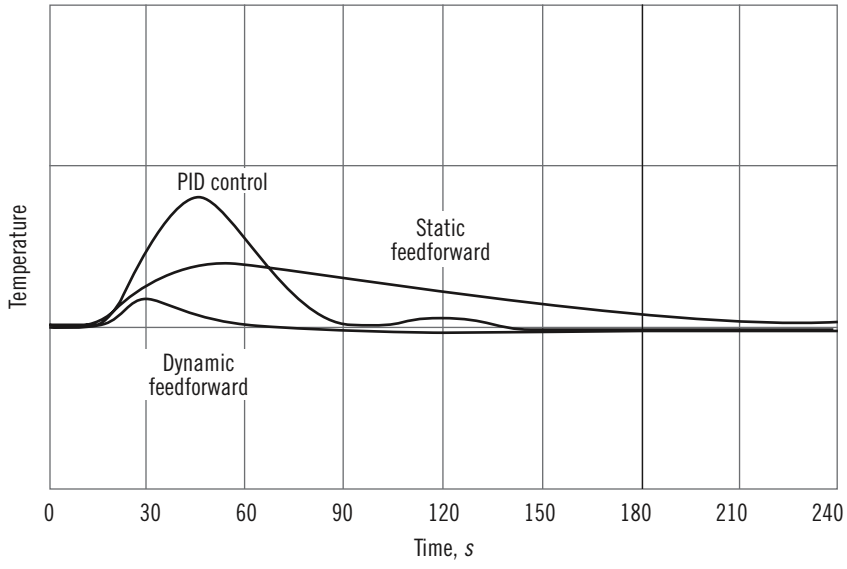


Figure 1: Reductions in the upsets in outlet temperature if the heat exchanger is controlled by PID feedback control, static feedforward control or dynamic feedforward control

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.

Solving the equation for steam flow (Ws), the required steam flow Ws is: Ws = W (Cp/ λs) (T2 - T1).

In the case of a static feedforward control loop, the ratio between the heat capacity of the process fluid (Cp) and the latent heat of steam (λs) are estimated, but not measured. If either change, the static model becomes inaccurate. For this reason, it's desirable to add a feedback cascade loop (Figure 2) that corrects the model for changes in that ratio by generating a correcting signal (m), which is included in the value of the setpoint of the slave controller (FIC-2). In this configuration, the setpoint of the cascade master (TIC-2) is the required process fluid outlet temperature (T2) and the setpoint of the cascade secondary (FIC-2) is corrected by the master output signal (m), which corrects for the variations in the heat capacity ratio (Cp/λs).

The feedback controller (TIC -2) should have an integral to eliminate any steady-state offset error that could be caused by sensors, model or the calculation errors, so it will respond only to the changes in the heat capacity ratio. Also, the dynamic compensator should be tuned with the feedback controller in manual, so the integrated error will be zero before feedback is added.

BÉLA LIPTÁK
liptakbela@aol.com

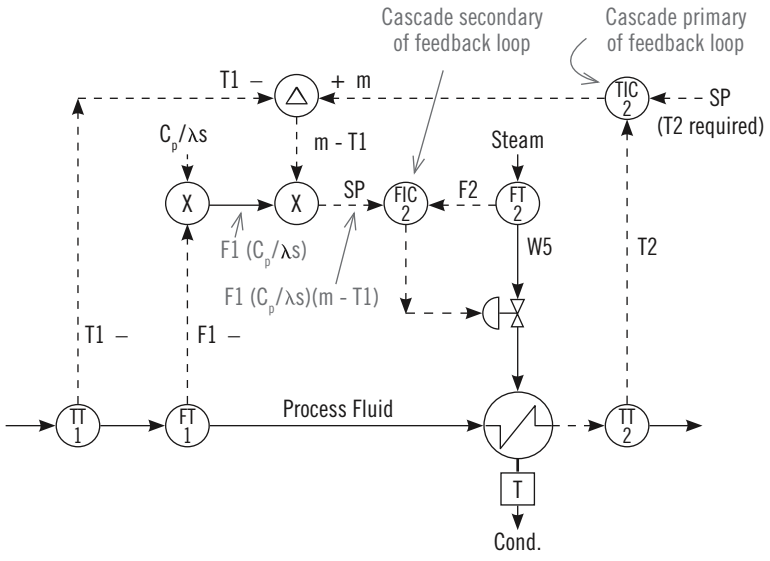


Figure 2: Feedforward heat exchanger control loop with dynamic feedback cascade trimming

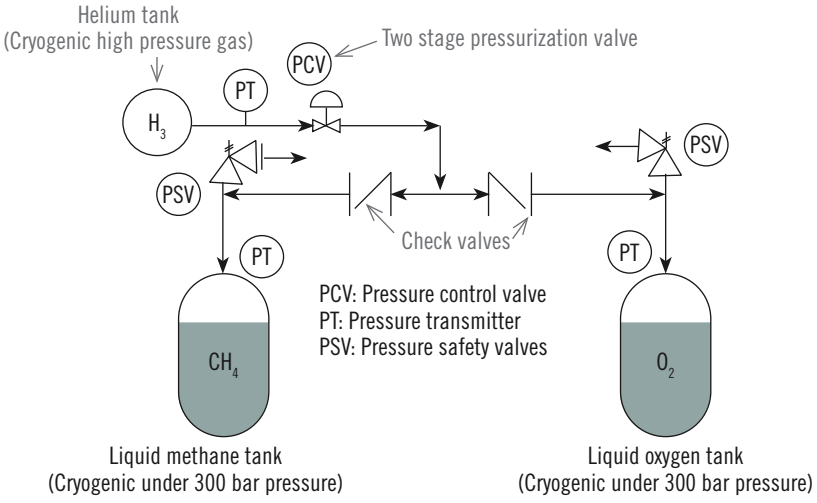


Figure 3: SpaceX pressurization system

Q: How can automation and control professionals contribute to the success of the SpaceX project? On April 18, a launch was cancelled due to pressurization problems. It was briefly successful on April 20, though a minute after liftoff, the rocket started to tumble and had to be destroyed.

A1: For the 33 engines that lift the enormous rocket to operate smoothly, both the cryogenic liquid fuel and the cryogenic liquid oxygen tanks must be under stable, constant pressure. This is guaranteed by charging the top of these liquids with super-cooled, high-pressure (around 300 bars) helium gas in the two tanks before ignition. This is provided by the simple pressure control loop (Figure 3).

On April 18, this charge valve (PCV) froze, and the test had to be canceled. If an automation and control engineer had designed the system, this freezing potential would probably have been realized and the PCV would have been heated before ignition, or absolutely dry helium would have been used, so there would have been nothing to freeze.

As to the rocket's tumbling, followed by its destruction on April 20, an automation and control engineer would have warned that successfully igniting 33 engines at exactly the same time is rather unlikely and therefore balancing controls are needed. One option is to balance the rocket by making the lifting force of some of the engines adjustable (variable fuel flow) and throttle them to compensate for force that's lost due to the failure of some engine(s). This balancing algorithm should have the feedforward format, so that tumbling is anticipated and corrected before it starts. ∞

Level stays level-headed

Frequency modulated continuous wave, Ethernet-APL enable accuracy in difficult, hazardous settings

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Low-cost FLS-VM-800 float switches have a ¾-inch PVC pipe fitting for use in HVAC condensate lines, while FLS-VD series includes a ¾-inch MNPT connection for mounting to most standard ¾-inch bungs in 55-gallon drums. They include top- and side-mount float switches in medium and large sizes, and are made of various materials for compatibility with liquid types, temperature ranges, and system pressures. ProSense switches are UL recognized, CE marked, RoHS compliant, and have a one-year warranty.

AUTOMATIONDIRECT
www.automationdirect.com/float-level-switches

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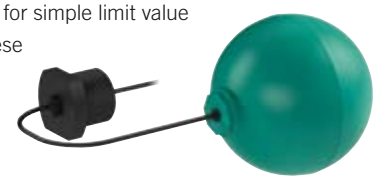
Micropilot FMR63B 80 GHz radar level sensor is built for hygiene requirements, turbulent surfaces, and foam formation and buildup without contacting the medium—and uses Ethernet-APL for hazardous areas. It employs patented Heartbeat Verification radar accuracy index (RAI) to assess instrument accuracy without process interruption, so results are traceable and ISO90001 compliant. FMR63B meets standards, such as EHEDG, 3-A and ASME BPE.

ENDRESS+HAUSER
www.endress.com/en/field-instruments-overview/level-measurement/Radar-Micropilot-FMR63B

FLOAT SWITCHES FOR SIMPLE LIMITS



Float switches are used for simple limit value detection in liquids. These switches consist of a float body with a built-in switching element and connection cable. Initiators and micro-switches serve as a switching element, which shifts when it crosses the horizontal position in either direction. They can be connected to an intrinsically safe (IS) switch isolator for operating in approved hazardous area location. They also feature a sleeve or ball design, and are available in various lengths and cable types.

PEPPERL+FUCHS
www.pepperl-fuchs.com

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Rosemount 3408 level transmitter is a non-contacting radar device that optimizes ease-of-use at every touch-poin; uses frequency modulated continuous wave (FMCW) technology for accurate, reliable measurements, even in challenging environments, and is SIL 2-certified according to the IEC 61508 functional safety standard. Likewise, Rosemount 1208 level and flow, non-contacting radar transmitters feature 80 GHz, fast-sweep FMCW on one electronic chip, which delivers accurate and reliable measurement.

EMERSON
Emerson.com/Rosemount3408 or Emerson.com/Rosemount1208

LONG RANGE IN EXTREME SETTINGS

T30R is a long-range radar sensor from Banner Engineering that provides reliable detection and position feedback in extreme applications. The sensor can precisely distinguish between targets and filter out unwanted ones, even in the presence of moisture or varying temperature conditions. T30R provides reliable detection of high-dielectric targets (such as metal or large amounts of water) and lower-dielectric materials (such as wood, rock or organic material) in a wider range of applications.

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RS (FORMERLY ALLIED ELECTRONICS & AUTOMATION)
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CL-10 G Series level detectors provide accurate, consistent results for lightweight or fluffy products or bulk solids that pack or bridge easily. They handle precipitated, fine, lightweight chemical powders with densities as low as 1 pound per cubic foot (lb/ft^3). They manage foods such as 12x milled products to silk sugar, as well as heavier solids in the 10-15 lbs/ft^3 range. CL-10 G is factory calibrated with no adjustments necessary. Specialized units handle temperatures exceeding 300 °F.

DYNATROL DIVISION OF AUTOMATION PRODUCTS INC.
800-231-2062; www.dynatrolusa.com

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W-200 Pilotrek is a compact, 80 GHz, frequency modulated, continuous wave (FMCW) radar transmitter for solids and liquids. Its new WES series model is a two-wire, 24 VDC, loop-powered radar transmitter, which uses the highly accurate FMCW technique. WES operates as low as 12 volts DC, and provides ±0.078-inch accuracy, 0.039-inch resolution. It also has up to 98 feet range, 7° beam angle, and measures dielectrics as low as 1.9.

NIVELCO USA LLC
630-848-2100; Nivelco.com

CAPACITIVE PROXIMITY, ADJUSTABLE SENSING

Capacitive proximity sensors from Carlo Gavazzi offer an adjustable sensing distance of 2-10 mm flush or 3-15 mm non-flush, and are available in 12 mm (about 0.47 inch), 18 mm (about 0.71 inch), and 30 mm (about 1.18 inch) diameters with AC and DC outputs. These patented Tripleshield sensors are tested to withstand electrostatic discharges up to 40 KV, line transients up to 4 KV, and airborne noise up to 15 V/m.

GALCO
www.galco.com

SONAR BED CAN MEASURE TWO DENSITIES

Orca Sonar Bed level system measures up to two density interfaces simultaneously. Typically, these are bed levels/RAS blanket and floc/fluff layers. Its sonar produces a high-power concentrated beam. Orca also features dual, independent analog outputs to track two different interfaces, or clarity simultaneously, with one sonar sensor. They also have easy calibration to track specific density interfaces, industrial scum cleaning mechanisms that don't require maintenance, no wiper blade assemblies.

HAWK MEASUREMENT
888-429-5538; www.HawkMeasurement.com

RADAR CHIP TAILORED TO USER SPECS

VEGAPULS 6X is a radar sensor for level measurement of liquids or bulk solids. Users simply specify their application details using VEGA's online configurator, and receive a VEGAPULS 6X built for their needs. Powered by VEGA's custom radar chip, 6X is capable of highly precise and reliable measurements independent of process conditions like dust or high temperatures. And now, VEGAPULS 6X is also certified to meet IEC 62443.4.2 cybersecurity standards, making it the ideal level sensor for Industry 4.0 processes.

VEGA AMERICAS
www.vega.com/radar

DIAPHRAGM SEAL WITH COMPENSATING CAPILLARY

EJXC80A with compensation capillary type diaphragm seal is the latest in the EJX differential pressure level series. The compensating capillary balances the volume and temperature of fill fluids between high and low pressure side capillaries. EJXC80A reduces the influence of ambient temperature drift caused by day-to-night, season-to-season, or shady-to-sunny swings. Combined with DPharp sensor, this solution provides stability for all DP level measurements.

YOKOGAWA
www.yokogawa.com/us/solutions/products-platforms/field-instruments/pressure-transmitters/diaphragm-seal-system

EQUIPMENT & MATERIALS

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1100 Series magnetic level indicator (MLI) uses its patented, 200° vista viewing angle to provide the most visible level indication. It's easy to read from 250 feet (76 meters). 1100 Series MLI includes nitrogen-purged and sealed indicators. It also complies with EU Directive 2014/68/EU (PED), ASME B31.1 and/or ASME B31.3. With designs for flashing/boiling and cryogenic services, SOR can customize a MLI for the most rigorous process conditions.

SOR INC.
913-888-2630; www.sorinc.com/products/magnetic-level-indicators/1100-series-magnetic-level-indicators

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ELS-1100 series single-point, optical level switch from Gems Sensors is a compact, no-moving-parts, polysulfone level sensor with built-in switching electronics. It's available with varied mountings, power requirements and electrical terminations. ELS-1100 is suitable for high, low or intermediate level detection. Installation is simple and quick through the tank top, bottom or side. The sensor offers ±1 mm repeatability and broad liquid compatibility. It's not recommended for liquids that crystallize or leave a solid residue.

NEWARK
www.newark.com

CONTINUOUS MEASUREMENT AND PUMP CONTROL

Sitrans LT500 HydroRanger is a digital level flow and pump controller for radar and ultrasonic transmitters or any two-wire, 4-20 mA device. It's used for radar sensor measurements at 80 GHz, and features single- and dual-point measurements, six relays and extensive datalogging capabilities. It also has a full suite of pump control functions and diagnostics, and can communicate via Modbus RTU, HART, Profibus DP and PA and Profinet protocols.

SIEMENS
800-365-8766; www.usa.siemens.com/level

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Talking machine learning, deep learning and nonlinear controls

Why you should be intrigued, and why you should be cautious

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

I was impressed with a presentation by Vivek R. Dabholkar, titled "Engineered DMC models with incremental mass balance constraints," and his comments on nonlinear control at the AIChE 2023 Spring Meeting. AIChE is an organization for chemical engineers. We're fortunate to take a break from the conversations with my mentor self and have Dabholkar, principal APC engineer at Ineos Group's olefins plant in Chocolate Bayou, Texas, give his view on new technologies.

GREG: What are your thoughts on recent developments in machine learning, deep learning and nonlinear controls?

VIVEK: On one hand, I want to embrace new ideas to implement them in industrial systems, keeping pace with modern developments, but underlying fundamentals tell me otherwise. The "sacred golden" principle of superposition is only valid for linear systems, no exceptions. In other words, one can't superimpose the effect of past independent moves along with the calculated future independent moves to calculate their combined effect on controlled variables. This is a fundamental hurdle in practical applications of so-called "nonlinear control."

GREG: How are linear controllers able to cope with the nonlinearity encountered in practice?

VIVEK: Over the years, APC engineers learned to implement global linearization of control valves with respect to flow. The range of operation change in the transformed valve, which is essentially a scaled flow, is linear with respect to flow. As a result, everything of interest in the transformed domain still behaves linearly, and the end results are anti-transformed, so they can be understood by the operators and engineers. This idea was also employed to control level in the horizontal drums within high/low limits by linearizing the level response accounting for the change in surface area based on the distance of level from the central plane.

Delta-Ps (differential pressure) in high-reflux columns have been transformed by using scaled internal reflux flow, log or piece-wise linear transformation for tower compositions, and the list goes on. Even for the hard problem of pH control, I came across "Characterizer for control loops" by F. G. Shinskey, May 1999, where both setpoint and PV of a pH control loop must be transformed. Essentially, the transformed pH PID output moves very slowly, where rise in pH is rapid because the perceived deviation seen by the PID algorithm is small in the transformed domain, but moves rapidly where change in pH is small or nearly "flat."

GREG: The benefits of using signal characterization to linearize process variables (PV) and manipulated variables (MV) are extensive. The dynamics from open-loop response tests aren't size- and operating-point dependent and filtering of noise is more effective. Without signal characterization, the open-loop, self-regulating process gain approaches the slope of the plot of PV versus MV for small steps, but becomes quite different for larger steps spanning various changes in slope. The change in slope can be a magnitude or more for pH systems and nonlinear installed flow characteristics of control valves. Without signal characterization, the beneficial effects of a process time constant from the residence time in a well-mixed volume can be lost.

GREG: How does a linear multivariable controller handle fast (front-end)/slow (back-end) dynamics, for example, in the case of an olefins plant where composite/CLP is implemented?

VIVEK: Since the steady-state targets for the front- and back-end constraints aren't dynamically aligned, APC engineers traditionally used CVStep (steady-state change in CV target) for up and down directions to limit total furnace feed movement, so feed is pushed slowly against the back-end (cold-side). There are issues with this approach, especially with respect to CVStep-down;

this is when MPC gives up on feed-limiting, back-end constraints for a few cycles depending on size of CVStep down. This is the main reason I don't like using small CVStep-down to restrict feed-cutting.

Often, the CVstep-up is programmed in a monotonically decreasing staircase pattern, knowing the history of total feed the back-end constraints can handle. But this results in abrupt changes to CVStep around the transition points. Based on total furnace feed, one can revise this based on smoother piece-wise linear function (PWLN) with respect to total feed. Unfortunately, even this approach leaves money on the table as feed pushing capability is greatly reduced during the summer vs. winter. I've used variable node values for total feed in the PWLN function to account for seasonality.

Another approach was first introduced by Doug Raven, an engineering specialist at Saudi Aramco. The idea is to push the front-end, feed flow-manipulated variable further into the future by using lower, move-suppression multipliers on furnace feeds. The lets the controller move smaller at first, so the back-end has a chance to respond. Care must be taken not to overdo it, or else important front-end furnace constraints, such O_2 and draft output may not be adequately honored dynamically.

GREG: Do you foresee any applications of machine learning in the chemical industry or refineries?

VIVEK: I see applications where a lot of manual steps are required with the lack of repeatability, for example, procedure-based decoking of furnaces. It would free operators from constantly watching the process over a long period of time and would lead to consistently safe transitions.

GREG: I think the potential for machine learning to supplement procedure automation for handling startups, shutdowns, transitions and abnormal operating conditions may be significant. I've extensively used procedure automation to automate difficult compressor and unit operation startups based on learning what operators have done and what first-principle dynamic process simulations confirm are good sequences.

Before we move on to machine learning we need to start with knowledge from plant operations, first principles, open loop tests, and what experts have documented in the ISA-TR106.00.01 and ISA-TR106.00.02 technical reports on procedure automation. See the Control Talk Column "Continuous improvement of continuous processes" with the leader of this technology.

A major concern is the unrealistic expectation that machine learning can replace PID and MPC in the process industries. For machine control, the dead times are usually insignificant, and the servo mechanism response is fast and precise. In the process industry, the dead times can be large and vary with operating point, and the control valves and variable speed drives have resolution limits, rate limits and dead band. Replacing PID and MPC is potentially unsafe.

GREG: What are the opportunities for neural networks?

VIVEK: I'm not an expert in application of neural networks, and I've yet to witness a working multivariable control application. Once again, the principle of superposition is a big hurdle. However, neural networks may be used in inferential measurement (soft sensor) development, with a good amount of validation and cross-checking on selected variables using PCA to avoid unreliable results. They can be used for pattern detection applied to fault detection and diagnosis by studying variable movements prior to, for example, equipment failures in the past. This know-how could then be applied to predict failures before they happen. They could also predict raw material prices based on past patterns among many variables and discrete events along with the current events that could trigger similar responses. ∞

Visit ControlGlobal.com for an extended version of this column and to see the Top 10 things you don't want to hear from executives.

What's left unsaid

Make sure that Ethernet protocols will perform as needed

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"Plug and test before implementation, or you may want to throw a little, plastic football at someone's head."

AMONG other beats, I've covered industrial networking, fieldbuses, Ethernet and wireless long enough to know their primary definitions and capabilities. I've observed how they've evolved over the years and where they're likely going. It's my loss that I've never plugged in anything more complex than a stereo speaker or laptop, but I've covered hundreds of people who developed, designed, integrated, installed and maintained them, and I remember much of what they had to say. The latest batch are in this issue's "Ethernet-APL gears up" cover story (p. 40).

At one long-ago tradeshow, I remember the debut of EtherNet/IP as the heir to the DeviceNet protocol. More than a few visitors were visibly upset. This was because many felt its promoters were trying to unfairly take over the Ethernet TCP/IP name that was long used to describe generic Ethernet defined by the IEEE 802.3 standards. It was as if someone had flagrantly overreached by trying to name their product "computer" or "Internet," and claim those well-known and long-accepted nouns for their exclusive use. I also recall that the booth or one near it was giving out little, green-and-white, plastic footballs, and several attendees had to restrain themselves from heaving them at the EtherNet/IP supporters.

Naturally, this initial outrage died down to barely a whisper over the years, and EtherNet/IP prospered. However, it remained as one of those gaps that never gets filled, particularly because some parties apparently keep making it wider. At least a dozen times over the years, sources have told me that EtherNet/IP is "open" and "interoperable" with devices using other Ethernet protocols. This bit of misdirection begins by using these two words interchangeably, even though they represent very different concepts.

The full deception is revealed when users learn that generic Ethernet is a physical-layer standard that only defines the wire and connections, while its Transfer Control Protocol/Internet Protocol (TCP/IP) only covers their interfaces. This means that many different protocols, such as EtherNet/IP, Profinet, Modbus-TCP and a few others, can be present on the same physical Ethernet network. However, their components can only talk to and interoperate with other devices that use the same protocol. Equipment using different protocols typically can't talk to each other directly.

Unfortunately, this situation seemingly hasn't changed with the advent of Ethernet-Advanced Physical Layer (APL) built using single-pair Ethernet (SPE) standard. Its physical networking can now reach devices in intrinsically safe (IS) applications, but if they're not using the same protocol, they can't talk and interoperate in hazardous areas either.

Oh sure, much progress has been made on adding switches and gateways that can translate between protocols. And, many of these functions have been combined in unified modules and/or taken over by software. Despite these improvements, translating between devices using different Ethernet-based protocols still requires added time, money and labor to implement, and adds latency to their communications.

More recently, advocates of the Ethernet-based protocols stop short of claiming outright interoperability for them, especially when faced with skepticism or pressed for details and proof. However, I can still feel what they want to promote, and I guess it's understandable. If you've been conflating "open" with "interoperability" for 20 years to preserve market share for a supplier, it's probably impossible to start truly advocating for users now. Heck, many suppliers used to claim that Ethernet itself couldn't be used on plant floors until they couldn't deny it any longer. Today, Ethernet is all over those plant floors.

Fortunately, more testing and plugfest events are being staged by users and system integrators to check that devices using Ethernet-APL and the other Ethernet-based based protocols will function as needed, and hopefully provide sufficient interoperability, too. So, plug and test before implementation, or you may also want to throw a little, plastic football at someone's head. ∞

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