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SLURRIES AND POSITIONERS

SPLIT-RANGE CONTROL

Good times

Pay is up, age and worry are down in our 2019 Salary Survey

JULY 2019

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Miscellaneous Manufacturers	6,982
Paper & Allied Products	2,856
Pharmaceuticals	3,945
Rubber & Miscellaneous Plastic Products	3,762
Stone, Clay, Glass & Concrete Products	1,686
Textile Mill Products	802
Tobacco Products	110
Total Circulation	60,003


TURCK
Mode
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Set

Certifiably responsible

The drive to prove sustainability is reaching all the way back to holes in the ground.

I'M nearing retirement and like an increasing number of us, facing it without a pension. We've done our best to stash away what we could, but it's not a fortune and a lot of it is in the stock market—in your companies—so naturally, we keep an eye on the economy and the Dow. We worry when we hear that the treasury bond yield curve has inverted (for three months now), that (as of July 1) this is the longest economic expansion in U.S. history, and that the president continues to threaten tariff increases (and rattle his saber) in ways that cast a shadow on our future.

But here in Northwest Indiana, nothing disturbs me more than a steel mill idling a blast furnace. On June 19, U.S. Steel announced it's shutting down two blast furnaces in the United States (one in Gary, Indiana and one near Detroit), as well as a third in Europe. ArcelorMittal announced previously that it was idling steel plants in Europe, but product mixes come and go. When you shut down a blast furnace—a source of new steel—due to overcapacity, that's chilling.

You might figure it's just due to competition from other suppliers, notably in China, and you might be right. Despite 25% tariffs on most foreign steel, prices of hot-rolled coil—a key metric—have fallen from their peak last year of $900 to less than $600 a short ton. Nine of the world's 16 largest steelmakers are in China, owned by central and provincial government. Tariffs or not, China knows how to make and sell steel, and no matter where in the world it's sold, other global suppliers feel the flood.

Cheap labor, cheap energy and cheap raw materials don't necessarily mean lower-quality steel, but they do tend to indicate higher costs in air pollution, energy efficiency, greenhouse gas emissions and quality of life for the workforce. As U.S. heavy industries struggle to attract competent, young employees, they're increasingly aware of their social profile—their environmental impact and influence on the many other issues of importance to the next generation.

So, what's a big, hot, stinky, dirty steel industry to do? How about developing a new certification standard that draws a distinction between responsible and irresponsible production? ArcelorMittal, other steelmakers, automakers and industrial associations have been working on "the steel industry's first, multi-stakeholder certification initiative that aims to set a single, global standard for the entire 'mine-to-metal' steel value chain," says Alan Knight, head of sustainable development, ArcelorMittal, as reported in my local paper, *The Times of Northwest Indiana*. Look for promulgation later this year.

Certifications of sustainability and responsibility aren't just for attracting new employees—they're also important to customers. Hence the involvement of some of steelmakers' largest clients, the automakers. Car companies care because, as other consumer goods suppliers raise awareness and expectations, their customers care. How can a Lafayette, Indiana-built Subaru mean "love" if making the steel it's built with exploited workers, filled the air with sulfur, and contributed to global warming?

Of course, pressure to demonstrate and document responsibility isn't only on steelmakers—it's just remarkable that its reaching back to ingots, melts, blast furnaces and iron ore mines. I'm sure most of you have felt the need to establish and provide proof of similar sustainable practices.

If not, well, you do the math. Many of the young people growing into consumers are noticing their lifespans exceed the coming global warming apocalypse. Their priorities are different from earlier generations.

As for little old retired me, I'd rather see my stocks soar on sustainability than a tariff-laden race to the bottom for air quality and wages. But if saving a little CO_2 means I have to cross the Hormel/Alpo line now and then, I can do that. So long as it comes in certifiiably sustainable and recyclable steel cans.

PAUL STUDEBAKER
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How can a Lafayette, Indiana-built Subaru mean "love" if making the steel it's built with exploited workers, filled the air with sulfur and contributed to global warming?

NEWS & BLOGS

Live from Honeywell Users Group
Our editors were on site at Honeywell Users Group last month to bring you the latest news, trends and insights from the event.
www.controlglobal.com/industrynews/2019/live-from-2019-honeywell-users-group-americas

Missed opportunities in process control - part 5
Greg McMillan provides the fifth part of a point-blank and comprehensive list of what we really need to know in an attempt to reduce the disparity between theory and practice.
www.controlglobal.com/blogs/controltalkblog/missed-opportunities-in-process-control-part-5

Unsecure sensor ecosystem can cause catastrophic damage
More than just a process sensor problem, a sensor ecosystem problem can make processes susceptible to cyber attacks.
www.controlglobal.com/blogs/unfettered/the-process-sensor-ecosystem-is-not-cyber-secure-and-can-cause-catastrophic-damage

AI improves crack detection in nuclear reactors
A system in development at Purdue University is poised to help operators detect cracks in nuclear reactors.
www.controlglobal.com/blogs/off-site-insights/ai-improves-crack-detection-in-nuclear-reactors

E-NEWSLETTERS

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Go to www.controlglobal.com and follow instructions to register for our free weekly e-newsletters.

How to postpone a migration

A must-attend event for professionals who plan to continue using legacy TDC2000/3000 control systems, this webinar at 2 p.m. EDT on July 31 will show how to support and maintain these systems to protect existing investments, avoid obsolescence, increase reliability and decrease the pressure of DCS platform migration. Monte Cadle, Azbil industry adviser, will share solutions for long-term support, resetting knowledge and skill sets, and how to return your current control network to its original performance and robustness.
https://info.controlglobal.com/webinars-2019-tdc2000/3000-how-to-postpone-a-migration

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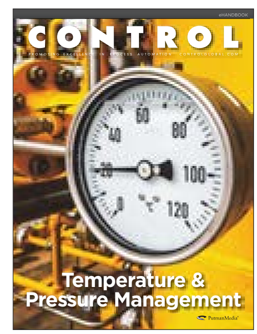
New temperature and pressure measurement ebook



The latest State of Technology ebook from the editors of *Control* tackles the topic of temperature and pressure measurement. Covering topics like diagnostics and validation, pressure transmitter problems, cascade reactor temperature control, compresser surge control and more, this eBook features the latest articles, case studies and trends. Process automation professionals are sure to find helpful information in this easily downloadable ebook. Get your copy now.
https://info.controlglobal.com/state-of-technology-2019-temperature-pressure

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Control Amplified: the process automation podcast

Make Control Amplified your go-to podcast for professional development. Executive editor Jim Montague is joined by experts like ARC Advisory Group's Craig Resnick and Larry O'Brien, Emerson's Bob Karshnia, and Seeq's Michael Risse to explore a variety of process automation topics from data analytics to the annual Top 50 suppliers. Control Amplified is available on Apple Podcasts, Google Play and most podcast apps. Download, subscribe and listen now!
www.controlglobal.com/podcasts/control-amplified

Share your thoughts on career development and gender diversity

Control has partnered with Putman Media's Influential Women in Manufacturing (IWIM) program to find out how industry is doing in terms of gender diversity and career development. Take this quick and anonymous survey to tell us if and how your company is encouraging gender diversity and career development. Your responses will contribute to a special report to be released in the fall, which will provide insights on several aspects of career development and gender diversity from the perspective of both men and women.
http://sgiz.mobi/s3/44c568d1cefe

Doubts the fake transmitter vector

Regarding Joe Weiss' blog (www.controlglobal.com/blogs/unfettered/the-ultimate-control-system-cyber-security-nightmare-using-process-transmitters-as-trojan-horses), I have my doubts if counterfeit transmitters would be the ultimate cybersecurity worry for the industry. A threat actor needs to worry about the efficiency/effectiveness of a cyber attack, and using counterfeit transmitters has a lot of disadvantages: it's a physical element, so more easy traceable to its roots. It can end up in many places in the plant, so very imprecise in delivery of the attack. It could mess up the transmitter settings, reverse range for example, but this would merely be experienced as a transmitter failure, something that happens regularly. The top-down path to the transmitter offers much more opportunities and flexibility.

Then there is the claim that a transmitter can be used to inject malware in the control system. Theoretically, there is a small path to do this, but a complex path. For example, to transfer data from a HART transmitter into the ICS would require some buffer overflow method that first needs to breach the HART modem software (either in the IO card of the controller or the IOMUX) by sending it data that doesn't meet the protocol limitations. If you managed to do that, the attacker needs a second buffer overflow in the controller that processes the data.

Then there are transmitters that connect directly to the Ethernet. These might become an issue with the rise of IIoT, but this class of transmitters is exposed to many cyber hazards, and should, in my opinion, only be used for monitoring purposes, not for control or safety.

But all of these considerations are taken into account in a cyber security hazop as part of risk analysis. For me, the biggest risk of counterfeit equipment is a physical risk leading to potential loss of containment.

SINCLAIR KOELEMIJ
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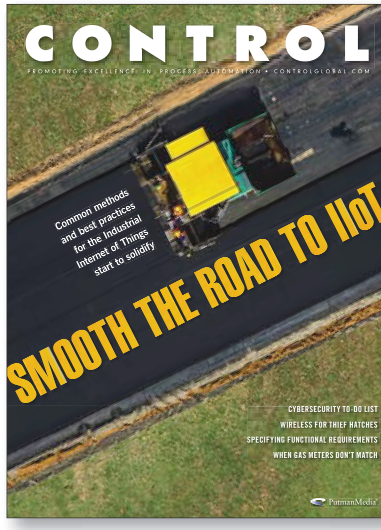

Fights the good fight

I've just read "Fake news" (June '19, p. 9, www.controlglobal.com/articles/2019/counterfeits-evolve-from-dangerous-crap-to-trojan-horses), and write to you from SnapDragon, where we fight fakes online. We monitor online marketplaces on behalf of our clients, removing illicit listings—and sellers—and gathering the data as we go for their future use. We're not lawyers, and don't use legal processes, but the official reporting procedures of the platforms themselves (in whatever language is relevant) and intellectual property relevant to the product.

SnapDragon was born out of defending our own products, so we've been at the receiving end of counterfeiters and piracy folk, and have felt the pain that ensued. Now the passion we put into defending our own brand, we put into working for and with our clients to defend their brand. Our aim is to empower businesses to understand and combat issues of intellectual property infringement, ensuring that corporate reputation, revenue streams and customer base are protected.

We have clients across many different sectors, including componentry. We, like you, are horrified at the lengths counterfeiters will go to.

MARY KERNOHAN
mary.kernohan@snapdragon-ip.com

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Measuring oceans and ice

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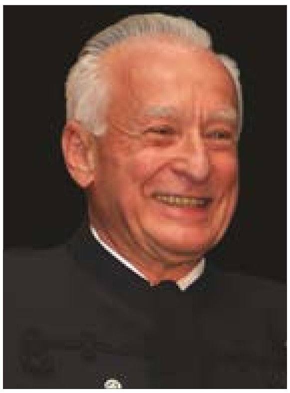

BÉLA LIPTÁK
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Accurate measurement of ocean levels must take into account that both the sea and the land experience vertical motion.

I'M optimistic about climate change, and not only because the 2018 United Nations Climate Change Conference has shown that mankind is waking up, or because in March, a 17-year-old girl was able to mobilize an estimated 1.6 million high school students in 125 countries around the world to protest the present inaction about global warming. I'm particularly optimistic because of the contributions our technology—the monitoring capability of the process control profession—are making.

Consider the fact that our scientific modeling was able to convincingly and accurately predict the future and thereby give us time to fix things. Consider that, based on measuring only a few millimeters of ocean level rise and less than a degree of global temperature rise, our models were capable of predicting that this process, if left uncontrolled, spells disaster for the future. This is a fantastic achievement!

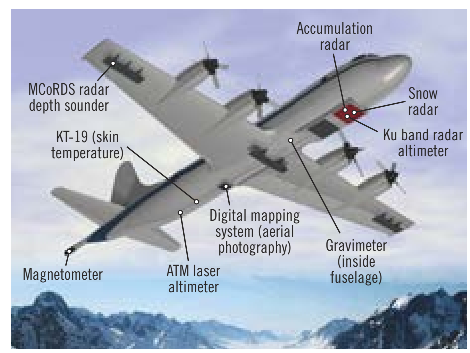
Here I'll focus on the accuracy of two additional measurements: the level of the oceans and the changes in the mass of the ice as polar and glacier ice formations melt. Accurate measurements are important not only to resolve the debate between denialists and alarmists, but also to establish the dynamics of the global warming process, so we can more accurately predict its speed, time constants, rate of rise and tipping points.

Accurate measurement of ocean levels must take into account that both sea and land experience vertical motion. Land can move vertically due to glacial and tectonic processes. Sea level is affected by tides caused by the gravitational forces of the moon and sun, and by "weak tides" (also called meteorological tides) generated by winds. Because these measurements are on the scale of millimeters, not only accurate detectors but sophisticated models are needed to correct observed sea levels for the effects of regular and meteorological tides.

The level models depend on two measurements. One is the relative sea level (the height of the water relative to the land), which is corrected for any earth movements. The second measurement is provided by satellite altimeters, which measure the distance between the ocean's surface and the center of the Earth. (Some of the following paragraphs are taken from a NASA document at https://sealevel.nasa.gov/understanding-sea-level/global-sea-level/ice-melt.)

Accurate altimeters

Laser altimetry: By the 1990s, laser altimetry from aircraft revealed thinning of the ice sheets on Greenland's coastal margins [Abdalati, et al., 2001] and

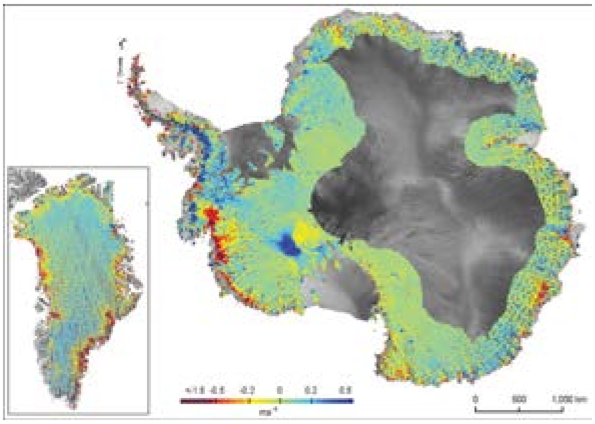


AIRBORNE TOPOGRAPHIC MAPPER

Figure 1: NASA's P-3B four-engine turboprop is equipped with radar and laser altimeters to measure annual changes in thicknesses and movements of ice. Source: www.nasa.gov/mission_pages/icebridge/instruments/p3b.html

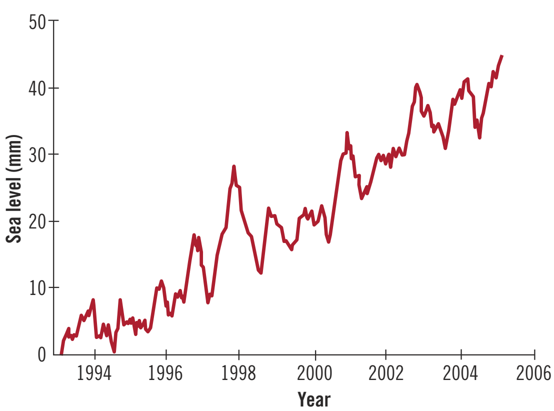
SATELLITE MEASURES SHEET ICE

Figure 2: NASA's ICESat2 (cloud and land elevation satellite) accurately measures ice sheet thickness at an accuracy of the width of a pencil. Source: www.click2houston.com/news/national/nasa-to-launch-laser-device-into-space-to-measure-earths-polar-ice



SATELLITE ALTIMETRY SHOWS ICE THINNING

Figure 3 : These photos from NASA's Ice, Cloud and Land Elevation Satellite reveal areas of dynamic thinning (red) in Antarctica and Greenland (left). Source: https://sealevel.nasa.gov/understanding-sea-level/global-sea-level/ice-melt



SEA LEVEL BY SATELLITE

Figure 4: The advent of gravimetric measurements with the twin Gravity Recovery and Climate Experiment (GRACE) satellites in 2002, along with more recent deployment of floating Argosensors, opened the way to closure of the sea level budget (when the sum of observed ocean mass and density changes equals total sea level change). Source: http://ossfoundation.us/projects/environment/global-warming/sea-level-rise

later surveys, using NASA's Airborne Topographic Mapper, showed a further increase in that thinning [Thomas, et al., 2009]. NASA's P-3B is a four-engine turboprop equipped with radar and laser altimeters (Figure 1). Researchers use highly sophisticated airborne instruments on these retrofitted aircraft to measure annual changes in the thicknesses and movements of the ice.

Satellite altimetry: A new NASA satellite, Ice, Cloud and land Elevation Satellite (ICESat2) was launched in September 2018 (Figure 2). It's expected to gauge future changes of the Greenland and Antarctic ice sheets at an accuracy of the width of a pencil. In the Arctic, NASA's Icebridge operation studies the effect of the polar ice on the Earth's climate. ICESat2 measures the time it takes for laser beams to travel from the satellite to Earth and back. Based on that information, scientists can accurately calculate the height of glaciers, sea ice, etc.

This is the largest airborne operation to survey polar ice, and it's designed to plug the gap between ICESat that ceased functioning in 2003 and the launch of ICESat2 in September 2018. Researchers used data from these yearly surveys to determine the rate of ice melting, and found it was increasing [Thomas, et al., 2011]. The study also relied on data from NASA'S Airborne Topographic Mapper, as well as the University of Kansas' ice-depth sounder, both of which have made almost yearly surveys since 1991 of the Jakobshavn Isbrae glacier in Greenland, and since 2002, of the Pine Island glacier in Antarctica.

The early 1980s saw the first attempt to measure ice sheet thicknesses using satellite radar altimetry, with observations of only limited parts of Greenland and Antarctica [Remy and Parouty, 2009]. The ice thickness on Greenland is about a mile, and about three miles on Antarctica. Since then, however, altimetry technology has advanced a great deal and became an important means of determining ice sheet and glacial mass balance, measuring the gains and losses in ice mass. While the primary measurement is by laser altimetry (ICESat2), with high accuracy and a very small footprint, radar altimetry was also used in the European Space Agency's (ESA) CryoSat-2 mission.

Radar interferometry: Satellite synthetic aperture radar interferometry techniques measure the speed at which ice streams move, as well as the position of the grounding line, which separates ice grounded over bedrock from ice floating on the ocean, as it breaks off from the same ice stream. One example of the power of this technique was the measurement of the retreat of Antarctic glaciers [Rignot, et al., 2014]. The researchers used data from the European Remote Sensing (ERS) 1 and 2 synthetic aperture radar to measure the rapid retreat of the glaciers in West Antarctica. The study produced color-coded maps (Figure 3) of the velocity of recession for the glaciers, which showed movement of the glacial grounding lines.

Satellite gravimetry: The advent of gravimetric measurements with the twin Gravity Recovery and Climate Experiment (GRACE) satellites in 2002, along with more recent deployment of floating Argosensors, opened the way to closure of the sea level budget—that is, when the sum of observed ocean mass and density changes equals total sea level change [Leuliette and Willis, 2011].

GRACE measures changes in water mass, including terrestrial storage in the form of groundwater, rivers, snow and ice, and mass changes in the ocean itself, as well as the movement of water between land and ocean (Figure 4).

Early attempts didn't achieve closure of the sea level budget for four-year trend lines [Willis, et al., 2008, Chang, et al., 2010], leading to concerns about possible instrument drift. However, more recent efforts led to reports of closure for more extended periods, including a NOAA report, "The Budget of Recent Global Sea Level Rise, 2005-2013" by Eric Leuliette, covering 2005 to 2013. ∞

Minding your things

Critical valves are a fine opportunity for applying smart sensors and self-diagnostics.

JOHN REZABEK
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Maybe such a large valve shouldn't be expected to respond to such a small change, but if the valve was sticking, was it going to jump and overshoot the desired position, upsetting the process?

THE 24-in., characterized-seat ball valve was one of the minority of instrument "things" in the plant that constituted a single point of failure, bringing all production to a halt immediately if, for example, it failed open. Like many continuous process plants, an outage would mean a day or more of lost production, unusual wear and tear on equipment and catalyst, and increased risk for operators forced to engage in many non-routine procedures. That it was the anti-surge valve for the facility's un-spared, turbine-driven air compressor was another reason to be mindful of its health—damaging this turbomachinery through an unmitigated compressor surge event could mean weeks instead of days of downtime.

It stood to reason that operators were skittish about its health when they noticed it didn't consistently respond to small position setpoint changes. One click, two clicks of the mouse, but no movement. Each click was less than a half-percent change in setpoint; even if you climbed to the top deck of the reactor where it was located, you'd be challenged to visually detect such a small move. Maybe such a large valve shouldn't be expected to respond to such a small change, but if the valve was sticking, was it going to jump and overshoot the desired position, upsetting the process?

Operations entered a work request to pull this valve for overhaul in the next outage, months away. It's not small and being high in the structure, requires a large crane to bring it down and reinstall it. Wouldn't it be great, one imagines, if we could precisely determine this valve's condition and confirm it needed an overhaul?

That operators could even detect their setpoint changes weren't getting the valve to move was evidence they had feedback from a smart positioner. Controller I/O capable of HART or fieldbus communication can be used to display the valve position "as seen by" its positioner. Since it had been in the MMI graphics for years, operators were accustomed to observing whether a valve was moving to its desired position, sticking or unstable. Valve position feedback—if reliable—is interesting and useful information for routine operations as well as control systems troubleshooting.

Valve positioners were among the first instruments to become "smart," i.e., microprocessor-based and capable of self-diagnosis. Even before smart positioners were commonplace, experts could be engaged to hook up sensors to laptops and assess (offline) whether a given valve was healthy or not. This particular valve's positioner had been smart for nearly two decades. You'd think that a critical "thing" such as this would get some measure of routine inspection—"Let 's see how it's doing today"—whether it was weekly or even monthly. Indeed, there are probably a number of critical valves that warrant routine attention, control valves whose health and performance have an immediate impact on operations. But who wants to tinker with critical positioners that are functioning adequately?

If you're fortunate enough to have a system that can communicate with smart devices, consider an investment in a late-model positioner. One can license access to features like on-process diagnostics to automatically monitor for a number of trigger events, such as a sustained deviation between setpoint and measured position, whereupon the positioner gathers data from its numerous internal sensors—supply pressure, actuator pressures, position sensors, drive signals, etc.—at 100-ms intervals. The HART version will store this data in a buffer for a minute or two after the trigger event, while the fieldbus version will store the data for both two minutes preceding and two minutes after. These records are preserved and can be examined offline, and sent to a specialist at your representative or the factory.

Even without a host system, diagnostic data from critical valves can be retrieved using a handheld communicator or a laptop/tablet running diagnostic software. If you're looking to get started on utilizing "intelligent" devices to avert unplanned outages and better prepare for scheduled shutdowns, deploying smart valve positioners on critical valves is a great place to start. ∞

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Slurry flow measurement

Even ordinary process fluids can present problems due to suspended solids.

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If you suspect solids may occur, it's always a good idea to rotate your meter or impulse line by one bolt hole to keep the important parts of the instrument away from settling materials.

FLOW measurement is important, especially when it's a custody flowmeter that's also the cash register. Obviously, there are many standards related to accurate flow measurement, including upstream and downstream straight-run rules to assure a nice, clean profile through the meter.

But very few process streams are 100% single-phase, with most having either small bubbles or low levels of solids. These are normally suspended close to homogenously, so the fluid still behaves as if it were single-phase, therefore not affecting the measurement. Once they start having a noticeable number of solids—less than 200 microns primarily by accident, non-settling slurry with specific gravity less than 1.05, and less than 5% solids by weight—streams are considered a "light slurry." Most of the time, until the second phase constitutes a significant percent of total fluid fraction, the fluid can be treated as a single phase.

Low levels of solids may be (and likely are) present in your process, even though you don't think so. If your flowmeter is downstream of a catalyst bed or some other process vessel with solids, chances are there will be some carryover, particularly during startup. Similarly, almost every well will contain some level of entrained solids, which normally continue with the liquid stream until they're removed in dedicated vessels. However, during different stages of plant operation, such as startup and shutdown, when the stream is at other than steady-state, even low levels of solids can have an impact.

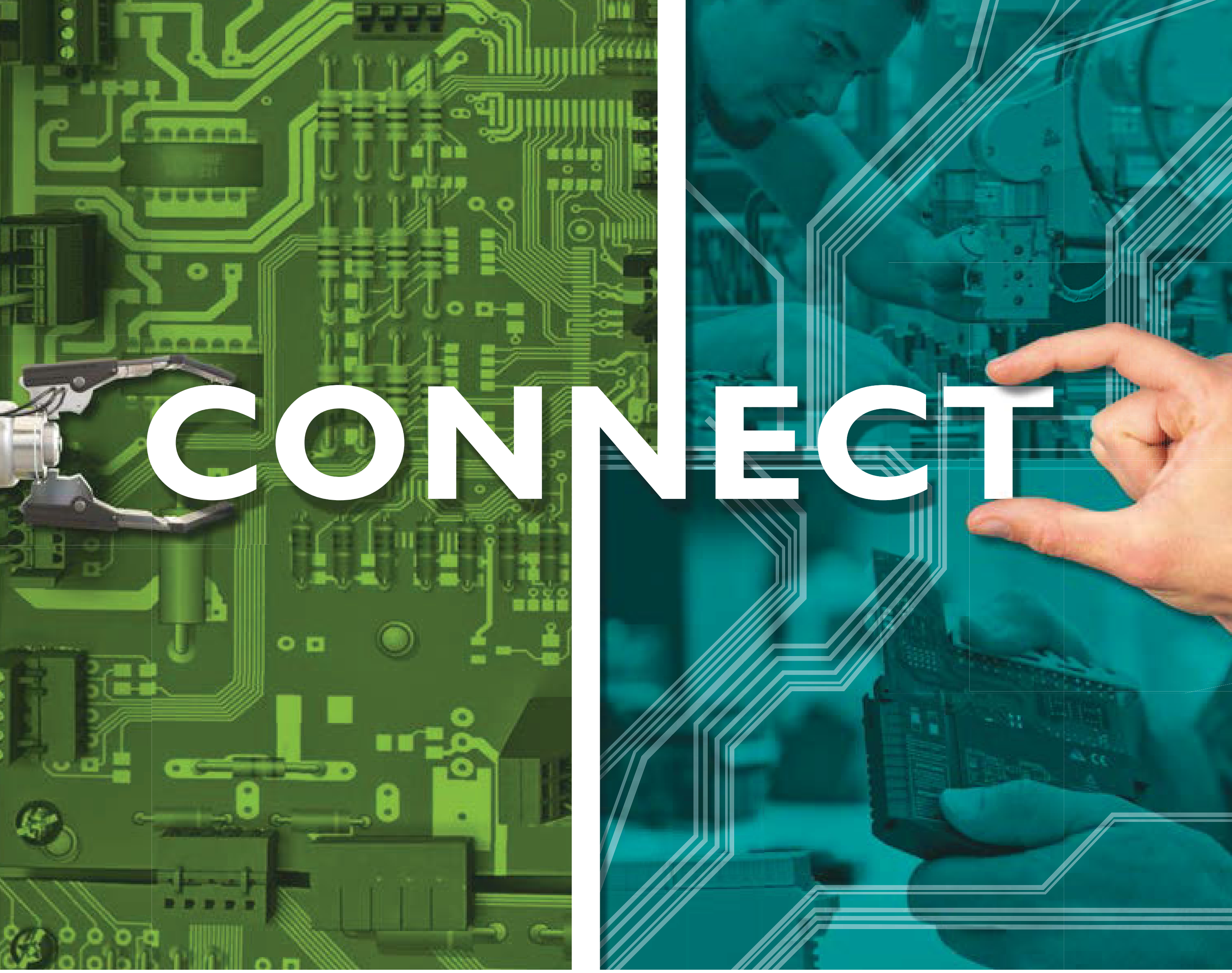
Suspended solids at low levels that will not affect a single-phase measurement (other than perhaps higher wear) may not always stay suspended, especially if the flow is stopped. Without the fluid velocity to keep them in suspension, they will settle to the bottom of the pipe. This may affect a wide range of flowmeters, especially if they have some part of the sensor in this position. Therefore, if you suspect solids may occur, it's always a good idea to rotate your meter or impulse line by one bolt hole to keep sensitive parts of the instrument away from settling materials.

In many cases with a light slurry, some meters will no longer work and the application will require special meters to handle the solids. Typical flowmeters used for slurry streams are ideally non-intrusive or venturi because they have less sudden change in the flow path. When using a venturi meter to measure a slurry that's severe due to either the type or size of solids, the meter internals are often coated with a hardened material, which adds roughness at the sacrifice of accuracy, or is fitted with a hardened cast lining that can be replaced when the accuracy falls below what's acceptable. Fortunately, these meters are rarely used for custody transfer, but more for plant balance and simple regulatory control.

The above examples apply for light or even medium (5-20% solids) slurries. However, in mining, "real" slurries with targets of close to 40% solids are often used in hydro transport technology where the solids are mixed with water and transported via pipeline relatively long (tens of miles) distances. One variable that needs to be controlled with hydro transport is the solids ratio, to prevent settling while still minimizing the amount of water being recycled.

Oil sands mining takes this concept one step further by going from two-phase, solid/liquid flow to four-phase flows of vapor(air), bitumen, water and solids (4-in. to micron size), where it's necessary to maintain both the solids content as well as the air content in the line. The good news is that with the help of industry and oil sands researchers, this has been done reliably for many years. The how is a story for another day, though I did enjoy working in this challenging environment.

Like many other field sensor applications, flow may seem relatively straightforward. However, like many other parts of our industry, there are also many ways for the process to be "not as it appears," and as a result, the opportunity arises to excel or fail miserably. Small details, such as low solids concentrations, can have a significant impact on your measurement—even though the stream may not be considered a slurry. ∞


CONNECT

Honeywell reframes digitalization vision at HUG

44th annual Honeywell Users Group (HUG) Americas 2019 draws more than 1,400 attendees

TO give users much-needed assistance as digitalization emerges in process control and automation, Honeywell Process Solutions (HPS, https://honeywellprocess.com) launched Experion PKS Highly Integrated Virtual Environment (HIVE) and Honeywell Forge for Industrial software on the first day of its Honeywell Users Group (HUG) Americas 2019 conference on June 10 in Dallas.

HIVE is a new approach to engineering and maintaining industrial control systems that simplifies control system design, implementation and lifecycle management, and reduces costs by decoupling I/O module assignments and control strategies from specific controllers, and leveraging IT capabilities in existing data centers. in his keynote address kicking off HUG 2019, John Rudolph, HPS president, said HIVE addresses four challenges: aging infrastructure costs, visibility of operations and risk status, lost of critical skills, and churning technology.

Honeywell Forge provides actionable recommendations, highlighted with potential economic impact, for intelligent business and operations decision-making. Based on process and asset digital twins as well as comprehensive, role-based analytics, Forge software enables enterprise-wide visibility and helps sustain overall performance of processes, assets, people and safety.

"Engineers don't want to do work over, but they do want to build on what's been learned before," Rudolph said. "This is what's really fun, but they need a way to prove it. That's why Experion PKS HIVE lets them link to and demonstrate their success."

Decoupling = freedom

Rudolph reported HIVE's primary attribute is that it separates hardware from software for much greater flexibility. "This lets users see their full control system on a laptop, which means dramatic operational improvements," he explained. "For instance, PLC functions are now on a server, instead of being daisy-chained together as they were in previous control environments. This means one system can quick scale up from being just one RTU to 100 PLCs to a full DCS, and be engineered from the edge to its HMI with solid solutions on each end."

DEALING WITH DIGITALIZATION
John Rudolph, president of Honeywell Process Solutions, introduces Experion PKS Highly Integrated Virtual Environment (HIVE) and Honeywell Forge for Industrial software during his June 10 keynote address at HUG Americas 2019 in Dallas.

HIVE can enable other disciplines, such as operator training simulations (OTS) and process safety. "Where process safety reports and responses could previously take two weeks, Experion PKS HIVE can base its safety reporting on live events and alarms," added Rudolph. "Each user can now see their individual contribution, know what success is, and how they contributing to their company."

Built-in knowledge

Meanwhile, Honeywell Forge converts data from equipment, processes and people into intuitive, actionable insights that enable monitoring of enterprise operations from a single screen, helping customers to optimize the efficiency, effectiveness and safety of their businesses. The software is designed with a hardware- and software-agnostic approach that allows it to be used with existing systems. It leverages predictive analytics to identify maintenance issues before they happen, and enables workers to be more productive, proficient and safe; reduce costs; and increase productivity.

Forge software includes four primary modules:

- Process Reliability Advisor module uses real-time operating data to detect and diagnose issues to improve unit performance. It leverages Honeywell UOP's comprehensive process expertise to assess process constraints and proactively mitigate operational issues.
- Process Optimization Advisor module yields expert operational recommendations to utilize assets effectively and derive maximum profitability. It provides an optimal set of operating conditions, based on customer economics, for the unit to run at minimal cost and waste.
- Profit Performance Monitor module identifies degradation of unit performance and provides expert guidance through actionable instructions to maintain unit profit performance, and it provides visibility into economic consequences of plant process performance as a cost of lost opportunity.
- Asset Performance Management module yields predictive analytics that deliver early insight on impending issues, as well as integrated process and asset data models that identify untapped productivity.

For all the coverage from HUG 2019, visit www.controlglobal.com/industrynews/2019/live-from-2019-honeywell-users-group-americas

CSIA announces new board

The Control System Integrators Association (CSIA, www.controlsys.org) announced its new board of directors during its recent 2019 Executive Conference in Asheville, N.C.

Luigi De Bernardini, CEO of Autoware S.R.L. in Vicenza, Italy, was named board chair. He replaces Jeff Miller, project management director at Interstates Control Systems Inc. in Sioux Center, Iowa, who remains on the board as immediate past chair. Other new members include treasurer Adrian Fahey, CEO of Sage Automation in Tonsley, Australia, and new members Karen Griffin, controls and automation division leader at Hargrove Controls + Automation in Mobile, Ala.; Frank Riordan, president of DMC Inc. in Chicago, and Greg Young, director of business development at Automation NTH in Lavergne, Tenn. They join current members Howard Huffman, CEO of Huffman Engineering Inc. in Lincoln, Neb., and Stephen Malyszko, president and CEO of Malisko Engineering Inc. in St. Louis.

OPAF employs ISASecure

ISA (www.isa.org) and the ISA Security Compliance Institute (ISCI, www.isasecure.org) reported June 27 that the Open Group's Open Process Automation Forum (OPAF, www.opengroup.org/open-process-automation/forum) will use ISASecure cybersecurity certification specifications to test OPAF's prototype O-PAS-compliant components. ISASecure certifies to the ISA/IEC 62443 cybersecurity standards. They're designed to make sure automation, control systems and IoT devices are free of known vulnerabilities, robust against network attacks, and meet security capabilities defined in the standards.

Under this arrangement, prototype O-PAS components will receive assessment reports based on ISASecure. The first ISASecure, ISO 17065-accredited certification body, exida, will conduct O-PAS assessments via a special arrangement with ISASecure. When market-ready O-PAS components become available, they can be submitted for certification testing to any one of the ISASecure, ISO 17065 accredited certification bodies, and receive globally recognized ISASecure certificates of conformance to ISA/IEC 62443.

PCB makers, GOP reps call for tariffs against China

Several local printed circuit board (PCB) manufacturers and national Republican officials met June 22 in suburban Chicago to demand sustained, targeted tariffs against China, which they claim will return thousands of jobs to the U.S.

Staged at the Rana-Reagan Community Center in Carol Stream, Ill., the event was attended by about 350 individuals, who heard speeches by Steve Bannon, former Trump Administration strategist; U.S. Air Force Lt. Gen. Steven Kwast; U.S. Rep. Chris Stewart (R-Utah); Frank Gaffney, founder and president of the Center for Security Policy; and others presenters; and also viewed video messages from former U.S. House Speaker Rep. Newt Gingrich and other experts.

"It's important for people to hear that China is not playing by the rules, and destroying jobs by refusing to allow fair competition," stated Gingrich. "It's important for business people to be hard-nosed when foreign governments cut production costs on technology products to one-third, so others can't compete. This why we're asking everyone to reach out to their governmental representatives, and insist that China not be allowed to cheat."

The event was presented by the Republican Hindu Coalition (www.RHCusa.com) and the National Indian-American Public Policy Institute (www.NIAPPI.com), both founded and supported by Shalli Kumar, who is also the founder of the AVG Group of Companies (www.avg.net), including EZAutomation (www.ezautomation.net).

"The U.S. lost 3.54 million jobs during 2000-2007, including 50,000 in the nearby Elk Grove Village industrial park," said Kumar. "This was the premeditated murder of U.S. jobs focused on PCB manufacturing and assembly. Part of AVG's business was in PCBs as the third-largest U.S. manufacturer and a top-20 assembler, employing thousands in our U.S. facilities. This center used to have 600 staff in 60,000 square feet, but there was no business after the Chinese invasion, so we donated it to the suburban Chicago's Hindu community. This is why we need sustained tariffs, but we also need them on finished goods, and not just on components. Tariffs could bring back 80% of the jobs we lost."

Kumar reported that China sold PCBs at one-third the cost of boards in the U.S., which was less than the cost of materials. "For 20 years, the strategy of China's communist party has been de-industrializing our country with the help of Wall Street and London. Turning this around will be a long struggle that won't return jobs immediately, but it will succeed long-term if we force Wall Street and Washington to do it."

Vikram Kumar, CEO and chairman of AVG, added that, "Lots of electronics are exported from China to the U.S., so if we had strong tariffs, hundreds of thousands of jobs could be brought back to the U.S. However, we need the right tariffs, not just on products, but on all components in the assembly process. Of course, AVG makes HMIs, PLCs and controls, so we know many of these tariffs would negatively affect us and our components, too. However, we committed long ago to not move our manufacturing and jobs to China, so even though our bills of materials (BOM) could go up 25% and it will be even harder for us to compete, we're still saying to go ahead with tariffs because they'll bring back 200,000-300,000 jobs."

DYNAMIC DUO

Shalli Kumar, founder of the AVG Group of Companies, and Steve Bannon, former Trump Administration strategist, headlined a gathering of manufacturers and GOP officials on June 22 to call for sustained, targetied tariffs against China.

Metso separates minerals, flow divisions

Metso (www.metso.com) reported June 18 that its board of directors has decided to develop the company's minerals and flow control businesses separately.

"All Metso's businesses and these two segments have attractive growth opportunities. Capitalizing on these opportunities will call for efficient decision-making and allocation of resources," said Pekka Vauramo, president and CEO of Metso. "However, our businesses have significant differences relating to customers, cyclicality, growth drivers, sales channels and product development. This is why we made the decision to develop our minerals and flow control strategies separately from each other. In addition, minerals and flow controls share a limited amount of synergies, the majority of which are administrative, so the separation will make the preparation and implementation of their respective strategies more efficient."

The minerals segment includes equipment and services sold to mining and aggregates customers, as well as the recycling business. The flow control segment consists of valves and related services sold to various process industries. The company adds its decision won't impact its organizational structure or external reporting.

In addition, the board appointed Olli Isotalo as president of Metso's valves division. He starts in his new role on July 15, and will become a member of Metso's executive team. Isotalo has previously served as CEO of Patria Oyj. ∞

SIGNALS AND INDICATORS

- **ABB** (www.abb.com) reports it's appointed Maryrose Sylvester as country managing director (CMD) and head of electrification for the U.S. effective on Aug. 1. She will succeed Greg Scheu, who will support a smooth transition until he retires at the end of October 2019. Sylvester was most recently president and CEO of Current, powered by GE, which is a GE startup business.
- **Brooks Instrument** (www.brooksinstrument.com) reports it will again offer a $2,000 engineering scholarship for undergraduate students enrolled in an engineering program at an accredited college or university. Applications must be received by Oct. 31 at www.brooksinstrument.com/en/about-us/scholarship.
- **FDT Group** (www.fdtgroup.org) announced June 25 that it's approved the FDT IIoT Server (FITS) specification for release to the FDT membership for final review. Slated for release by the end of 2019, the FITS standard will enable open, secure and flexible deployment architectures and sensor-to-cloud integration with embedded OPC Unified Architecture (UA) and web servers, as well as built-in security features and multiple deployment options.
- **The Industrial Internet Consortium** (www.iiconsortium.org) announced June 24 its IIoT Maturity Assessment, a web-based, self-service survey tool included in the IIC Resource Hub that enables users to better understand their enterprise IIoT maturity. IIoT Maturity Assessment helps organizations become best-practice adopters of IIoT by guiding business managers through a range of questions about the adoption, usage and governance of IIoT in their organizations.
- **Omron Corp.** (www.omron.com) reported June 18 that it's appointed Andy Zosel as the new president and CEO of its Omron Microscan division. Zosel joined Microscan in 1997 as a design engineer, and has held several leadership positions in customer service, marketing and engineering.
- **Mitsubishi Electric Automation Inc.** (MEAU, https://us.mitsubishielectric.com) named Scott Summerville as its new president on June 19, filling the position formerly held by Toshio Kawai. Before joining Mitsubishi Electric, Summerville had been the CEO of Omron Microscan since October 2017.

Power supplies juice process controls

Control's monthly resource guide

RELIABILITY WHITEPAPER

This 16-page technical whitepaper, "Power supply reliability" by Mark Timieski and Robert Schosker, covers built-in redundancy and diagnostics, power reliability with minimal configuration, network data delivery, and standards and efficiency. It's at https://files.pepperl-fuchs.com/webcat/navi/productInfo/doct/tdoctb0l8__usa.pdf?v=29-AUG-18

PEPPERL+FUCHS
www.pepper-fuchs.com

BASICS OF DISTRIBUTION

A 40-minute webinar, "Basics of industrial power distribution and factory automation for non-technical professionals" by Craig Edlin, covers electricity concepts, power distribution, circuit protection, controls, electric motors, PID control and related components. It's at www.youtube.com/watch?v=dXHfuflbpSc

ABB
www.abb.com

DESIGN, SETUP A 4-20MA LOOP

An online whitepaper, "Fundamentals, system design and setup for the 4-20 mA current loop," covers use of current to transmit transducer data, current loop components, transmitter and current-measuring DAQ choices, and power supply selection. It's at www.ni.com/en-us/innovations/white-papers/08/fundamentals--system-design--and-setup-for-the-4-to-20-ma-curren.html

NATIONAL INSTRUMENTS
www.ni.com

UPS PRESENTATION

The four-minute video, "UPS basics" presented by Josh Bloom, shows how offline and online uninterruptible power supplies (UPS) provide emergency power to a load when regular input power is lost, and demonstrates how a UPS can protect against voltage spikes or surges. It's at www.youtube.com/watch?v=KEnEOtltZZQ

RSP SUPPLY
www.rspsupply.com

PLC POWER VIDEO

The five-minute video, "How PLC power supplies work" by Kevin Cope, shows how controllers convert and step down AC line voltage into usable DC current, which powers the rest of the PLC and its components. It's accompanied by a blog on the same topic. The video is at www.youtube.com/watch?v=Cl8Uwe1tJ3E

REALPARS
https://realpars.com

LINES, LOOPS AND 4-20 mA

This three-part series of web pages, "Back to basics: the fundamentals of 4-20 mA current loops," "Back to basics: the fundamentals of loop-powered devices," and "Back to basics: the fundamentals of loop vs line power" by Simon Paonessa provide some history; show how process control applications are powered; cover 4-20 mA loops, parts and pros and cons; define loop-powered devices and their advantages; and examine two-, three- and four-wire connections. They begin at www.predig.com/indicatorpage/back-basics-fundamentals-4-20-ma-current-loops

PRECISION DIGITAL CORP.
www.predig.com

DIGITAL INTRO PAPER

A 30-page paper, "A practical introduction to digital power supply control" by Laszlo Balogh, traces how digital technologies are applied to power supply management, and clarifies digital control for analog power supply designers. It also covers the benefits, limits and performance of digital power control, and compares analog to digital implementations. It's at www.ti.com/lit/ml/slup232/slup232.pdf

TEXAS INSTRUMENTS
www.ti.com

DISTRIBUTED AND REDUNDANT

A two-minute video, "UPS: distributed redundant systems," reports a distributed redundant system (DRS) is the most reliable UPS configuration for reducing downtime because it uses two UPSs that each support their own distribution system with no power connections between them. It's at www.youtube.com/watch?v=HvqcLOGXoN0

TITAN POWER INC.
www.titanpower.com

DIY LAB SUPPLY SERIES

This series of six 30-40-minute videos, "Lab power supply" by Dave Jones, shows viewers how to design a simple, constant-current, constant-voltage lab power supply that can be controlled by a microprocessor and software, or employ a traditional pot. They're located at www.youtube.com/watch?v=CIGjActDeoM

EEVBLOG
www.eevblog.com

ELECTRONIC SUPPLY BASICS

Three five- to eight-minute videos, "Basic Electronic Power Supplies," parts 1-3 by Lewis Loflin, cover all the basic concepts of power supplies, construction and rectification. They begin at www.youtube.com/watch?v=x3Z7lyKG3g0

BRISTOL WATCH
www.bristolwatch.com

If you know of any tools and resources we didn't include, send them to ControlMagazine@Putman.net with "Resource" in the subject line, and we'll add them to the website.

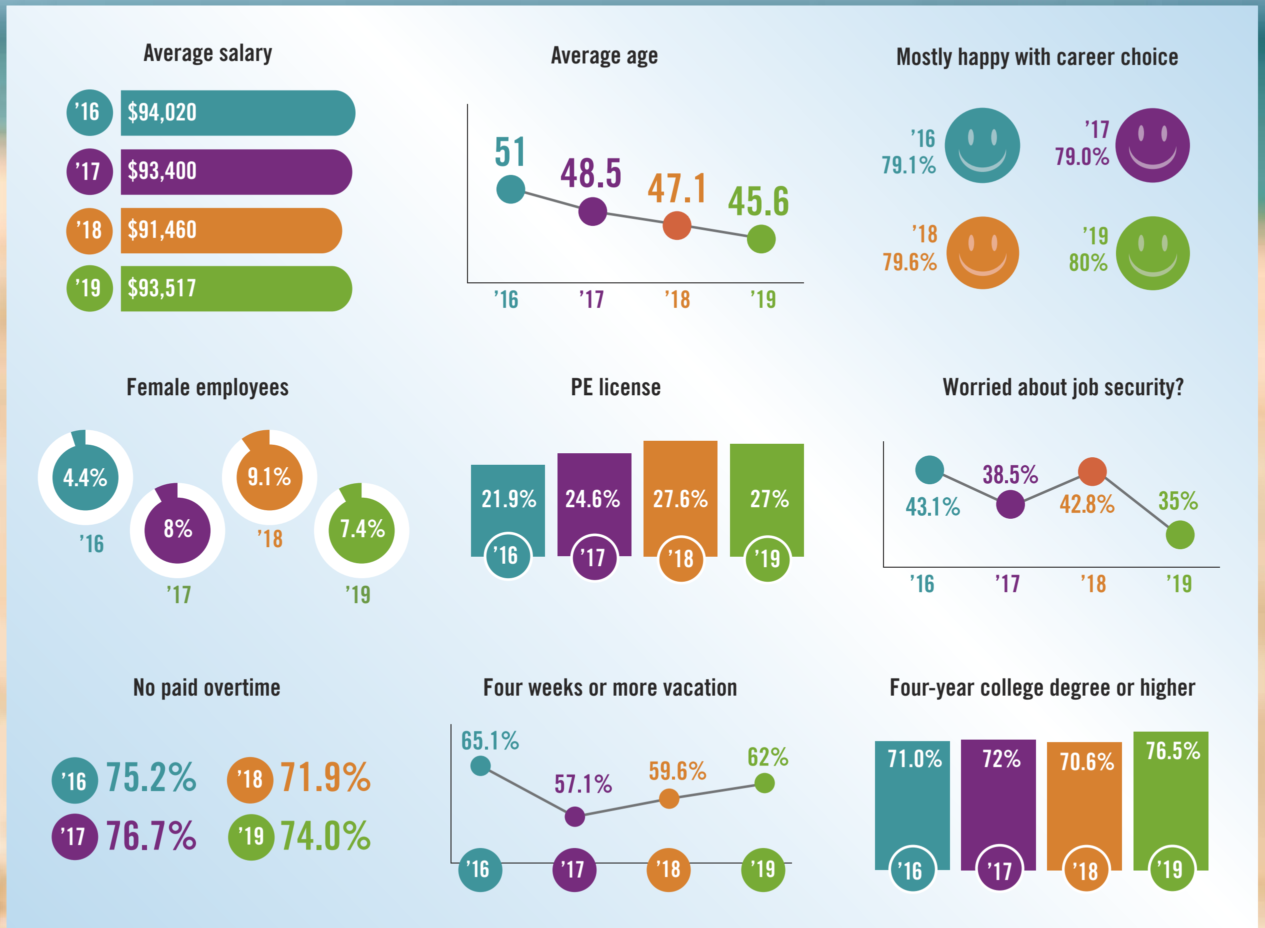
Good times

by Jim Montague

Age and worry down. Pay up anyway. Benefits dip. Social media and IIoT gain.

THE young get richer—amazingly and maybe logically. Following three straight years of declines in average age and two years of decreased average salaries, the more than 500 respondents to *Control*'s annual salary survey reported their 2019 average pay increased by 2.2% from $91,460 last year to $93,517 this year, even though their average age continued to fall from 47.1 years to 45.6 years during the same period.

At first glance, this result can seem counterintuitive because the younger, less-experienced personnel entering the process industries typically earn far less than their older, more-experienced counterparts. These veterans are, of course, retiring in accelerating numbers, which depletes the institutional expertise and tribal knowledge their applications and organizations need to run optimally and handle unusual situations. However, even though youth and smaller salaries should go hand in hand, the unexpected 2019 pay hike likely shows that retirement-driven brain drains are finally driving employers to compete more intensely by offering higher salaries to secure replacements. Likewise, this year's group also reports higher percentages receiving four weeks of vacation or more, experiencing less worries about job security, and earning four-year college degrees or higher, though slightly more aren't paid for overtime (Figure 1).



YOUTH PAYS DIVIDENDS

Figure 1: After two years of overall decreases in pay, respondents to Control's 2019 salary survey reported a 2.2% increase in average salary this year, even though their average age continued to decrease for the third straight year. Likewise, the percentage receiving four weeks or more vacation jumped significantly, even as slightly more are working unpaid overtime. Meanwhile, women respondents dipped to 7.4% after two years of increases.

	2016	2017	2018	2019
Received raise up to $4,000	87.0%	82.9%	81.6%	81.5%
Received bonus	57.1%	66.1	64.1%	64%

RAISES, BONUSES HOLD STEADY

Figure 2: Both the percentage of pay raises up to $4,000 and bonuses appear to have remained steady over the past two years. Before that, raises declined slightly, while bonuses increased.

	2016	2017	2018	2019
Medical insurance	91.4%	90.2%	89.7%	85.4%
Dental insurance	74.3%	72.8%	70.0%	68.0%
Life insurance	77.7%	75.5%	74.1%	70.3%
Disability	61.2%	61.9%	57.6%	56.8%
Pension	40.7%	31.6%	34.8%	32.0%
401K	63.0%	60.6%	57.6%	56.8%

BENEFITS SLIDE AGAIN

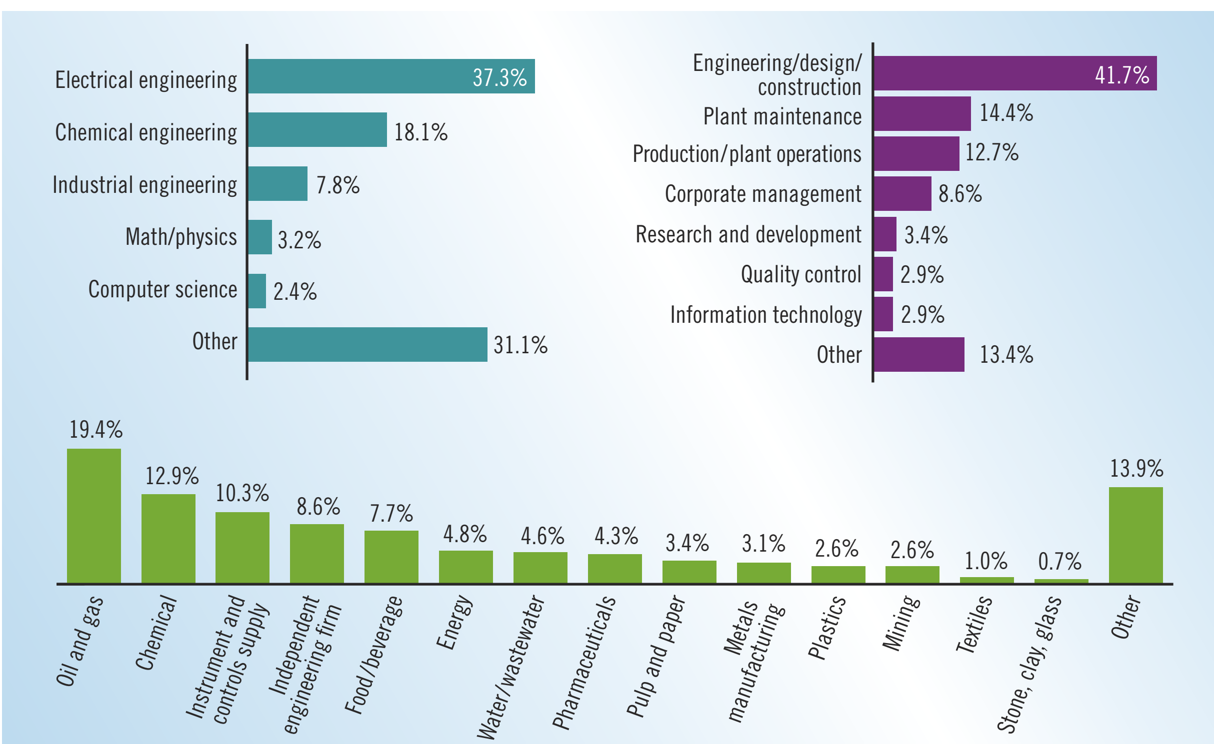
Figure 3: For the third straight year, benefits in the top six categories were reduced. This could be because veteran staffers built up more benefits than their rookie counterparts, and the presence of those packages is shrinking as older personnel retire.

On the other hand, respondents receiving raises up to $4,000 or bonuses remained flat in 2019 as they did for the two years prior (Figure 2). Meanwhile, traditional benefits in all categories in 2019 continued to slide by one to four percentage points, as they've done for the past three years (Figure 3). This is a likely remnant of the formerly dominant trend of veteran personnel having more benefits than their rookie counterparts, even though impact of those packages is shrinking as retirements increase.

Fighting for talent

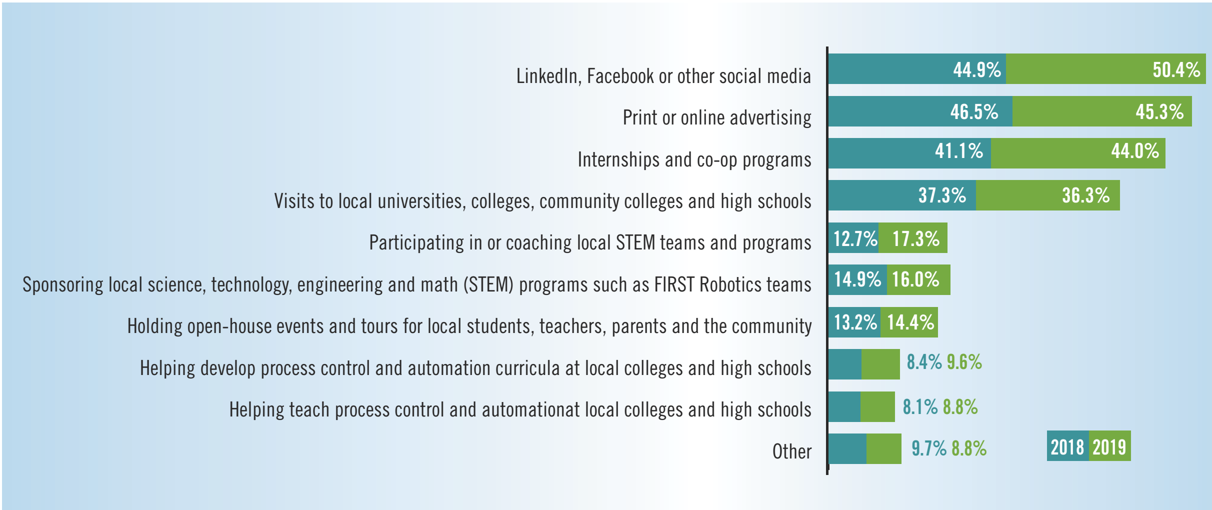
Recent age and salary shift aside, one situation that's been clear to everyone in the process industries for years is how hard it is to find and retain expert personnel.

"We have 33 total staff who average about 40 years old, but we've lost several hourly and salaried employees in the last three years, not so much to retirements, but more to pursuing different career paths," says Ron Cash, combined cycle technician at Lawrenceburg Power's 1,096-megawatt, combined-cycle power plant in Lawrenceburg, Ind., which is owned by the Lightstone Group LLC (www.lightstonegroup.com). "We also just found a person for one job, but it was very hard to fill because it required both mechanical engineering and electrical engineering skills. We considered approximately 40 candidates over two years, and eventually filled the position with an individual in his mid-30s. However, even then, he's an electrical engineer, and still needs



VARIED EXPERIENCES, APPLICATIONS

Figure 4: As usual, process operators, technicians and engineers possess educations and experiences that are as widely varied as the applications, businesses and industries in which they work.



GROWING STAFF

Figure 5: Process industry managers and their companies employ many strategies to find, recruit, hire, nurture and retain new personnel, such as interacting with local organizations and communities, and joining and/or sponsoring science, technology, engineering and math (STEM) programs such as FIRST Robotics. For the first time, more employers used social media for recruiting than print or online advertising.

	2016	2017	2018	2019
No program	64.7%	58.3%	60.2%	56.9%
1 year or less	14.3%	17.1%	18.8%	21.3%
1-3 years	11.3%	14.3%	11.3%	10.3%
3 years or more	3.7%	4.5%	3.0%	5.1%
Length varies	6.1%	5.8%	6.7%	6.4%

UPTICK IN APPRENTICES

Figure 6: Beyond recruiting and development, apprenticeship programs are on the rise with one-year and three-year-or-more programs increasing, and one-to-three-year programs decreasing.

some training on the mechanical side. We recruited on the company website, at Indeed.com, and even used headhunters, but none worked for us. We eventually heard from a vendor that another utility was cutting some positions, and that helped us find an experienced person because we needed someone that already had some years of service."

Cash reports there are many maintenance engineering jobs in the utilities, but they're often persistently hard to fill due to insufficient compensation. "Our positions pay more than similar manufacturing jobs in the Cincinnati area near us, but it's still not enough," he explains. "You can't offer to start engineers at just $60,000 and expect to fill jobs."

In addition, just as job applicants need more comprehensive skills, Cash adds his three-person maintenance staff also face technical challenges, such as calibrating transmitters, rebuilding and calibrating valves and actuators, rebuilding pumps, shaft alignment, general fabrication and programming software, and must learn to address new tasks if they don't know how already. "We know how to build and edit logic for Emerson Ovation software and our GE Mark 6E that runs the plant. Our company is good about getting us the training we need that can't be acquired on our own. For instance I'll be taking Ovation classes soon to get certified," says Cash. "We build relations with all our vendors, and they're usually willing to bend over backwards to help give us the tips we need. We also have a Sure Service agreement with Emerson that helps as well."

Social overtakes ads

Beyond this year's age and salary and shifts, another milestone was that more employers used social media for recruiting than print or online advertising. For the first time, just over half of 2019's respondents (50.4%) reported using Linked-In, Facebook or other social media to recruit, which was up from 44.9% in 2018. At the same time, just over 45% reported using print or online advertising, which was a slight drop from the more than 46% using advertising the year before (Figure 5).

In-person visits to colleges and schools dropped one percentages point from 37% to 36%, but all other strategies for finding and nurturing the next generation of process control personnel increased by about one percentage point or more. Meanwhile, the big winner was participating in or coaching local science, technology, engineering and math (STEM) teams and programs, which increased to 17.3% in 2019 from 12.7% the year before.

Investing in the future

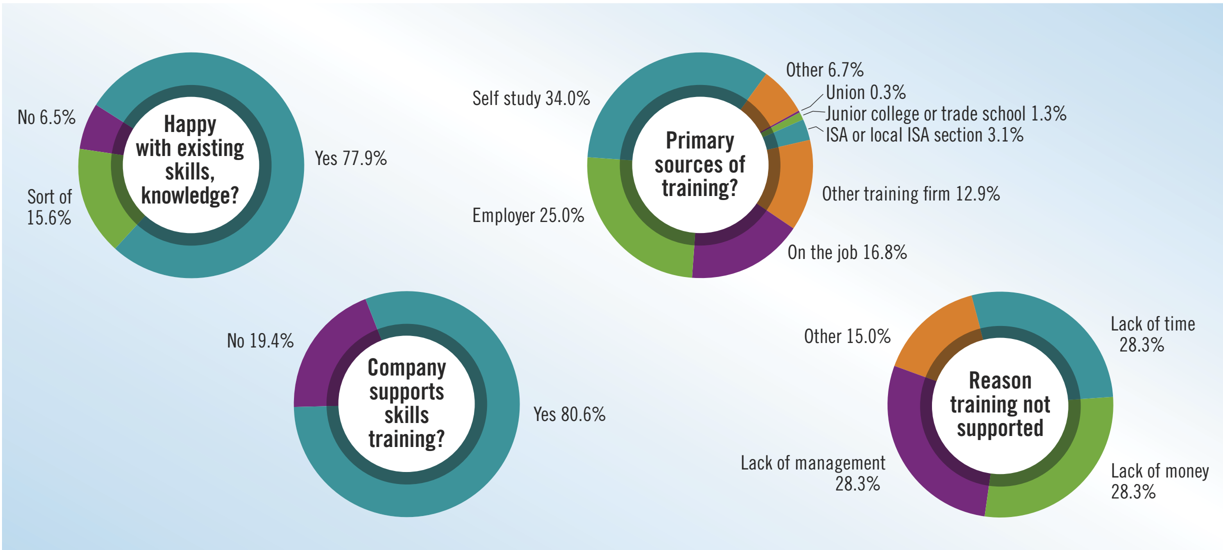
Likewise, the reason even a slight bump up in 2019's average salary is such a big deal in the face of declining average age is it demonstrates that employers are investing in their new people and their future, which was often rare in the past.

"In our industry, average ages are down because of all the recent retirements and because we've been dealing with such a large age gap," says Dean Hammond, business development manager for life sciences at ABB Inc.'s (www.abb.com) Americas-based industrial automation and energy division. "The process industry has many people 50 years old and up and many others 30 years old and younger, which is due to all the hiring freezes, mergers and acquisitions in the 1990s through to 2005. There was a lot of consolidation then, which often meant no one was hiring, and this continued through the 2008 recession."

Hammond reports average salaries are up because so many soon-to-retire veterans are already at high-earning levels, while competition for skilled, younger staff is getting fierce, too. "Many young people are moving around to different companies, so employers have to offer higher salaries and better benefits to attract and retain them. Also, because so many students are graduating with such high debts, I think in the near future, we're going to see more companies in the process industries use matching student loan repayment benefits similar to 401k matching funds as a tool to differentiate themselves and recruit new employees.

Development and retention

Just as recruiting is on the upswing, 2019's respondents add that in-house apprenticeships and training programs are also making gains. Apprenticeships of one year or less are presently



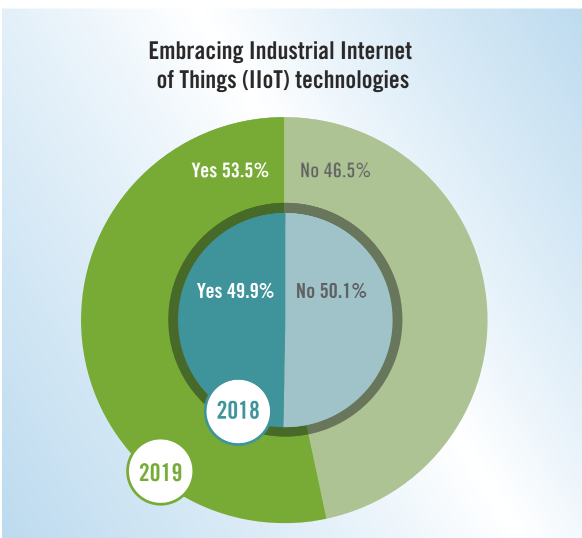
TRAINING REQUIRES COMMITMENT

Figure 7: More than 80% of companies support skills training, which comes from a variety of sources, led by self study and employers. Firms that don't support training cite lacking time, money and management in equal proportions.

	2018	2019
Challenging work	37.7%	41.0%
Salary/benefits	23.4%	20.5%
Appreciation	14.4%	16.7%
Job security	12.2%	10.5%
Opportunity for advancement	10.5%	10.0%
Other	1.9%	1.3%

CHALLENGE = SATISFACTION

Figure 8: As usual, challenging work continues to be the most important ingredient in job satisfaction for respondents to Control's salary survey, but this year it and overall appreciation also posted significant gains over 2018, while salary and benefits experienced a similar decline in importance during the same period.



IIOT GAINS GROUND

Figure 9: The Industrial Internet of Things (IIoT) continues to make steady gains among process control and automation users and applications, which are increasingly adopting Ethernet networking, internet protocol (IP) communications, cloud-based computing and other IIoT technologies.

offered by more than 21% of their companies, which represents a steady increase over the 14% that offered them in 2016. At the same time, those with no apprenticeships decreased to almost 57% this year from almost 65% in 2016 (Figure 6).

Similarly, for the past two years, about 80% of respondents report they're happy with their existing skills and knowledge, while 81% report they're satisfied with the training offered by their companies (Figure 7). Primary sources of training remained consistent with 34.5% using self study and 24.5% relying on their employers in 2018-19. However, on-the-job training increased to almost 17% this year from 15% last year.

Challenges beat pay again

While recruiting and professional development programs are crucial, they're aided by the most rock-solid and commendable trend in *Control*'s salary survey, which every year shows that respondents value challenging work above salary and benefits.

Plus, this trend appears to be increasing because 41% reported that challenging work was most important this year, which was up from close to 38% last year. Similarly, close to 17% said appreciation was most important this year, up from 14% in 2018.

Meanwhile, just over 20% reported salary and benefits were most important this year, which was down from 23% last year. Likewise, 10% said job security was most important this year, down from 12% in 2018. All these results may reflect increased opportunities for employees across the process industries.

IIoT and digitalization keep rolling

Finally, one other well-known trend identified in 2019's salary survey is the ongoing emergence of the Industrial Internet of Things (IIoT) in the form of internet protocols (IP) using Ethernet networks to communicate among devices, and access cloud-computing services. Passing the halfway mark for the first time, more than 53% of this year's respondents report they and their companies are embracing IIoT, while 49.9% were doing it last year. Likewise, just over half were not embracing IIoT last year, while only 46.%% aren't doing it this year (Figure 9).

"Everyone wants more time to interact with customers, and tools like Salesforce, Skype, SharePoint and Google Classroom can reduce coordination time and increase interaction time. Many of these tools have been available for years, but it's only in the past few years that they've been widely deployed, so enough people can use them," says ABB's Hammond. "For instance, video conferencing used to require finding a conference room, using technology that people weren't proficient with, and determining what technology those on the other end had. Now, we can all do it in 30 seconds on a laptop.

"Process control engineers are gaining the same advantages because they can access systems remotely in real time. Previously, the technology was available, but the backbone wasn't always there to support it. Now, the backbone is there, or it's available often enough that it's no longer a novelty. This lets me store information in the cloud; use software like OneNote to access it from many devices; and tie in to OneDrive in the cloud for immediate context for notes, sharing with others, and access via any device.

"Eventually, even process controls will be sold as subscriber-based services. Training is already getting more virtual; users are recording operations they can watch anytime; and maintenance routines displayed on Google Glass for walkthroughs are coming, too. This means staff that usually only get a couple days training every year can now get training whenever needed." ∞

How to acquire **SIS expertise**

Safety instrumented systems are becoming an essential part of everyone's engineering portfolio.

by William (Bill) L. Mostia, Jr., P.E.

ENGINEERING of safety instrumented systems (SIS) and functional safety systems has become a specialty discipline, and there are some signs it's started to be a commodity engineering skill for instrument, automation and control system engineers. One only needs to look at some of the online job sites like Indeed and Glassdoor to see job postings for engineers that commonly require or desire them to know SIS.

To be competent in this discipline requires experience, knowledge and skills related to SIS and functional safety, as well as a good working knowledge of process safety and plant operations, as well as chemical, electrical and mechanical engineering. So, while developing knowledge and specific skills in the SIS area is important, one shouldn't pass up learning activities in these other areas to broaden your horizons. You should plan your training to cover a broad range of knowledge and skills related to process and functional safety.

Functional safety isn't rocket science, but our plants are becoming increasingly more complex, other standards are picking up the SIS philosophy, and there can be a lot of subtleties.

While it's generally not required for SIS engineers to be cybersecurity experts, they must have a working knowledge of methods of protecting the SIS and other functional safety systems against cyber threats, as the SIS and mechanical protection systems may be the last lines of defense to a cyberattack on an instrument and control system (ICS). They should also be able to work at a technical level with ICS IT/OT cybersecurity people to help ensure the safety integrity of the SIS from cyberattacks.

It's difficult, though not impossible, for someone without some level of training to achieve the competence required for a functional safety engineer to competently engineer safety related projects and/or support plant functional safety activities. Functional safety isn't rocket science, but our plants are becoming increasingly more complex, other standards are picking up the SIS philosophy, and there can be a lot of subtleties and twists and turns in applying the standards and achieving an acceptable level of functional safety. The standards are becoming more complex, and understanding the technical basis of the standards and functional safety is necessary to properly apply functional safety to achieve the requisite safety for our plants and people in the process industries.

The IEC 61511 standard requires people involved in SIS safety lifecycle activities to be competent to carry out the activities for which they're accountable, and provides guidelines for determining competency. One key indicator of competency besides experience is training. This article discusses some of the training options available to develop skills in SIS engineering, and help engineers become competent in this area to meet the requirements of IEC 61511.

Course quality can't be assumed

The object of this article is to examine a wide range of training activities available to help an engineer enter this field, and enhance the knowledge and skills of those already in the field. Here, the term "SIS engineer" refers to people who apply engineering skills and knowledge in implementation of the complete SIS safety lifecycle and related functional safety systems, and the term "SIS training" refers to training in the areas of SIS, functional safety and related cybersecurity.

SIS training can come from many sources. In recent years, many commercial companies developed SIS-related training as a profit center. While many of the educational opportunities are in a paid format, there are, surprisingly, a lot of free training opportunities if you look around a bit. A primary difference is paid training typically leads to an official certificate of completion, and may contribute to an industry-recognized certification in functional safety when combined with experience, other requirements, and passing a test. These certificates and certifications make a good addition to one's resume, but may not provide all the education you really need to be fully competent or a true expert in the area, even of the certification says so. Being competent in this field and retaining competency requires continuing education.

Of course, all training isn't equal and one should select a training supplier that can provide the desired training that you consider reputable. I make no recommendations regarding any of the training discussed in this article—I've heard war stories over the years regarding the poor quality of training from various sources, and have even attended a few of these sessions. While the source of the training is a good indication of the expected training quality, the complaints most commonly revolve around the instructors, so always look at the qualifications of the instructors when comparing courses—don't assume that because they give the course that they're an expert in the area. Your chances improve if the instructor is a well-recognized expert in this area.

There are far too many educational suppliers of SIS training and courses for all to be mentioned in this short article, but a good cross section is provided of well recognized companies and educational sources. The fact that a company's training is not mentioned does not reflect on that company's ability to provide SIS training or the quality of that training.

When choosing a training source, it's always a good practice to talk to some of your colleagues or friends who have attended the course to see what they say about it. Always do a little research, and you'll be less likely to be disappointed with the training.

Formal SIS training courses generally come in two formats: classroom and online. These are typically provided by professional societies and by commercial companies, and along with a certificate of completion, also typically provide continuing education credits (CEUs). Other options include university courses and self-study.

Classroom training sets the standard

A number of organizations offer SIS training and cybersecurity in the classroom setting, typically with durations from half a day to five days. The classroom setting has a number of advantages, such as person-to-person interaction with instructors and classmates, ability to sometimes see what others are doing in this area, and the potential to develop technical contacts. Some of the disadvantages are: training can be intensive, giving you limited time to digest the information; you may have to travel, which adds to the time away from work; and the costs of the courses plus the expense of time away from work. Many of these courses are offered at sites in the U.S. and around the world, and can be delivered at your company's site if you have enough students.

TABLE 1: A FEW GOOD BOOKS

Title	Author(s)
Safety Instrumented Systems—A Life Cycle Approach	Paul Gruhn and Simon Lucchini
Safety Instrumented Systems Verification—Practical Probabilistic Calculations	William M. Goble and Harry Cheddie
Guidelines for the Safe Automation of Chemical Processes, 2nd edition	CCPS
Reliability, Maintainability and Risk—Practical Methods for Engineers	Dr. David J. Smith
SIS Design Engineering—Collected Works of Kenexis Marking Their 5th Anniversary (a very inexpensive book)	Edward M. Marszal
Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis	Edward M. Marszal, Eric William Scharpf
Layer of Protection Analysis—Simplified Process Risk Assessment	CCPS
Control Systems Safety Evaluation & Reliability	William M. Goble
Guidelines for Initiating Events and Independent Protection Layers in Layer of Protection Analysis	CCPS

These courses are provided by non-profit organizations such as ISA (www.isa.org) and the Mary Kay O'Conner Process Safety Center, and by for-profit companies such as exida (www.exida.com), Kenexis (www.kenexis.com), aeSolutions (https://www.aesolns.com), Primatech (www.primatech.com), and Risknowlogy (https://risknowlogy.com), to mention a few. Many of the ISA SIS courses are also available through commercial companies.

If you meet the requisite experience and other requirements, some of these courses can result in an industry-recognized certification via tests. A typical advantage of this type of course is training will tend to be tied to the test, making it easier to pass the test, and there's an expectation that the pass rate will be high.

ISA is an excellent provider of SIS training and has a number of classroom courses in SIS and functional safety. ISA has arranged its functional safety training around three SIS certifications levels: SIS Fundamentals Specialist, SIL Selection Specialist, and SIL Verification Specialist. Completing them all allows certification as an ISA/IEC 61511 Expert. Each certification level typically has required prerequisite ISA courses and tests. ISA also offers classroom training and certification in the area of ICS cybersecurity, with four levels of certification.

Another well-known training provider, exida, provides a wide range of classroom SIS, alarm management and cybersecurity training that can help prepare you for the Certified Functional Safety Professional (CFSP)/Certified Functional Safety Expert (CFSE) exams and certification if you have the requisite experience level and meet their other requirements. The exida training is not a perquisite for the CFSP/CFSE certifications.

Kenexis and aeSolutions also provide a wide range of classroom training on SIS, process safety management, alarm management and cybersecurity, as well as the ISA SIS training courses. Kenexis and exida also have training courses on fire and gas system engineering.

TUV Rheinland provides classroom SIS training through commercial company partners that can lead to a functional safety engineering certification once you complete the course, pass its test, and meet other requirements. For more information, visit www.tuv.com/usa/en/functional-safety-trainings.html. Some of the TUV training providers are TUV, Honeywell, Rockwell Automation, ACM and SIS-TECH Solutions. TUV also provides classroom training in cybersecurity.

If you're looking for a certification, discuss with your employers which type they might prefer before you jump into it. While a certification isn't necessary for a person to be considered competent in this area, the industry trend appears to be that engineers who work in this field are getting certified.

Online training may lower costs

Online training is somewhat less available than classroom training, but its availability is increasing. While it can reduce the overall cost (e.g. travel time and days away from work), course costs are typically on the same order of magnitude as equivalent classroom courses. The online student will typically do it on their own time, which can be a selling point to your company, and the total costs are typically somewhat less.

These courses may not have a live instructor, and you can take the course at your convenience (self-paced/on-demand). Or the course may have a live instructor and will occur at a scheduled time.

While a certification isn't necessary for a person to be considered competent in this area, the industry trend appears to be that engineers who work in this field are getting certified.

ISA also offers its first-level SIS certification course in an eight-week online format. All the cybersecurity certification classes are also offered online in a multiweek or an on-demand format. exida and Kenexis also provide online SIS and cybersecurity training.

As an aside, Udemy (www.udemy.com) is a good source of inexpensive online courses (typically from $10-$13 USD), and has a wide variety of technical topics. There are many courses on instrumentation and electrical controls, computers, programming, artificial intelligence (AI), machine learning, complexity, electrical and chemical engineering, and cybersecurity. Udemy doesn't currently have courses available specifically on SIS or functional safety, but they do have quite a few about OSHA and safety in general. Some of its available topics are potentially relevant to the future of SIS (e.g., machine learning, AI, etc.).

Universities are joining in

While there aren't many process safety at the undergraduate level, some universities offeronline courses and degrees at the master's level. Texas A&M University offers a master's degree in safety engineering via the Mary Kay O'Conner center that can be done on campus or online through Texas A&M's distance learning program. The distance-learning program also offers master's degrees in other engineering disciplines at https://engineeringonline.tamu.edu/online-degrees. The University of Aberdeen in the U.K. also offers a master's in engineering in process safety at www.abdn.ac.uk/study/postgraduate-taught/degree-programmes/249/process-safety/.

Some North American universities are also interested in offering SIS certificate programs as part of their engineering continuing education programs. In general, distance-learning from universities is becoming more prevalent, so you may find courses in safety engineering and process safety. You may also find instrument technology courses related to SIS at your local junior college.

Self-study opportunities abound

In general, formal training programs provide only part of the necessary education of a SIS engineer, and self-study is needed to fill in the rest. Many times, an employer's training budget is limited, and unless there is a specific need, it can be difficult to get employers to pay for training. That leaves a number of free or inexpensive educational resources:

Webinars, mail lists, newsletters and blogs: Several companies offer free webinars on SIS and related topics. Exida provides a webinar weekly and Kenexis provides them periodically. You can typically sign up for notifications about these webinars at the suppliers' websites. While webinars are commonly given live, they're often available in recorded versions at the providing company's site. Some trade magazines such as *Control* (www.ControlGlobal.com) and *Hydrocarbon Processing* (www.hydrocarbonprocessing.com) also offer free webinars on a wide variety of topics related to the process industry and process safety, most of which are available in recorded formats.

While many people poke fun at YouTube videos, there are a surprising number available on SIS, functional safety and instrumentation from manufacturers of SIS equipment, SIS consultants and SIS engineers.

ISA has a safety email list where you can see and participate in discussions on SIS. The ISA email list can be found at www.isa.org/division/safety along with a lot of other useful information. There is also an interesting System Safety email list in Europe that discusses a broader range of functional safety topics (https://lists.techfak.uni-bielefeld.de/mailman/listinfo/system-safety).

An interesting newsletter that can help you keep up with safety incidents, breaking news related to safety, and cybersecurity happenings is "The Shield" from ISS Source (www.isssource.com). Most suppliers of SIS services offer newsletters and blogs on SIS and functional safety. Some interesting and informative blogs can be found at the SIS Engineer website (https://sisengineer.com/blog) and at eFunctionalSafety (https://efunctionalsafety.com/blog).

YouTube: While many people poke fun at YouTube videos, there is a surprising number available on SIS, functional safety and instrumentation from manufacturers of SIS equipment, SIS consultants and SIS engineers. There's a good ISA introduction to SIS by Paul Gruhn at www.youtube.com/watch?v=XE7biJf4dgc and one from exida on the importance of the safety requirements specification (SRS) based on one of their webinars at www.youtube.com/watch?v=dsxaoFpzOPU. These videos typically vary from a few minutes to an hour. Like all YouTube videos, you must consider the source of the information on a "caveat emptor" basis.

Papers: There is a tremendous amount of information about SIS on the Internet. It's common for the suppliers of SIS services to publish whitepapers on SIS topics and provide access at their websites to papers published at technical symposiums by their employees. ISA also provides limited access to safety papers published at its symposiums. Collecting and reading these papers and attending symposiums where they're presented can give an engineer wider perspective and access to technical information on SIS and functional safety.

A good website originating in Australia and providing a concentration of papers on SIS and functional safety topics is ICEweb (www.iceweb.com.au). Another source of good papers is the 61508 Association (www.61508.org), as is ISA (www.isa.org/division/safety).

Books and magazines: A number of good books on SIS are listed in Table 1. Many of the industry trade magazines have free article archives. *Control* magazine has many articles on SIS and cybersecurity in its archive.

As an ISA member, you can gain access to collections of papers regarding safety and related topics, ISA standards, and the ISA TR84 technical reports on SIS topics. Unfortunately, since the main standard ISA/IEC 61511 is now an IEC standard, you can no longer access the main standard for free.

Join a standard committee

If you're a member of ISA, you can join the S84 standards committee, and participate in the ISA SIS standard's activities and development of SIS technical reports. If you join as an informational member, you get all the committee documents, which you can review and comment on, attend meetings when you're able, and generally be kept up to date on the ISA standard developments. Voting members have stricter requirements. Contact Charlie Robinson at ISA crobinson@ISA.org for more.

Developing expertise and/or becoming a functional safety engineer isn't really a destination, but more of a journey of formal training, on-the-job training and experience. The need for training and expanding your knowledge in functional safety doesn't go away once you complete a class, or even if you're certified as an expert. The SIS and functional safety engineering field is growing more complex with the evolving SIS standards (about every five years), new SIS technology development, and the continuing cyber threat environment. In recent years, SIS standards have started impacting other standards (e.g. API 2350, API 553, API 556, NFPA 85, ISA 18, ISA 99/IEC 62443, etc.).

The concentration of the standard's development (on SIS for the past 30 years) has also started to shift to other functional safety areas. This all leads to the need for functional safety practitioners to have a continuing education process to help ensure they're up to date and remain competent in process and functional safety to help ensure our plants and people operate in safe environments. ∞

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Signal filtering: Why and how

Prevent over-filtering by simultaneously optimizing loop tuning and filter parameters.

by Mark Darby and Greg McMillan

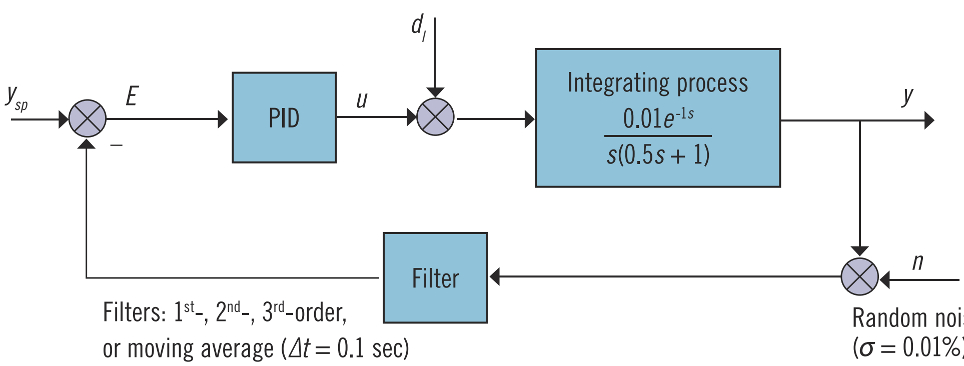
[For a version of this article with much more background on noise and explanation of filter types, visit www.controlglobal.com/assets/digital_edition/2019/July/filtering.pdf]

FILTERING is the modification of a measured or calculated signal—using an algorithm and/or logic—to remove undesirable aspects of the signal before it's used in a calculated signal or a controller. Examples in control are the feedback (or controlled) variable to a PID or APC controller, or the input to a feedforward controller. Calculated signal examples include computations based on steady-state material/energy balances or process-oriented relationships, as well as process and control metrics.

The main reason to filter a signal is to reduce and smooth out high-frequency noise associated with a measurement such as flow, pressure, level, pH or temperature. A common example is the noise associated with the differential pressure (DP) across an orifice plate used to infer flow rate. High-frequency noise is normally considered to be random and additive to a measured signal, and is usually uncorrelated in time; i.e., the value of the noise at any time *t* doesn't depend on previous values of the noise. Ideally, we want to estimate the underlying signal without noise, introducing as little distortion as possible.

When a noisy signal is used in control, filtering is important for effective derivative action and avoiding excessive movement in the controller output that causes valve wear or disturbs other control loops. A complicating factor for the control case is that both filtering and controller tuning can be used to reduce movement of the controller output.

The downside of filtering is the lag introduced, especially with heavier filtering, which can have a detrimental effect on timely detection of changes in the underlying signal. When used for feedback, the filtered value can result in control that's sluggish or, in the worst case, becomes oscillatory or even unstable. In the authors' experience, the more typical problem encountered



PID:
Standard Form with proportional and derivative on PV
$\Delta t = 0.1$ sec
Derivative filter = $0.20T_d$

	K_c	T_I	T_d
PID ($\lambda = 2$)	55.57	5.0	0.5
PI ($\lambda = 2$)	55.57	5.0	0

Process:
K_i = Open-loop integrating gain = 0.01%/%·sec
τ_o = Open-loop time constant = 0.5 sec
θ_o = Open-loop dead time = 1.0 sec

SIMULATED CLOSED-LOOP SYSTEM

Figure 1: To evaluate filters in a closed loop, we simulate an integrating process with a noisy measurement signal and an aggressively tuned PID controller. Lambda tuning formulas modified by McMillan to provide better load disturbance rejection for a Standard Form PID (shown in Table 1) are used for an integrating process where seemingly insignificant noise is amplified by a high PID gain.

TABLE 1. MCMILLAN LAMBDA TUNING FORMULAS

Algorithm	K_c	T_i	T_d
PID	$\frac{2\lambda + \theta_o}{K_i(\lambda + \theta_o)^2}$	$2\lambda + \theta_o$	$\min\left(4T_i, \max(\frac{1}{2}\theta_o, \tau_o)\right)$
PI	$\frac{2\lambda + \theta_o}{K_i(\lambda + \theta_o)^2}$	$\max\left(4\theta_o, 2\lambda + \theta_o\right)$	

K_c = Gain, T_i = integral (reset) time, T_d = derivative (rate) time. $\lambda \geq \theta_o$ recommended.

is excessive filtering of a signal, as opposed to under-filtering.

The source of the noise may be electronic or from the process itself. "Process noise" may originate from mixing, flashing, condensation/vaporization or from improper installation of a measurement device, for example, not enough straight-run pipe length upstream or downstream of a flowmeter. Unfortunately, in many cases, filtering is used in an attempt to mask the effect of an unmeasured disturbance or a problem such as valve resolution or dead band in the control loop. In many cases, filtering makes problems worse. A filter will often be set and forgotten until the loop is reexamined due to loop troubleshooting of poor performance, or when a control project is executed (e.g., APC).

Let's consider the impact of filtering on PID loop performance. An important reason to filter the feedback variable (PV) is to ensure effective derivative action. Derivative action is important when aggressive control is required, particularly for integrating and near-integrating (lag-dominant) systems with additional lags(s) and significant dead time. If not properly filtered, noisy signals will cause derivative action to be ineffective due to erratic movement of the PID controller output. Fortunately, most industrial PID controllers include a filter on just the derivative term, expressed as a fraction, or divisor, of the specified derivative time. The fraction is usually in the range of 0.10 to 0.20 of the derivative time.

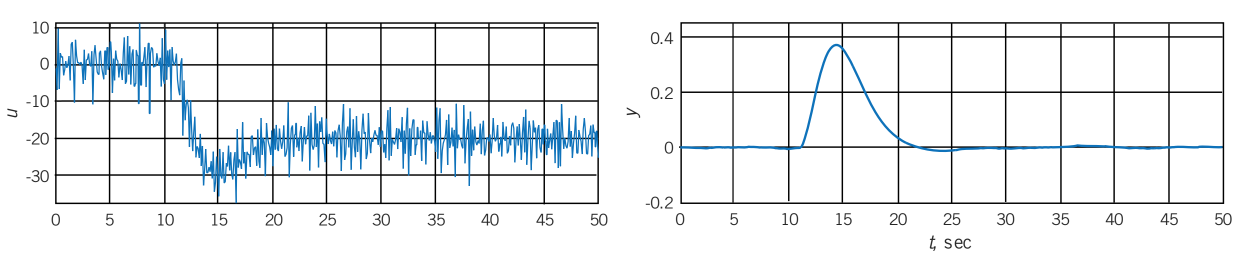
The other reason to filter the PV is to temper the controller output (CO), so the noise doesn't lead to excessive movement (and wear) of the valve, or cause disturbances to other control loops. In the past, another reason to filter the PV was due to resolution limits caused by the A/D converter, which would show up as noticeable steps in the measurement value. However, with 16 bit I/O cards, this is no longer an issue.

Simulation leads to optimization

To evaluate filters in a closed loop, we simulate an integrating process with a noisy disturbance signal and an aggressively tuned PID controller. The loop and simulation details are shown in Figure 1. Lambda tuning rules modified by McMillan to provide better load disturbance rejection for a Standard Form PID (shown in Table 1) were used for an integrating process. A value of λ = 2 sec (twice the loop dead time) was used as the arrest time (time to stop excursion) for the tuning, as it produced a non-oscillatory response in both the PV and CO, provided the system is linear and the dynamics are fixed and well known. The following loop criteria are evaluated for each filter:

Peak error: Maximum error following an unmeasured step in load disturbance on process input. Peak error is important to prevent relief, alarm and SIS activation, and environmental violation.

IAE: Integrated absolute error over time is a common criterion for measuring loop performance. It directly relates to economics as it provides a measure

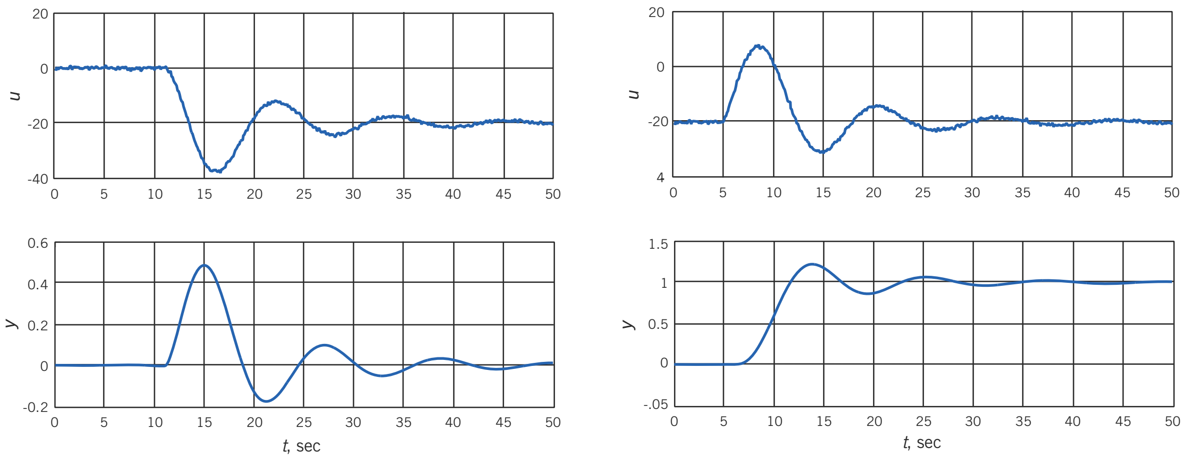


STEP RESPONSE WITHOUT FILTERING

Figure 2: The closed-loop response in y (process value before introduction of random noise) and u (controller output) to a 20% step in load (d_1) at time = 10 sec. for PID control without filtering clearly shows the effect of noise on u.

TABLE 2. PID VS. PI RESULTS WITH LOAD DISTURBANCE, NO FILTERING

	Peak error (%PV)	IAE (%PV·sec)	IAD (%CO·sec)
PID	0.373	1.974	280.7
PI	0.444	2.436	32.538



RESPONSES WITH 1ST-ORDER FILTER

Figure 3: The PID closed-loop time responses for the load (left) and setpoint (right) start to become oscillatory and the loop becomes unstable at $\tau_F = 0.73$.

of the amount of process material that's off-setpoint.

Setpoint overshoot: The maximum error overshoot for a setpoint change. Excessive overshoot can have economic or safety implications.

IAD: Integrated absolute difference of the controller output. For the case that the PID directly manipulates a valve, this is total valve travel distance, and directly relates to valve wear.

For closed-loop evaluation of the filters, we decided to keep the PID tuning the same, and not increase the filtering to an extent that causes cycling. Heavy filtering of the PV contributes lag and changes the process response, which would necessitate retuning. Since our objective is aggressive control, we want to minimize the impact of filtering on control, but reduce CO movement. Figure 2 shows the response in *y* and *u* (the CO) to a 20% step in load (d_l) at time = 10 sec for PID control without filtering. The effect of the noise on *u* is clearly seen. Table 2 shows the results for PID control and, for comparison, also includes the results for PI control. While the PID achieves noticeably better PV results compared to PI, it does so at the expense of significantly more movement in *u*.

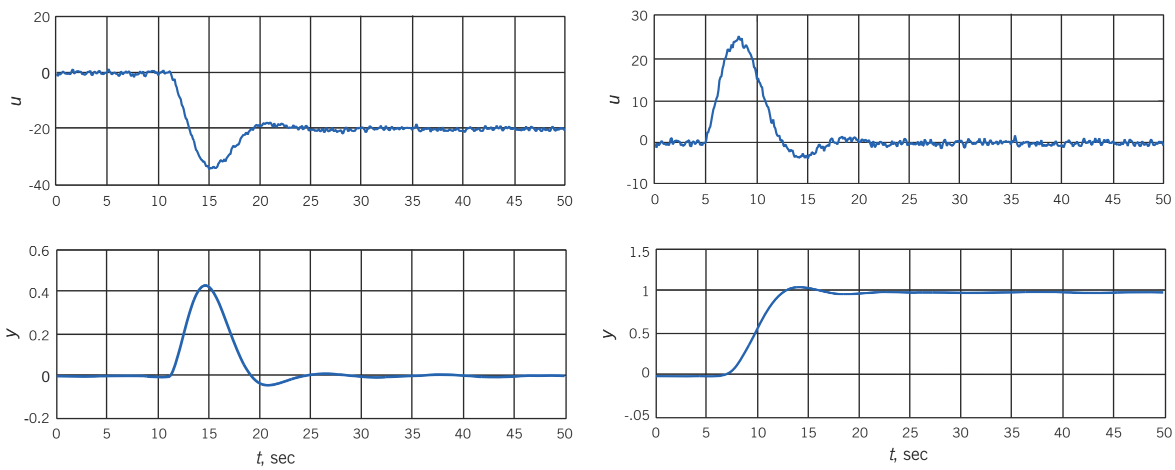
To evaluate the various filters for PID control, we tuned the filter parameter

TABLE 3. PID RESULTS WITH FILTERING, SAME LOAD IAD AS PI

	Load response			Setpoint response		
PID with filter	Peak error (%PV)	IAE (%PV·sec)	IAD (%CO·sec)	Peak error (%PV)	IAE (%PV·sec)	IAD (%CO·sec)
1st order, $\tau_F = 0.5439$	0.453	2.538	32.538	0.116	5.301	32.526
2nd order, $\tau_F = 0.1771$	0.420	2.051	32.538	0.046	5.013	32.268
3rd order, $\tau_F = 0.1180$	0.433	2.122	32.538	0.057	5.014	32.346
Moving average, *N*=7	0.428	2.087	37.158	0.052	5.006	36.678
Moving average, *N*=8	0.437	2.169	31.992	0.064	5.035	31.800

TABLE 4. PID RESULTS WITH FILTERING, 91.5% REDUCTION IN LOAD IAD

	Load response			Setpoint response		
PID with filter	Peak error (%PV)	IAE (%PV·sec)	IAD (%CO·sec)	Peak error (%PV)	IAE (%PV·sec)	IAD (%CO·sec)
1st order, $\tau_F = 0.8161$	0.488	3.597	23.886	0.222	6.372	24.174
2nd order, $\tau_F = 0.2177$	0.434	2.167	23.886	0.064	5.045	23.676
3rd order, $\tau_F = 0.1388$	0.443	2.235	23.886	0.073	5.066	23.748
Moving average, *N*=11	0.464	2.555	23.886	0.114	5.285	23.892



RESPONSES WITH 2ND-ORDER FILTER

Figure 4: Comparing the PID closed-loop responses of a 1st-order filter (Figure 3) to the 2nd-order filter here shows improvements for both the load (left) and setpoint (right).

(τ_F or N) to achieve the same load IAD result (0.5423) as for PI control. Because the moving average parameter N is an integer value, it's not possible to exactly match the same IAD value, so results are shown for filter N values above and below the PID value of 0.5423. Results are shown in Table 4 for both load and setpoint responses. We see that the 1st-order filter with PID control achieves worse results across all metrics than PI control with no filtering. Notably, the higher-order and moving average filters all perform better than PI control. The 2nd-order filter is the best performing filter across all metrics. Compared to the 1st-order filter, the 2nd-order filter achieves 7.3% smaller peak error and 19% smaller IAE for the load response, and 60% and 5.4% smaller peak error and IAE for the setpoint response. Compared to PID control with no filtering, the 2nd-order filter has 12% worse peak error and 3.9% worse IAE error for load response.

To compare all filters on exactly the same basis, we first select a moving average filter to achieve at least a 90% reduction in IAD compared to PID control without a filter, and then tune τ_F for the higher-order filters to achieve the same IAD. These results are shown in Table 4. Again, we see that the 2nd-order filter yields better results across all metrics. Compared to the 1st-order filter, the 2nd-order filter yields 11% smaller peak error and 40% better IAE for load response, and 71% and 21% better results for the setpoint response.

Figure 3 shows the time responses for the 1st-order filter, and Figure 4 shows the time responses for the 2nd-order filter. The improvement from the 2nd-order filter over the 1st-order filter is clearly seen. Figure 5 also shows that the response with the 1st-order filter is starting to become oscillatory. Note that at τ_F = 1.875 for the 1st-order filter, the loop becomes unstable. For the other filters, loop instability occurs at τ_F = 0.73 for the 2nd-order, τ_F = 0.45 for the 3rd-order filter, and N = 26 for the moving average filter. Thus, it does not take much filtering to cause loop instability.

Based on the above results, the closed-loop simulations show that significant improvement over the 1st-order filter is possible when significant noise is present, and aggressive control and significant reduction in IAD is needed. These results also show that a 2nd-order filter provides the best metrics, although not always by a large margin.

Conclusion: Don't overdo it

What have we learned? What are the lessons? Be careful to not overly filter. What's good to the eye is usually too much filtering, especially for control. Excessive suppression of noise and the consequential instability or reduced response to disturbances can be costly. The more attenuation, the slower the filtered signal approaches a new average value—i.e., more time lag. For the same amount of noise attenuation, higher-order filters (2nd- and 3rd-order) and the moving average filter approach a new average value quicker than the often-used exponential or 1st-order filter. The moving average filter can achieve higher levels of noise attenuation than the 2nd- and 3rd-order filters at the added cost of more coefficients and storage of previous signal values, but this should not pose a problem with today's control systems. An advantage of the moving average filter is it can eliminate a periodic cycle if the filter Δt and N are selected appropriately.

When a noisy PV is used in control, the deciding issue to filter is unacceptable movement in the manipulated variable (controller output) caused by the noise. In this case, if aggressive control is required (higher gain with derivative action), higher-order and moving average filters allow tighter control with improved metrics (peak error and IAE) compared to the exponential or 1st-order filter.

Before retuning a loop, make sure to note what the filter parameters are: time constant or filter factor and *Δt*. Only use filtering to temper movement in the manipulated variable (controller output) caused by the noise. If aggressive control is required (higher gain and derivative action), higher-order and moving average filters allow tighter control with improved metrics (peak error and IAE) compared to the exponential or 1^{st}-order filter. One should be careful to not cause loop instability with filtering. Although not extensive, these simulation results, plus others we've performed, generally show that of the filters considered, the 2^{nd}-order filter provides the best metrics when targeting reduced levels of IAD.

We took the simple approach of keeping the tuning the same to show the improvement possible with more sophisticated filters. Ideally, the tuning and the selection of filter parameters should be jointly optimized, e.g., using a loop tuning optimizer.

Wait, there's more

We've focused on linear filters. However, the following additional suggestions are offered:

When a process variable (PV) can't respond faster than by an amount X per second, a PV rate limit with this setting can be used to screen out noise without adding a lag. Alternatively, a setpoint rate limit to reduce CO movement can be put on the analog output block or secondary loop manipulated by the PID and external-reset feedback (e.g., dynamic reset limit) turned on to prevent the PID output from changing faster than the imposed setpoint rate limit. However, upon download or during tests for checkout and maintenance, the rate limit must be turned off.

For pH measurements, the use of middle signal selection of three electrodes can reduce noise and eliminate spikes that commonly occur due to imperfect mixing and ground potentials without adding a lag, in addition to ignoring slower responding electrodes due to aging or fouling.

For electrodes and temperature sensors, increasing back mixing and minimizing phase changes, and for pipeline installations, ensuring the tip is in the middle of the pipe at least 25 pipe diameters downstream of a pump discharge or equipment outlet can greatly reduce the source of process noise for these critical primary loops. ∞

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EQUIPMENT & MATERIALS

AD INDEX

When to use positioners in flow control

A positioner on an actuator that's too slow for the process can be worse than none.

This column is moderated by Béla Lipták (http://belaliptakpe.com/), automation and safety consultant and editor of the Instrument and Automation Engineers' Handbook (IAEH). If you have an automation-related question for this column, write to liptakbela@aol.com.

Q: I stumbled on www.ControlGlobal.com while searching for information about PID control of flow. This question may have been answered, but the couple of threads I found didn't seem helpful specifically for my problem. I'm controlling gas flow with a flow sensor and an electrically actuated (servo) valve positioner. The positioner is slow, taking up to 90 seconds for full travel.

I'm using a microcontroller to read the flow signal (F) and call out a control output of c(t) = Kp + Ki*[∑{e(t)*Δt}] + Kd*(ΔF/Δt). The error is e(t) = Fsp - F.

The slow positioner has been causing constant position adjustment and overshoots. I'm able to get decent control only with a huge averaging of the input flow signal (over almost a two-minute time scale). I guess we can live with it, but is there a better way?

MURTHY TATA
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A: This is a very basic and very important question. I'm glad you brought it up because, in my experience, the use and selection of positioners is the cause of the most frequent control problems. (The other error seen most often is usually caused by valve response.)

The answer to your question applies to all cascade systems. The slave controller in all cascade control loops must be faster than the master controller. No exception! This is kind of self-evident from everyday life. After all, how could, say, a pilot do his/her job if the second pilot was still busy carrying out the previous order when the next was given?

People often don't realize that a positioner is a slave controller, with all its advantages and limitations. It can both help and hurt the performance of the loop. Therefore, I'll give a brief discussion of the subject of positioners before giving my advice concerning your specific question.

The purpose of a positioner is to improve the accuracy and response of control valves. This means it will help to have the valve position more closely approach the position commanded by the controller. A positioner can reduce the effects of many dynamic variations. These include changes in packing friction due to dirt, corrosion, lubrication or lack of lubrication; variations in the dynamic forces of the process; sloppy linkages (causing dead band); and nonlinearities in the valve actuator.

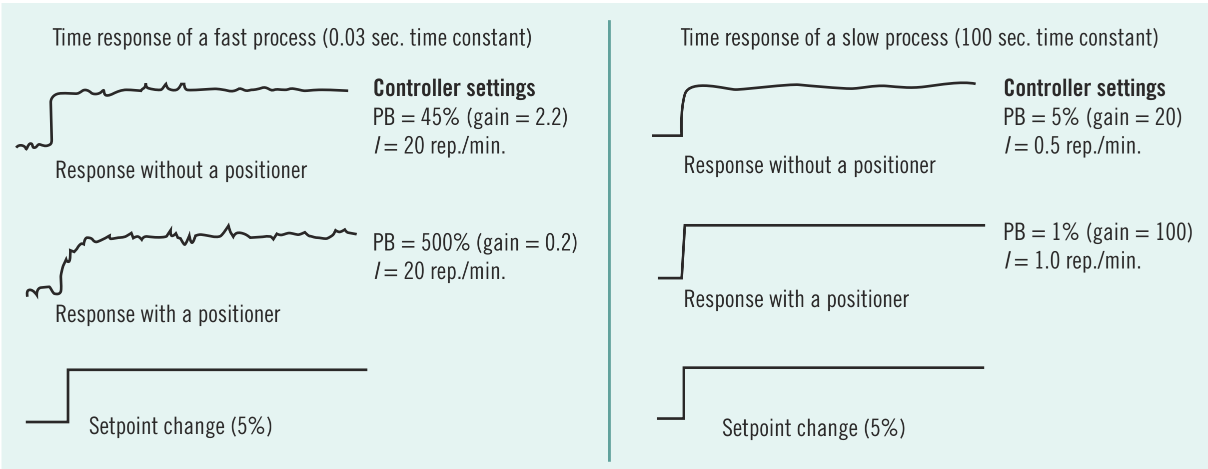
The dead band of a good valve/actuator is up to 5%. Large plug valves and ball valves with less than perfect linkages and inadequate actuators may be far worse. A better positioner with the proper actuator can often reduce the dead band to less than 0.5% of stroke.

A pneumatic positioner increases the actuator speed or thrust by increasing the actuator pressure and/or air flow volume, and can modify the valve characteristics through the use of mechanical links and cams or by electronic function generators. While these positioner capabilities are very important, some of these capabilities can also be obtained or approximated with other accessories.

The positioner/actuator combination is the secondary control loop in a cascade system, receiving its setpoint from the master controller. For a cascade secondary to improve control, it must respond more quickly than the primary loop. The ideal situation would be if the time constant of the secondary was one-tenth (open-loop speed of response 10 times as fast) of that of the primary (but certainly less than half). No process control response time can be faster than the slowest element in the control loop, therefore, the performance of a cascade system improves with fast secondary response.

It's clear that poor valve response reduces the quality of control much more than one would expect. If that's the case, the controller tuning must be modified (gain reduced, integral lengthened) to avoid oscillation due to dead band and response delay. In typical real applications, controller tuning is conservative and avoids any hint of oscillation, and therefore response is even worse than it it could be. (Operators usually object to cycling processes.)

Figure 1 illustrates a fast flow process, where the loop without a positioner can be tuned more tightly (for higher gain and more repeats/minute). Such a



WHEN POSITIONERS DON'T HELP

Figure 1: In slow processes (right), a positioner always improves loop performance, but in fast processes (left), particularly if the controller is pneumatic and the process is faster than the positioner, it can hurt loop performance..

loop responds better without a poor positioner. It might also be noted that after a new state is reached, the positioned installation gives better and noisier control because of increased speed of response.

Electric actuators are used where air isn't available and where their typically slow operating speed is acceptable. There are some specialized electric valve actuators that can provide very high position precision; others can provide reasonably fast response.

Sorry for taking so long to come to an answer to your question, but I believe it's useful to understand the cascade nature of positioning, as described above. So, turning to your specific question, assuming that your valve is linear and you have no derivative in your controller, you can disconnect the positioner. Or if the positioner is an integral part of the actuator, insert a lag into the controller output to make its time constant at least double that of the positioner.

Another option is to use gap control, where as long as the flow is inside the gap, the controller stays inactive. Today's microprocessor controllers provide broad tuning adjustment ranges, so you can set the controller gain much lower (portional band wider) and leave the integral (reset) fast to match the time constant of your relatively fast flow process.

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A: I have few follow-up questions before I can guide you for a reasonably stable tuning. Which software PID block are you using? Is it PID_IND or PID_ISA block? Or are you doing your own logic? Have you done a step test? I've tuned liquid flow control, and we don't use D, but for gas, you'll need to use D gain.

Another problem I've seen is the range for the transmitter. What is the inherent deadband of your positioner? Discuss it with the manufacturer of the positioner, and ensure that the setup/configuration is appropriate for your application.

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A: Yes, there is a better way to do flow control, but it would require that you replace the slow-acting electric control valve actuator with a pneumatic or a direct-acting, electric solenoid-type control valve actuator. What you describe is not a solenoid actuator but a reversible electric motor driving the control valve position through a screw-thread mechanical linkage. These have been in use for many years to control very large objects, such as air dampers in boilers, but are not suitable for gas or liquid flow control.

If your actuator is more like a large air damper rather than a control valve, then you'd probably benefit from using a gap-action control algorithm or an error-squared control algorithm. These algorithms have a characteristic of taking little action when the measured value is close to the setpoint. Both algorithms are common variants of the PID algorithm you seem to be using, and are commonly found in the algorithms of most DCSs and even most PLCs used for closed-loop control.

Most process control textbooks also discuss these variations of PID control. The gap-action controller is simple: establish a zone around the setpoint and when the error is within this gap, don't change the controller output. The error-squared controller is more complicated, and you can find a discussion at this website: https://pdfs.semanticscholar.org/921e/c98836dda49347d1d-99f6a751b548b475283.pdf.

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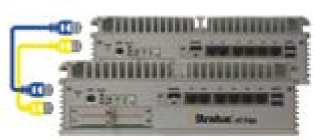

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Improving split-range control

Strategies and tuning to increase precision, smooth transitions and avoid oscillations.

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@putman.net

GREG: Split-ranged control valve applications are particularly challenging. Here, we look at the many sources of the problems and the innovative solutions possible using the functionality of today's PID. To address this, we've enlisted the help of great leaders in maximizing the functionality of the PID. We start with George Buckbee, who has considerable experience in process control, and is currently an outstanding source for getting the most out of your PID, as seen in his many presentations and papers. George is an ISA Fellow and author of the focused book, *Mastering Split Range Control*. He heads up the Performance Solutions group at Metso. We then move on to seek a creative, relatively unknown approach form Nick Sands, DuPont senior manufacturing technology fellow and ISA Fellow, who was inducted this year into the Control Process Automation Hall of Fame. Nick has been advancing our profession by involvement in the International Society of Automation. He was the 2015-16 vice president of the ISA Standards and Practices department and co-chair of ANSI/ISA-18.2-2016, "Management of Alarm Systems for the Process Industry." Nick and George are leading participants in a new ISA Standards Committee to develop an ISA Technical Report on PID Algorithms and Performance.

GEORGE: First, we should mention that split-range control refers to a situation where two final control elements are managed by one controller. Usually, different fluids flow through each of two valves, for example, steam and cooling water, or acid and base. Split-range is often misapplied to the common situation where a large valve and a small valve supply different amounts of the same fluid. That situation is better handled by other strategies, such as mid-ranging or coarse-fine control.

GREG: What are sources of oscillations, and what are some of solutions?

GEORGE: In many systems, the valves are configured or calibrated, so there will be a small gap between valve actuations. For example, the cooling valve may close at 49% control output signal, and the heating valve starts to open at 51%. As with any form of gap controller, it's common to oscillate back and forth across the gap. In the case of split-range control, the oscillation may be further exacerbated by the fact that many valves don't come smoothly off their seats from fully closed to small openings. In some processes, the oscillation may be acceptable. However, if the process demands smooth control through the transition point, there are a few strategies.

For tight control at the setpoint, overlap the transition point. For example, the cooling valve can remain open from 0-51% of output, and the heating valve can start opening at 49% through to 100%. You lose a little efficiency between 49% and 51%, but ensure a smoother transition. Note, however, that there can be significant process issues, depending on the two fluids used (i.e. steam and water). So, be sure to consult with the process engineer before choosing this technique.

Another option is to eliminate controller integral action near the transition point. The controller will operate with some small amount of offset from the setpoint, but you'll greatly reduce oscillation.

It's particularly important to minimize nonlinearities. Aside from the nonlinearities at valve opening, there's one other major nonlinearity—the process gain differences over the range of operation. Dead time and time constant may also differ. It can be extremely difficult to size the two valves so that the process gain remains constant across the full range of operation. You can compensate for this in several ways. You can select controller tuning according to the valve with the larger process gain, effectively detuning the loop. A better solution is to add a signal characterizer to compensate for the nonlinear installed characteristic, do response testing, and develop dynamic models for each valve, writing the resulting tuning settings to the PID.

NICK: In the old days, split-range control was done with a single output signal to two valves, and the valves, or I/Ps, were calibrated to operate so one valve would close from 0-50%, and the other valve would open from 50-100%. Usually, both valves were closed, or close to it, at 50%, as George described. Later, each valve was given an output signal, and the split was done in the control system, still 0-50% and 50-100%. But independent signals allowed for the possibility of different control.

The single controller suffers from the disadvantages that George mentioned.

GREG: How did you eliminate split range?

NICK: It might seem like a good idea to use the same process variable to two different controllers, one for each valve. Two controllers would allow for each controller output of 0-100% to correspond to the percent-open of the associated valve, independent gain for each controller and valve, independent response time (integral and derivative) for each controller and valve, and reduced oscillations at the split. However, this solution without additional intelligence leads to the controllers fighting each other and both valves open at the same time. An offset in the setpoint could help reduce this fighting.

With a nicely developed PID control algorithm, we can make the two-controller solution much better. I call it one directional control (ODC).

ODC is a technique for coordinating multiple controllers by limiting control action. Think of ODC as half automatic mode: a controller will respond to process variable changes in one direction as if in automatic, but not respond to process variable changes in the other direction as if the controller were in manual. Another way to think of ODC is by comparison to cascade control: cascade loops are PIDs in series, one cascading to the other. ODC can use PIDs in parallel, often responding to the same process variable.

For example, using PT101, PIC101A controls PV101A to add nitrogen to the vapor space of a tank, and PIC101B controls PV101B to vent the tank pressure to a vent header. The controllers are coordinated, so if either valve is open beyond a set limit, it sends a signal to the other valve, preventing an increase in controller output. This will result in only one valve being open at a time, and only one of the two controllers responding to a change. If the output of PIC101A is greater than 0% (or x%), then it would limit PIC101B from increasing the output. This is done differently in different control systems, but a general way is to set the controller high output limit to the current value.

For each change in pressure, controller PIC101A responds. Controller PIC101B would be constrained to a high output limit of 0% (or y%). Once PIC101A closes to 0% (or x%), the constraint on PIC101B is removed and PIC101B takes control, and when the output is greater than 0% (or x%), PIC101A is constrained to a high output limit of 0% (or y%).

GREG: It's often not realized that deadband introduced in a PID configuration or a variable-frequency drive (VFD) setup, or from backlash in a control valve, will result in a limit cycle if there are two or more integrators in the control loop. Integral action can occur in many important processes (e.g., gas pressure control and batch composition, pH and temperature control), digital positioners, and each PID in a cascade control system. Stiction requires only one integrator to develop a limit cycle. Oscillations also break out when actuator or positioner sensitivity is poor (e.g., spool positioners and piston actuators).

Would you care to offer some parting words of wisdom?

GEORGE: You can save a lot of time and frustration by using the right tools. Make use of software to accurately identify process dynamics, provide tuning and diagnose valve issues. Operator training is critical, but often overlooked. Training is especially important for shutdown planning, when these valves may help to isolate the process. For split-range and other "non-standard" control schemes, we must be sure to provide training and documentation to the operator.

NICK: Get to know your PID algorithms and put them to work for you. And then document any of the tricks you use, so the next automation engineer can follow your work. ∞

For much more guidance, including links and the "Top 10 thank-you notes from consultants," visit www.ControlGlobal.com/articles/2019/ways-to-improve-split-range-control.

Don't think old

Age is inevitable. Hypocrisy and unkindness are choices..

JIM MONTAGUE
Executive Editor
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Who's more of a true American? Someone that wants to come the U.S. and work to make a better life for their family, or someone that wants to prevent them from doing it?

TIME passes faster as we rack up the years and experiences. I've witnessed more older relatives and friends die recently; seen more people my own age—and me—complain of stiff joints, and rock forward and groan to get up from chairs; and watched youngsters I knew as babies take on some adult-level stresses and disappointments.

All this is inevitable, of course, because as multi-cellular vertebrates, we're slaves to our biology. However, even though many of us are one torn ligament away from walking like an old person, physical aging isn't as scary as some of the mental shifts I've seen lately. I'm not talking about Alzheimer's or other physiological ailments. I'm talking about the perfectly healthy rigidity, intolerance and unkindness that seems to seep in and creep up on us during middle age.

Lately, I've heard repeated grumbling about Millennials and their crazy habits and work/life balance priorities. When you think about it, it's pretty hilarious to hear Baby Boomers talk about those lazy kids, which was the same label pinned on them when they were young. I realize age may drive perspective, but you'd think people might pause before hurling the same insults that used to be lobbed at them.

This reminds me of then-new homebuyers in suburban Chicago, who I watched protest the residential development of a cornfield across the street, even though their own subdivision had been a cornfield just nine months earlier. It was my introduction to what I've called "pulling up the ladder, and the heck with everyone else."

Of course, the latest example of this selfish phenomenon is the children, grandchildren and great-grandchildren of immigrants seeking to deny and restrict entry to many of the most recent arrivals. The argument that today's immigrants are illegal doesn't wash because severely restrictive laws, intimidation and abuse have always been heaped on each new group when it shows up, including the parents, grandparents and great-parents of many of those now doing the persecuting. What a proud legacy. As I've asked before, who's more of a true American? Someone that wants to come the U.S., and work to make a better life for their family, or someone that wants to prevent them from doing it?

Personally, I'm just waiting for someone I saw get scolded for batting or kicking a ball into a neighbor's yard become the one that yells "get off my lawn!" to some present-day kids. I promise that I won't do it, but who knows?

Even the quickly digitalizing technologies used in process control and automation aren't free from this taint. Most recently, I encountered several self-made, formerly independent entrepreneurs, whose devices replaced the relays and pneumatic controls of former decades. They'd originally faced huge resistance, too, but they persevered because their components were far more cost-effective and efficient.

However, fast forward 20 years, and these same entrepreneurs are seeking regulatory shelter and corporate welfare for their increasingly obsolete devices. which they didn't update fast enough to compete with today's rapidly emerging Raspberry Pi, Arduino and other types of generic silicon and the software that runs on them. As usual, everyone's all for free trade and against government regulation until our own rear ends get bitten by someone willing work or sell products for less. We can't let them do to us what we did to someone else just a few years before.

What's the solution? Well, diet, exercise and other good behaviors can put off physical decay and aging for awhile. In the same way, I'm learning it's possible to maintain mental flexibility and acuity even longer, behave consistently, and actually treat others as we'd wish to be treated. Didn't that used to a rule or something?

Seriously, I believe we have to recognize resentful, fearful thinking for what it is, and practice being a little more flexible and empathetic. This may help us be more tolerant, patient and maybe generous to those in different circumstances, who could just as easily be us or our relatives a few years ago when everyone was younger. ∞

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