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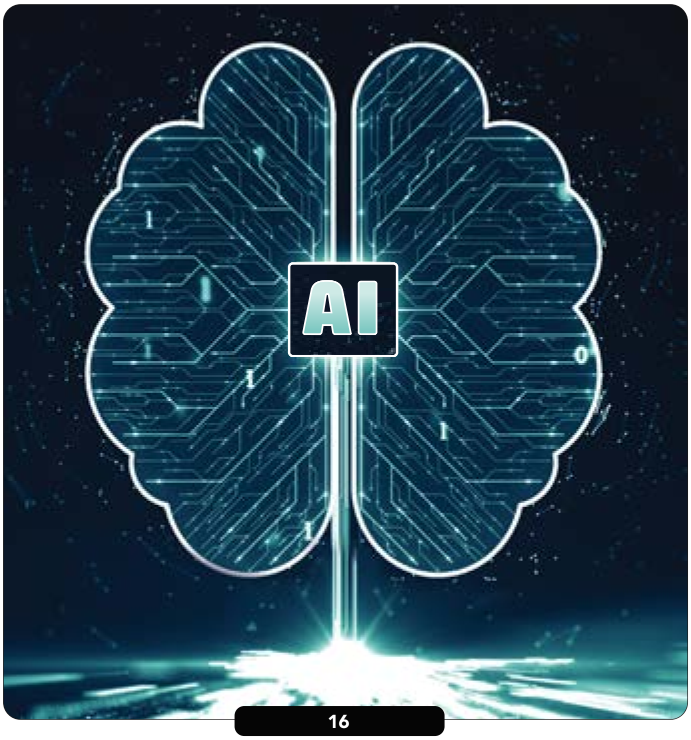


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COLUMNS



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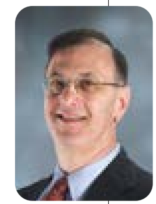
# End the Drama at the CSB

## Turmoil at the top has hobbled its essential work for far too long



**Let's hope we now see less drama and more attention to crucial work.**

**FOR NEARLY** 25 years, the U.S. Chemical Safety and Hazard Investigation Board (CSB) has played a crucial role in finding the causes behind significant safety incidents at facilities handling chemicals and sharing the lessons learned from these events with industry. Unfortunately, for more than a decade, the CSB has suffered from issues, both internal and external, that have hampered carrying out its mission.

Way back in 2008, I noted how the U.S. Government Accountability Office issued a report that detailed serious shortcomings at the CSB ("Chemical Safety Board Gets Rebuke," https://bit.ly/3Jd9HGt). Next, in 2014, I commented on how conflict among its board members as well as staff turnover undermined the CSB's effectiveness ("Turmoil Takes a Toll on Chemical Safety Board," https://bit.ly/3S23wJo). Then, in 2017, the very existence of the CSB came into question when President Trump's proposed 2018 budget completely eliminated funding for the agency, spurring my editorial "Save the U.S. Chemical Safety Board," http://bit.ly/2mlgXqt. While that existential threat was averted, the CSB remained somewhat dysfunctional because of a lack of board members. President Trump nominated Katherine Lemos in June 2019 to be chair of the CSB, an appointment the Senate confirmed in March 2020. Soon after she joined, the only other board member resigned, leaving her as the only person on the board, which should have five members. President Biden in 2021 nominates and the Senate approved two board members, Steve Owen and Sylvia E. Johnson. (See: "Add Industry Perspective to the U.S. Chemical Safety and Hazard Investigation Board," https://bit.ly/3xdz3ND.) At that time, I applauded the addition of more members to the board but lamented its lack of anyone with actual process safety experience.

Unfortunately, turmoil continues. According to reports, e.g., by *The Hill* ("Inside the contentious Trump-Biden appointee fight on the Chemical Safety Board," https://bit.ly/3JdyEla), infighting among board members erupted, particularly over internal rules — including one approved by Lemos when she was sole board member that gave her what the other two board members call "unprecedented authority." Lemos also faced criticism from Public Employees for Environmental Responsibility, a nonprofit organization of local, state and national environmental professionals, for her spending, particularly her travel between her home in San Diego and Washington, D.C. ("Chemical Safety Board Chair's Spending Spree — On Herself," https://bit.ly/3zayKFE).

In early June, President Biden nominated Catherine J. K. Sandoval, a law professor at Santa Clara University in California, for the board. Almost immediately, Lemos announced her resignation. According to Bloomberg ("US Chemical Safety Board Chair Resigns Citing Lost Confidence," https://bloom.bg/3vmdEms), she declared in her resignation letter to President Biden, "Recent priorities of the Board have eroded my confidence in our ability to focus [on the CSB's mission]." Her resignation took effect in late July.

Let's hope we now see less drama and more attention to crucial work at the CSB.

Let's also hope President Biden restores the board to its full strength. I urge him to nominate someone with deep experience in process safety and knowledge of the chemical industry for at least one of the two vacancies. ●

**MARK ROSENZWEIG**, Editor in Chief
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# Understand How Drying and Dust Interact

This can provide insights on dust-control and attrition issues

**You can learn a lot by observing Mother Nature.**

**WE LIVE** in the mountains of Colorado in the summer. I'm amazed at how much we are surrounded by solids processing operations. First, there is intense sunshine that can dry a deck in under an hour, or cook your skin in less than a minute. (Actually, as I mentioned in my previous column, "Dry Your Solids Properly," https://bit.ly/3Jc5bs3, it's not the heat but the vapor pressure that determines the drying rate.) Second, there are dust storms that demonstrate the efficiency of a cyclone in capturing dust. (The suction created by the lowest pressure is at the bottom of the cyclone.) Finally, there is the coating of larger particles that makes for slippery walkways even without rain.

We are surrounded by crystallization, solid/liquid separation and drying processes, not to mention the agglomeration and attrition that occur on gravel roads. When I see a fluid bed dryer, these analogies come bursting out — especially the issues of dust control. What most people like about a non-fluidization operation is a much-simpler dust control step. For example, consider a drum dryer. You may need only a very small amount of gas to carry off the solvent because the solids are heated by conduction. Often, the amount of dust not only is very low but also the particles easily drop back into the dry product. However, you must do a mass balance to ensure the gas flow provides an adequate safety margin to carry all the moisture out and you don't inadvertently condense the solvent. I got a call along this line where the engineer assured me the plant had plenty of gas flow. However, the relative humidity of the gas was close to 90% at the discharge to a filter that was un-insulated. You can guess what happened. If you plan to operate at high exit humidity, a better choice for dust control is a wet scrubber. You even may use wash liquor from the solid/liquid separation to capture the dust as product.

Fluid bed dryers avoid the humidity issue because they supply an excess of gas to heat the product. You can get into trouble when using internal bed heating and have the same problem as the drum dryer example.

Dust control in industrial dryers is much more difficult than dust control on a pneumatic or belt conveyor because of possible solvent condensation. In addition, you must expect some attrition; these fine particles can be troublesome. An example is the handling of fines in a fluid bed. I was called to a plant because a fluid bed would run for $\approx$2–3 h before the bed collapsed and plugged everything up. Raising the gas flow made the problem worse because it increased attrition. The plant used a batch fluid bed that had been converted to run continuously. The bag filter was built into the dryer body and fine particles dropped back into the bed. This reduced the average particle size of the bed; only a small portion of the fines was going out with the larger particles. This continued until the gas no longer could support the mass of solids. Relocating the bag filter outside the dryer and dropping the fine solids into the product discharge solved the problem.

**EXPLORE ISSUES POSED BY SOLIDS**

Check out previous Solid Advice columns online at www.ChemicalProcessing.com/voices/solid-advice/.

You can learn a lot by observing Mother Nature. We live near a water park on a river. The kayakers can go upstream against what appears to be a strong current by taking advantage of a low pressure area behind a boulder. I was reminded of a case where we were having erosion inside a distributor that had no solids in the gas. We built a model and were able to visualize what was happening. (Note: we didn't have computational fluid dynamics software then.) Even though the velocity through the jets was over 100 ft/s, we could see a reverse flow occurring around the edges of the jet (a low pressure area) that drew in solids from above. These subsequently went through the jet, eroding it. A slight change in the jet configuration eliminated this reverse flow.

Dust control issues can show up in many other parts of solids processing such as conveying and handling operations, which is the subject of the next column. ●

**TOM BLACKWOOD,** Contributing Editor
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# Winterization Goes Beyond Equipment

Pay attention to how your people dress for the cold

**Don't issue work clothes based on measured sizes.**

**AS WINTER** approaches, you should assess how well your plant is protected from problems that frigid conditions can pose. Heat-tracing, deadlegs, and other equipment-related aspects certainly require attention. *CP* articles, e.g., "Get Ready for the Next Big Freeze," https://bit.ly/3S4U6wM, and "Time to Prepare for Winter," https://bit.ly/3PHXR9Z, provide useful pointers. Other valuable references include a vintage video from the U.S. Chemical Safety Board, "Prevent Accidents During Subfreezing Weather," https://bit.ly/3Bm31E9, and the blog post "Winter Weather Dangers: Why Winterizing is Crucial for Chemical Plants," https://bit.ly/3PHDiu6.

The risk of personnel slipping or falling increases in the winter, as noted in "Winter-proof Your Workplace to Prevent Slips and Falls," https://bit.ly/3Ozkjkh. Indeed, I am reminded of an incident many years ago involving someone in our department who had a limp. She stepped out of her car on one foot, slipped on some ice and broke her femur.

Let's look at another aspect that often doesn't get adequate attention — providing personnel with suitable clothing and other gear.

Consider the experience of my co-worker Fred. His face was bright pink. He had no face mask to provide the minimum of protection against a -10°F windchill. The company jacket he wore was meant for a chilly fall day, not frigid conditions. Moreover, he trudged through the ankle-deep snow in steel-toed boots poorly designed for the real threat that day: frostbite.

It's hardly an isolated incident. Even with all the tricks I've learned over the years, I suffered cracked frost-bitten hands when doing as-built drawings of a plant last winter.

Let's start with the boots. Your people likely are walking on last year's tread. Fix that by arranging for new boots every fall. Issue two pairs of heavy wool socks with the boots. For especially cold weather, it is important to keep boots properly waterproofed. Nothing melts snow faster than boot leather — and wet boot leather means wet socks and trench foot. (Thank goodness for good military training.)

Silicon sprays for waterproofing shoes are effective and easy to apply. Old-fashioned treatments like Bear Grease work well, too. Apply product weekly to dry leather.

Also, don't limit workers to a single pair of work boots. As a minimum, I use two pairs; this allows one pair to dry and gives enough time for an application of boot polish and waterproofer. Make sure there is room for thick socks; add the insert that came with the boots for a spacer in the summer.

Now, look at the pants. Don't issue work clothes based on measured sizes. Always go up a size. Baggy work pants provide better cooling in the summer and some insulation in the winter. Besides, you can put long underwear on under baggy pants (and an oversized shirt). Also, pay attention to the pockets. I changed pants because I couldn't fit my hands in the front pockets. This is a good spot to warm fingers if you're doing something that requires you to take your gloves off.

Don't skimp. Provide arctic gear, e.g., insulated overalls and proper arctic boots, for workers spending more than half a week in brutally cold conditions.

**CHECK OUT PAST FIELD NOTES**

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Face protection also is crucial but more difficult in the age of COVID. An ordinary balaclava won't do because it allows a gap between your mask and your face. I prefer to wear the mask in place of the balaclava and add a hoodie with a fleeced hood liner for a hard hat. (Note: fire-retardant versions are available.) The trick is to pull the draw strings for the hoodie tight enough to insulate the forehead; this is an area most helmet liners won't insulate. Now, put on goggles over eyeglasses and leave a gap underneath. Don't forget your ear plugs — put them on before you tighten the hoodie.

Fogging always is an issue. So, use alcohol lens wipes on all lenses. Masks are a real problem even without goggles. I take my glasses off when I don't need them for detailed work. I really don't have a good answer for this except to suggest you keep them close to your body heat, in a case, until you need them; then, they won't fog as badly.

Lastly, consider warming/cooling stations. Like eye-wash stations, you should have places throughout your facility where workers can heat up or cool down.

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# Catalyst Boosts Butadiene Production

Butane-based process generates higher yield using less energy

REDOX CATALYST

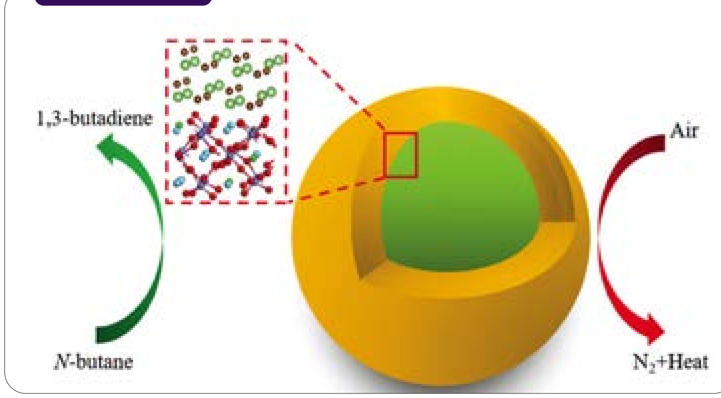



Figure 1. This schematic depicts the core-shell structure, where the core material is lanthanum strontium ferrite and the shell material is lithium bromide. *Source: Yunfei Gao, NCSU.*

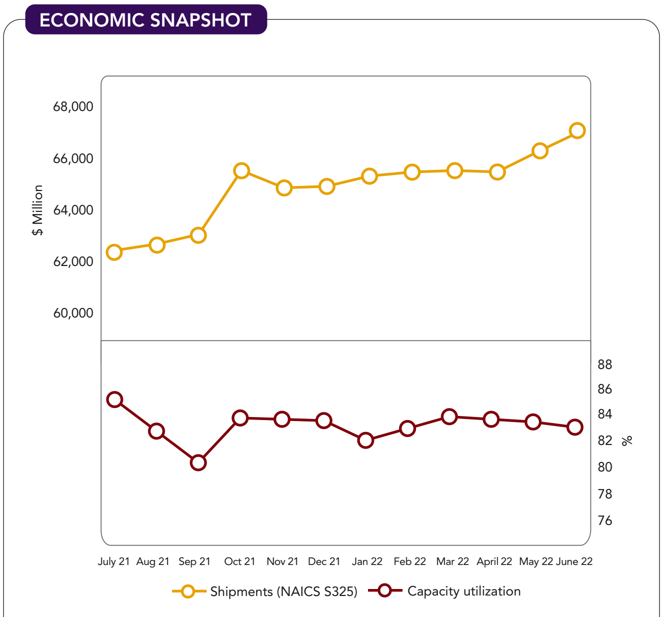
**RESEARCHERS AT** North Carolina State University (NCSU), Raleigh, N.C., have developed a new catalyst that improves n-butane-to-butadiene conversion efficiency, and could lead to increased butadiene production to meet growing demand.

Existing conversion techniques create unwanted byproduct, or convert only a small fraction of the butane in each run through the reactor, note the researchers.

"This is an expensive process in terms of both energy and money," says Fanxing Li, a professor of chemical and biomolecular engineering at NCSU. "Because after every pass through the chemical reactor, you have to separate the butadiene and byproducts from the butane — which takes a lot of energy — and run the butane through the reactor again."

Because of this, few plants produce butadiene. According to the researchers, much of the butadiene used in manufacturing comes from plants where butadiene is a byproduct of other reactions.

ECONOMIC SNAPSHOT




Shipments rose but capacity utilization fell. *Source: American Chemistry Council.*

"That's a problem, because the demand for butadiene far outstrips the available supply," Li emphasizes.

So, to make butadiene production facilities more commercially viable, the researchers engineered a lithium bromide (LiBr) shell catalyst surrounding a core of lanthanum strontium ferrite (Figure 1). Using a modular reactor, an oxidative dehydrogenation reaction run at 450°C to 500°C converts more butane into butadiene with each pass through the reactor than achieved with previous catalysts, they report.

"We were able to convert up to 42.5% of the butane into butadiene in a single pass. The previous best performance we could find was around 30%. We may be able to push it up to the 50% range, but we believe it is more important to decrease the $CO_x$ yield to, say <5%," says Li.

In an article in *Science Advances*, the team writes, "Further investigations on the effect of long-term LiBr loss and strategies for on-stream replenishment of the LiBr promoter would be important from a practical standpoint." Such experiments are planned to take place sometime within the next 6 months, notes Li.

"This is a big first step," he adds, "but we view it as a proof of concept — we think we can still do a lot more to improve the selectivity of this process. We believe the main drawback of our redox catalyst is its relatively high selectivity towards $CO_2$/CO ($CO_x$). We believe that $CO_x$ formation can be minimized by further improving the promoter and promoter oxide combinations and we have a few ideas about that as follow up studies," he explains.

The core-shell-structured redox catalyst reportedly offers adequate mechanical stability in packed bed reactors. "We have not quantified its attrition resistance for fluidized-bed operations, but our preferred reactor design is packed bed," elaborates Li. Furthermore, "Based on our previous testing, the redox catalyst performance should not be affected by other light hydrocarbon contaminants in industrial n-butane," he adds.

Further work is needed before scaleup can begin. "We believe it is feasible to use industrially proven methods, such as extrusion and wet impregnation, to scale up the production of the catalyst. But further improvement of the catalyst performance, e.g., reducing $CO_x$ selectivity and yield, would be important before we scale up the production of the catalyst, stresses Li.

"We're open to partnerships to further explore the potential of this work," he concludes.

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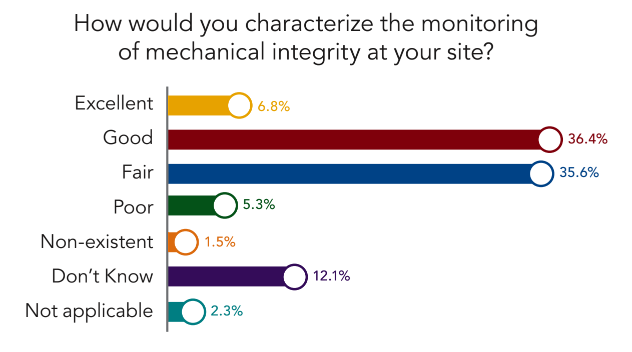


Almost an equal number of respondents rate monitoring as good or better and fair or worse.

# Membrane Eases Flue-Gas $CO_2$ Removal

**A NEW** membrane separates and concentrates carbon dioxide from any type of flue gas, including gas mixtures where $CO_2$ concentration is very low, say its developers at SINTEF, a research organization in Trondheim, Norway.

The researchers use so-called "hybrid integrated membrane technology" in which ultraviolet light integrates a nanometer-thick polymer layer onto a base polymer membrane (Figure 2). Then, a $CO_2$-philic grafted-chain surface layer chemically functionalizes this high-permeability thin film.

ULTRASELECTIVE MEMBRANE

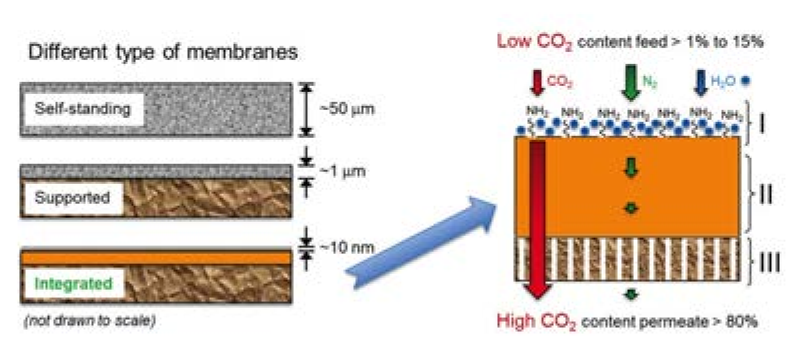


Figure 1. Ultraviolet light integrates a thin layer, which then undergoes functionalization. *Source: SINTEF.*

The hair-like strands that rise from the surface layer contain reactive groups such as amines that bond with $CO_2$ in the presence of water vapor. Pressure in the flue gas or a vacuum on the other side forces gas with $CO_2$ removed across the membrane.

A 20-cm$^2$ membrane was tested at 1.2–5 bar and from 25–55°C, and produced $CO_2$ selectivity up to 150-fold higher than the unmodified membrane.

"The lab-scale membrane was subjected to over a thousand hours of stability testing using a variety of gas pressures, temperatures and water vapor contents. It remained intact and performed well," explains SINTEF researcher Marius Sandru.

The next stage is gradually upscaling the membrane, initially to 500 cm$^2$.

"We plan testing stability using real flue gas first in static tests — i.e., exposure — followed by pilot testing in natural-gas-fired and Waste2Energy pilot facilities in an ongoing project," he adds.

Another benefit of this novel membrane — whose development also involved researchers at the chemical engineering departments at North Carolina State University, Raleigh, N.C., and the Norwegian University of Science and Technology, Trondheim — is that the base membrane is made of easily available and inexpensive olydimethylsiloxane and another polymer similar to polytetrafluoroethylene.

The surface polymerization process is not very complicated either, although Sandru admits it does require careful attention to get the best results. So, the price of this technology never will exceed that of already existing membranes, he says.

The technology suits more than treating flue gases; it could be tweaked to remove $CO_2$ from other mixtures of interest, too —for example from hydrogen as part of hydrogen purification and from biogas mixtures.

"It is possible to graft other polymers on the surface to 'attract' other gases, too, but this would require knowledge of their thermodynamic compatibility. The chemical affinity of $CO_2$ in amines is well-known," he concludes.

# Is Hydrogen the Wonder Fuel?

The drive for decarbonization has created new interest in hydrogen

**Hydrogen compares poorly to its main competitors.**

**JEREMY RIFKIN,** an economist and social theorist, envisaged in his book, *The Hydrogen Economy*, a worldwide hydrogen energy web as an answer to peak oil and as a way to democratize global energy. How well has Rifkin's vision fared in the twenty years since it was first published in 2002? And how does this affect the process industries?

Concerns about peak oil and gas have receded with the advent of fracking. However, the quest for decarbonization has spurred increasing attention on hydrogen, because when pure hydrogen burns, it does not produce any carbon dioxide — only water. ("Drive Energy Efficiency with Decarbonization," *Chemical Processing*, July 2021, https://bit.ly/35YKCwk.) However, this is only part of the story.

Today, most hydrogen is used in oil refining and chemical processing as a chemical reagent, not as a fuel. Emerging energy uses include transportation (fuel cell vehicles, such as cars, trucks and trains, and possibly ships and airplanes); domestic, commercial, and industrial heating and power generation; and grid-scale energy storage.

In the International Energy Agency's Sustainable Development Scenario, global hydrogen demand increases by a factor of more than seven, from 71 Mt/year in 2019 to 520 Mt/year in 2070. At this point, it would represent about 15% of the world's energy budget. This is a huge supply chain expansion — though far short of Rifkin's worldwide hydrogen energy web.

While some known natural reserves of elemental hydrogen exist, they are very small compared to the demand. So, meeting this demand would call for massive amounts of decarbonized hydrogen production, mostly from fossil fuels (e.g., by steam methane reforming with carbon capture and storage) or from electrolysis using renewable electricity. In addition, it would require many thousands of miles of new hydrogen pipelines to move the hydrogen, together with distribution by road, rail and ship.

All of this is exciting, but there is another catch besides the massive investment in new facilities — that is cascaded efficiency (see, "Take a Closer Look at Cascaded Efficiency," *Chemical Processing*, March 2020, https://bit.ly/2R0yYd5). Making decarbonized hydrogen, distributing it, and then using it to deliver heat or power to a consumer requires multiple steps, each of which dissipates energy. Of course, this is true for all energy sources, but hydrogen compares poorly to its main competitors. For example, recent studies have shown hydrogen-fueled cars use two to three times more primary energy than battery electric cars, after accounting for cascade losses.

So why should we even consider hydrogen? The answer is that, in some cases, it is currently the only viable decarbonization option. For example, while hydrogen-fueled cars don't compete well against battery electric cars, the size and weight of the batteries become prohibitive in large trucks; at that scale, hydrogen vehicles are competitive. An added advantage: hydrogen refueling is much quicker than battery recharging — a very important consideration in commercial applications.

**FIND MORE ENERGY SAVINGS OPPORTUNITIES**

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Another area where hydrogen shows promise is in grid-scale energy storage. Electric grids are increasingly vulnerable to fluctuations in power production, especially as wind and solar sources proliferate. This variability creates a need for energy storage to balance the grid. Studies have shown that for long-term energy storage (more than about a day), storing hydrogen in salt domes, and then using it to generate electricity when needed, offers better economics than grid-scale battery storage for electricity.

In the industrial sector, hydrogen is a promising option for hard-to-abate $CO_2$ emissions. These include very high temperature processes that are not amenable to electric heating, and also processes that need a "clean" reducing agent. Prominent in the latter category is the DRI (direct-reduced iron) process, in which hydrogen can be used in place of metallurgical coke to remove oxygen from iron ore.

So how has Rifkin's vision fared? Hydrogen is not a silver bullet for the global energy system. However, current indications are that it will play significant roles as the future energy transition plays out. This includes an increased use as both a chemical reagent and as an energy source in the process industries. ●

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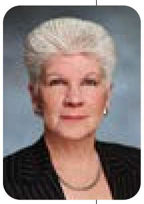
# EPA Eases TSCA Testing Demands

Newly issued documents offer a reprieve for TSCA Section 4 test orders



**Companies qualifying for this relief should be aware of it.**

**THE U.S.** Environmental Protection Agency (EPA) has issued two new documents for recipients of Section 4 test orders under the Toxic Substances Control Act (TSCA). The good news is these documents offer relief to stakeholders who otherwise would be responsible for chemical testing costs for certain chemicals they produced or imported.

The August 5, 2022, document entitled "Policies Regarding Manufacturers and Processors Subject to TSCA Section 4(a) Testing" provides two policies:

*Policy 1.* Companies engaged in manufacturing activities for a chemical substance during the five years prior to the projected signature date or effective date of a Section 4(a) action (i.e., a rule, consent agreement, or order) will generally be included in the scope of the action. The EPA may apply a longer or shorter period of time when appropriate in specific cases, however. The agency states that "[w]here (1) a five-year period fails to identify a sufficient number of manufacturers, (2) fairness reasons warrant inclusion of a manufacturer, especially a high-volume manufacturer, of the chemical substance with less recent manufacturing, (3) a chemical substance has persistence and/or bioaccumulative properties that warrant inclusion of companies that contributed to potential exposures associated with such substance, or (4) where warranted for other reasons, which the Agency would explain as part of the Section 4(a) action, EPA will consider a longer manufacturing period than five years for the identification of companies as manufacturers subject to TSCA Section 4 testing obligations for a given chemical substance." An example of where the EPA may not subject a company that has manufactured in the past five years to testing requirements would be a firm that "may have gone into bankruptcy and be in the hands of receivers who do not seek to continue the company's manufacturing activities involving the chemical substance subject to the testing requirements."

*Policy 2.* Section 4 actions will not include an option to cease manufacturing to satisfy the requirements of the action. Test orders issued in January 2021 included this option. The EPA removed this option to ensure enough entities remained subject to an order (e.g., for one 2021 order, no manufacturers identified by the order remained available to conduct the testing due to their use of the cease manufacture response option). According to the EPA, were all entities subject to the testing requirements able to exit the market to forgo producing the required data, the agency would be unable to seek and obtain data under Section 4(a) to better support its assessments and action. The EPA states where it is conducting a risk evaluation on chemical substances that have conditions of use that "are not currently ongoing but are reasonably foreseen to reoccur or for which the effects and exposures are ongoing, EPA generally believes it is appropriate to include companies responsible for those activities in testing obligations."

In the policy document entitled "Removal of Certain Companies from Seven TSCA Section 4(a)(2) Orders Issued in 2022," the agency acknowledges a company that ceased its manufacture of a chemical substance in response to a 2021 order "forewent a business opportunity in reliance upon EPA's representation that testing on the chemical substance would not be required by the company." The EPA will remove from a 2022 order on a chemical substance any company that made successful use of the cease manufacture response option for a 2021 order on that same substance, "provided the company has not, and does not, recommence its manufacture of the chemical substance while testing obligations remain in effect for that chemical substance under the applicable 2021 Order and/or 2022 Order."

Removal of such companies due to the EPA's approval of the "cease manufacture" response option provided in the 2021 order applies only to 2022 orders issued for the eight subject chemical substances. Any future Section 4 action involving the applicable chemical substance will include manufacturers and/or processors as deemed appropriate upon any final future action (e.g., should such companies resume their manufacturing and/or processing of the chemical substance following the completion of the testing requirements in the 2021 and 2022 orders).

The EPA stresses these documents are not intended to bind the EPA or members of the public. The EPA "may revisit and depart from these policies based on reasoned consideration as it deems appropriate in the future." For now, however, this is good news and companies qualifying for this relief should be aware of it. ●

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Lynn is managing director of Bergeson & Campbell, P.C., a Washington, D.C.-based law firm that concentrates on chemical industry issues.

# AI Transforms Sustainability, Topples Silos

Improving manufacturing "top to bottom" with advanced analytics.

**JAMES NEWMAN**
Head of product and portfolio marketing, Augury

**Our goal is to rip out the ampersand between maintenance and operations...to really get into collaboration.**

**NO LONGER** a warm-fuzzy concept, sustainability is increasingly becoming as good for the bottom line as it is for the environment. To explain how AI-driven solutions that target machine and process health can help with strategy and results, Chemical Processing spoke with James Newman, head of product and portfolio marketing with Augury, a production health solutions provider that combines advanced sensors with AI capabilities and human expertise.

***Q: What are the unique challenges that chemical manufacturers face in terms of sustainability efforts?***
***A:*** Chemical processing, by its very nature, is energy intensive and the processes themselves are full of chemicals. But the biggest sustainability challenges center around the necessary cultural mind shift.

Most companies don't know what strategies will make the biggest impact on their investments. The zero-sum game of profitability versus the planet versus people has been a problem for well over 100 years now. It puts us in a mindset where you can optimize for something, but you can't optimize for everything, where you have to make trade-offs with all kinds of downsides.

***Q: What has changed in the past five years in terms of outlooks and goals for sustainability?***
***A:*** Almost two decades ago the phrase "carbon footprint" came into being. To be quite honest, it was an attempt to shift the concept of sustainability and accountability away from corporations and toward the general public. Today, investors, regulators, the general public, and even employees know better. There's a lot more pressure applied to every level of an organization to be more sustainable. A company's ability to greenwash their activities is going to come under a lot more scrutiny. But the good news is most companies have fairly robust and well-communicated strategies and policies for sustainability efforts.

Plant Services magazine just published a report, "The ESG paradox: policy vs. practice." And in that report, focusing specifically on the chemical industry, the research shows that most companies have clearly defined ESG policies in place. But at the same time, they haven't permeated through the organization in a meaningful and tangible way. To improve sustainability, chemical manufacturers have to be able to translate policies and procedures into goals and objectives.

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***Q: Are there examples of technology available today to help translate to true sustainability?***
***A:*** What's really changing the dynamic is our ability to use AI and other advanced analytics solutions to transform the way we manage the manufacturing process, top to bottom.

For example, continuous asset monitoring isn't really a new concept. What is new, however, is having prescriptive, real-time asset insights that do two things: prevent machine failure and understand suboptimal operation.

Machines that run inefficiently consume a lot more energy. When you're alerted to this you can make better decisions on how to maintain them to avoid downtime, but also to ensure they do their job with the least amount of energy necessary.

On the process side, it's always been a single-dimensional challenge: Do you have your team pick the best operating envelope for quality, or do you pick throughput or energy emissions? Those three things are not necessarily all lined up, and in the traditional methods, you can pick one of them and maybe get lucky and do something about one of the others.

Today, we have AI-driven solutions that enable you to do dynamic and multidimensional process optimization, which means you now get to set your objectives for all those factors at one time and find the right operating envelope that lets you get as close to perfect as you can and continually update that as your business objectives and your external conditions change.

***Q: These goals need to pay off for many different areas: companies, shareholders, the environment, and the employees. What's different today?***
***A:*** If you look at our newest generation of workers, they're highly environmentally and socially conscious, and they want to work with companies that have similar goals and objectives.

Sustainability is not a new topic. What's different, however, is sustainability allows them to do what they should do to make their assets more profitable, make their production lines better, and improve quality. All those things are now embedded inside sustainability objectives.





Most sustainability efforts today are lagging indicators. "Oh, I have burned this much energy, and I'll look and see if there's a way I can change that next time." What we're able to do now is say, "I am burning too much energy. What adjustment can I make right now to bring that down without sacrificing my other objectives?" That's the big change we're talking about here.

***Q: How do you get plant managers and maintenance staff to grasp these KPIs and goals?***

A: People work toward what they're measured against. If I have a goal in my production line to reduce energy emissions by 10%, and that's part of my performance metric, I'll pay a lot more attention to that than to a vague corporate goal of dropping energy emissions by 10%.

We need to have real, tangible goals in place that are measurable and part of what you do every day. The second half of that is to deploy technologies and solutions that help people achieve it.

***Q: For manufacturers using predictive maintenance, how do they use the productivity and efficiency gains to lead to sustainability gains?***
***A:*** Machines that run correctly use less energy. But what if you can't see that? You need solutions that show you when a machine has an imbalance or when there's structural looseness or when there's bearing wear or friction rising in the system. If you have to fight friction, you use more energy. Seeing what your assets are doing lets you make a tangible impact.

The National Institute of Standards and Technology did a study several years ago that found unplanned downtime resulted in $3.3 billion of waste. Think about your process. You have lots of inputs — chemicals, energy, water. Those are also potential waste streams. If you have a defect, then all of that stuff you put in is now lost, including the energy to generate the product, which has now failed.

***Q: Sustainability focuses on long-term outcomes, not the short-term gains. How can machine health help?***
***A:*** Machine health and process health work together to reduce energy consumption and waste streams. If I use less electricity today, I can report that. If I generate less waste today, that's a short-term thing.

Imagine a world where we can actually choose what we want to optimize for across a bunch of objectives. I have throughput, I have quality, I have energy emissions. What if you could put those into the same model and find out how to reach all of those objectives at the same time? And sustainability is baked in – those goals are an ingredient in the recipe when you make the cake.

Today, you can begin to do that. You can, every single day, look at your production line based on your constraints and your needs at the time. You're going to have periods where demand is higher or raw materials may be more expensive. You need to be able to account for all of those things to reach your objective — sustainability being one of them.

I don't believe sustainability should ever be a three-year objective. It should be, "What can I do today to make progress?"

***Q: What about cross-functional collaboration, and where does machine health and process health enable that coordination?***
***A:*** Our vision for the world's workforce is that machine health and process health completely transform the way teams work. Instead of working in silos with separate goals and objectives, they can see shared objectives and targets, which include their sustainability goals. And this aligned view means we can ask very different questions than we ever could before.

THE WHOLE ENVIRONMENT

With AI, sustainability becomes part of the chemical processing formula.

Instead of saying, "How do I manage maintenance and how do I manage operations?" It's, "How do I manage my maintenance plan to optimize performance while at the same time maximize throughput and minimize our waste streams and our energy consumption, and how is my team going to achieve that today?"

Our goal is to rip out the ampersand between maintenance and operations. And these technologies, these solutions, allow us to do that — to tackle sustainability and other goals together.

I think it's a tremendous opportunity for chemical manufacturers to be a leader in this effort because they get a lot of scrutiny for their environmental and sustainability objectives just by the very nature of their processes. They have the opportunity now to leverage the right technologies with the right cultural mindset, with the right organizational objectives, to actually be the leaders in sustainability. They'll do it by driving how manufacturing is done and how we empower people to actually be responsible for and contribute to sustainability every single day.

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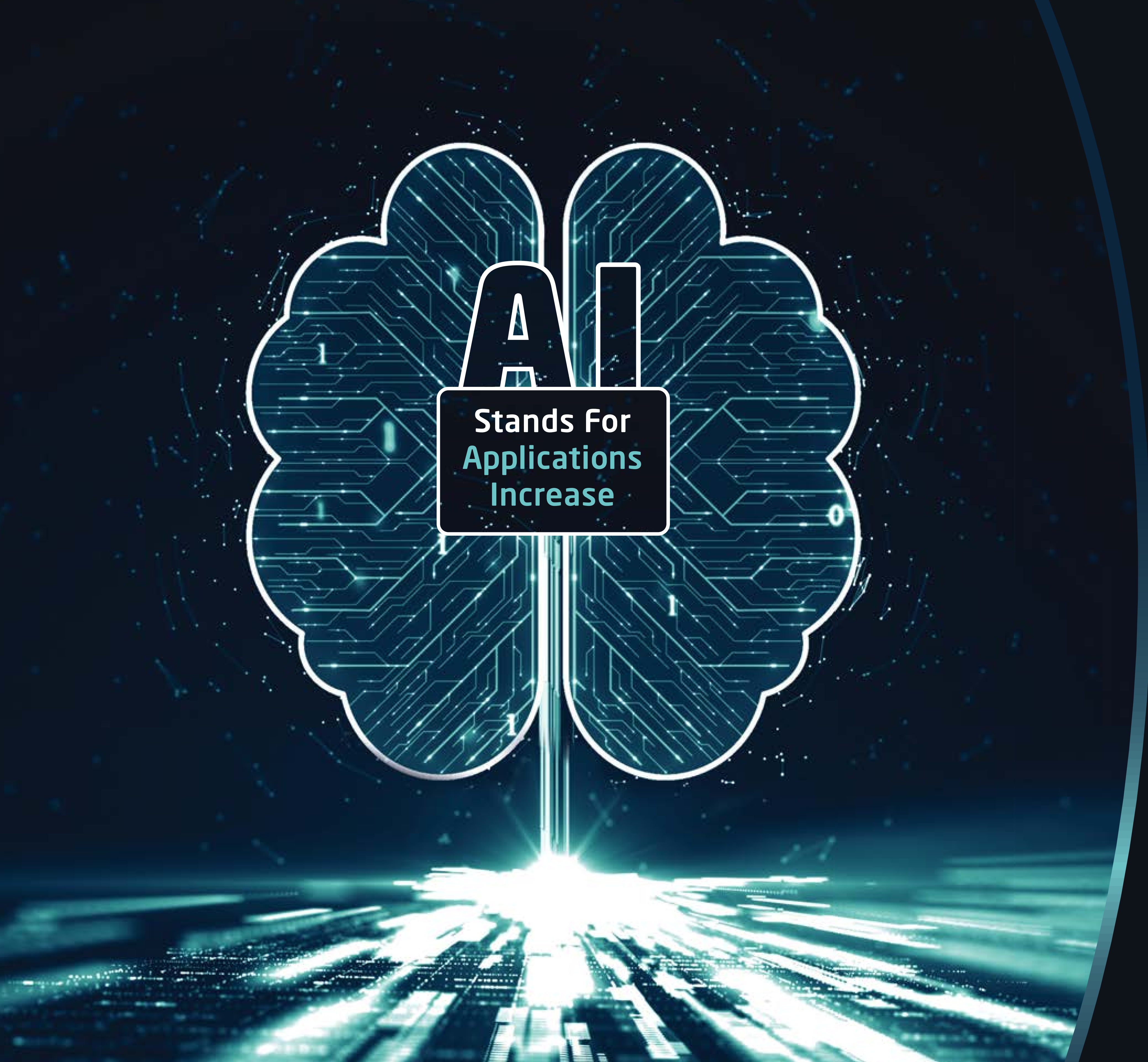


## Pioneering efforts with artificial intelligence target diverse opportunities

By Seán Ottewell, Editor at Large

**ARTIFICIAL INTELLIGENCE** (AI) and its related digital transformation technologies promise to impact a broad swath of operations and products in the chemical industry. Recent developments by Yokogawa, Seeq and Dow Polyurethanes highlight the diversity and significance of AI to the industry now and in the future.

Yokogawa and Japan's largest cellular phone company Docomo, both based in Tokyo, have successfully conducted a proof-of-concept (PoC) of remote control technology for industrial processing.

Completed at the end of May, the test involved the use in a cloud environment of an autonomous control AI, the Factorial Kernel Dynamic Policy Programming (FKDPP) algorithm, which was jointly developed by Yokogawa and the Nara Institute of Science and Technology, Ikoma, Japan, and a 5G cellular communications network provided by Docomo.

The FKDPP AI algorithm uses reinforcement learning technology and suits many control applications where either proportional-integral-derivative (PID) control or advanced process control (APC) can't achieve challenging simultaneous goals such as high quality and energy efficiency.

Yokogawa and Docomo started work on the PoC following an agreement in April 2021. The aim of the demonstration test was to verify whether using FKDPP in the cloud via a 5G network could handle a three-tank level-control system.

A target water level was set and then tests with low- to high-speed control cycles were conducted, and the effects of cellular-communications latency on FKDPP control were investigated.

Compared to 4G, the test demonstrated that, especially with high-speed control, 5G delivers lower latency and less overshoot relative to the target water level, and can handle a control cycle as short as 0.2 sec, thereby achieving better control for more-stable quality and higher energy efficiency.

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In effect, the test successfully controlled a simulated plant processing operation, demonstrating that 5G is suitable for the remote control of actual plant processes.

Besides confirming this is the first time the FKDPP algorithm has been used on a 5G network, Keiichiro Kobuchi, vice center head/AI business senior manager, control center, Yokogawa Products, notes the two companies intend to carry out further advanced initiatives aimed at facilitating a shift towards industrial autonomy.

"Both Yokogawa and Docomo will continue to evaluate the use of 5G for remote, autonomous plant operations. By carrying out demonstrations in a wide range of customers' plants and examining communications reliability and latency-related issues during long-term use, the two companies will strive to achieve 5G and AI-enabled autonomous control," he adds.

### EARLIER FIELD TRIAL

The Docomo project builds on a field test in a chemical plant carried out in February. Here, FKDPP was used successfully for 35 days to deal with the complex conditions needed to ensure product quality and maintain liquids in a distillation column at an appropriate level while making maximum possible use of waste heat as a heat source (Figure 1).

**FIELD TRIAL SUCCESS**

Figure 1. Test at distillation unit was the first in which artificial intelligence directly changed a manipulated variable. *Source: Yokogawa.*

The test took place at an ENEOS Materials Corp. chemical plant in Japan and was aimed at controlling processes known to be difficult to automate using existing PID and APC technologies and which, therefore, had been performed manually. (Editor's note: More details on this application will appear in a forthcoming "Making It Work" article in *Chemical Processing*.)

In particular, the project wanted to tackle the many situations where veteran operators must step in to halt automated change and configuration values when, for example, atmospheric temperature suddenly shifts due to rainfall or some other weather event.

Yokogawa cites this common issue as a longstanding hurdle when trying to institute autonomous control in situations that currently must rely on manual intervention. The hope is that the collaboration with ENEOS has opened a route to resolving it.

According to Kobuchi, this project is a world first on two counts: one, because AI hasn't been used to directly change the manipulated variable in a chemical plant before; and, two, because the process ran for 35 days.

"We believe that it will be a disruptive innovation that will automate processes known to be difficult to automate using existing PID and APC control technologies and which, therefore, had been performed manually. FKDPP automates areas that cannot be automated with existing technology. It's a technology that expands automation," he says, adding the challenge now is getting customers to fully understand the value FKDPP will offer.

Commercial confidentiality prevents him from revealing the next steps in the Yokogawa/ENEOS project.

However, the project has led to more interest than expected from chemical companies, Kobuchi notes. "Customers are interested in FKDPP not just because it will automate processes known to be difficult to automate… but also because it achieves safe operation and improves productivity, with stable quality, high yield and energy efficiency."

With safety being a chemical industry priority, clearly demonstrating that new processes and methods ensure safety is as high or higher than with manual operations is essential, he emphasizes. So, the next step is to demonstrate the value and benefits of implementing FKDPP compared to the status quo.

"Quantified results are obviously valuable for this, so the more field tests we can perform across various industries, the easier this will become. It is also important for the customer to have a proactive mindset about implementing DX [digital transformation] initiatives like this. So, Yokogawa welcomes customers who are interested in these initiatives globally."

In general, the tangible benefits include improved productivity and contributing to a more-sustainable society.

"By linking information on production, inventory, demand and other matters with cloud-based autonomous control AI, it will be possible to align management directives with the actual control of operations on the plant floor. We are looking forward to making more breakthroughs with FKDPP in the near future," adds Kobuchi.

Meanwhile, the company is promoting the concept of IA2IA – Industrial Automation to Industrial Autonomy — to its global customer base. The idea here is to achieve strong and flexible production that takes into consideration the impact of differences in humans, machines, materials and methods.

"IA2IA refers to the transition to industrial autonomy, and at Yokogawa we are working on roadmaps and solution portfolios that will enable customers to work toward that goal. There is certainly strong interest in the concept," he says.

Turning to standards, Kobuchi believes industrial autonomy is too broad to have a single one. "But work is already taking place on standards for some enablers, and this is especially necessary in areas like data analysis and AI. This is an evolution from the standards work done for industrial automation over the last several decades, so the ISA-95 standard that has served as a framework for many years will need to evolve, too," he concludes.

**DIFFERENT PRIORITIES**

Other companies see the potential of AI in other contexts. Seeq, Seattle, for example, is focused very much on cloud-based advanced analytics technologies.

"Currently, we don't see autonomous plant control as an important driver for our chemical customers" says Ashwin Venkat, senior principal scientist for advanced analytics/machine learning (ML).

"Given the complexity of most chemical processing plants and the constantly varying nature of process feeds, energy sources and weather effects, successful autonomous control remains a significant challenge. In our experience, PID and APC control technologies still require frequent human oversight and detailed process understanding to be successful," he notes.

Rather, Seeq's customers are focused on using AI and ML technologies for monitoring and diagnostics such as anticipating equipment anomalies and failures, optimizing production, detecting precursors for process quality deviations, and providing real-time monitoring and diagnostics of batch operations.

"Customers are also often interested in scaling these types of AI applications across similar assets," Venkat adds.

To this end, the company is partnering with industrial automation and digital transformation company NECI, Mansfield, Mass., to help customers harness diagnostic and predictive analytics in a way that will improve their operational efficiencies and provide deeper insights across entire organizations.

"We find the most successful chemical plant monitoring and diagnostic programs are driven by subject matter expertise in combination with fully featured, extensible AI/ML and analytics software for industrial time series data," he explains.

Typical concerns for less-experienced chemical customers include: how to utilize subject matter expertise to build application/domain-specific models; how to reliably apply the technology in a plant — i.e., demonstrate it is not a black box; how users can collaborate and communicate insights to stakeholders; how the technology fits into existing workflows; and how it has created value for others using, for example, case studies.

FASTER FORMULATION

Figure 2. Virtual laboratory cut foam formulation times by 30%. Source: Dow Polyurethanes.

### REAL-TIME FOAM FORMULATION

Dow Polyurethanes, Horgen, Switzerland, is harnessing the power of AI to cut by a third the development time for new products for its customers (Figure 2).

In March, its efforts won the 2022 Artificial Intelligence Excellence Award from the Business Intelligence Group, Beverly, N.J., for its flagship Predictive Intelligence (PI) digitalization initiative. This annual award recognizes the application of AI to solve real-world problems.

PI combines Dow's material science expertise with AI and ML capabilities in a virtual laboratory to allow real-time prediction of polyurethane foam formulation properties. PI also can recommend formulations based on desired properties directly inputted by customers.

The company officially launched PI in July 2021 but had been working on computational models, AI, ML and data collection for several years beforehand.

"Predictive Intelligence is a cloud computing capability that accesses global formulations, properties, computational models and process conditions. The data is used to power AI/ML models to predict the properties of new formulations, accelerate product innovation and support faster business decision-making," explains Clint Schmidt, global Predictive Intelligence leader.

Chemical innovation typically involves running experiments in physical labs that pose personnel, equipment, and scale constraints, he points out. Even the most-advanced, high-throughput labs have limits; so, typical innovation cycles for formulated products range from six months to several years depending on the complexity involved.

"Polyurethane product development specifically involves running several statistical design-of-experiments (DoEs). Collecting the data from different DoEs to predict properties from hundreds of components is challenging and time-consuming. However, AI/ML can ingest data from hundreds of DoEs to reduce the number of experiments required to develop a new product," says Schmidt.

To achieve this, the company combined expertise, including domain knowledge and the knowhow of data engineers, data scientists, data analysts and cloud computing architects, to create the virtual lab for the company's global polyurethane formulation efforts. The design of the interfaces with the AI models reflects feedback from users currently piloting the system, enhancing ease of use.

"Our virtual lab can reduce the time involved in traditional formulation development work by up a third, allowing our development scientists to explore new applications," he stresses.

Overall, PI has made Dow appreciate both the value of its formulations and its domain expertise more than ever. In fact, data from new formulations, such as their properties and manufacturing process conditions, are used to retrain existing models, making them more versatile.

"The intent is eventually to evolve the formulation library into a complete business intelligence platform that can predict customer requirements and develop more cost-effective and environmentally friendly polyurethane products. It will be an accelerator in the space," believes Schmidt.

Based on Dow's PI experience so far, Schmidt urges process engineers not to underestimate the value of their own data and domain expertise. With these as a foundation and using expert help to create a virtual lab, it can become a highly valued and regularly used asset for product development scientists.

"Data empowers us to make the right decisions and no longer rely on trial and error or hunches. Everything we need to know to chart the path ahead is now at our fingertips to help us create a better future," he concludes.

For now, trials continue with selected but unnamed customers. The hope is to make PI available to all polyurethane customers later in 2022. ●



# RETHINK YOUR CONTROL VALVE SERVICING

The right approach can cut turnaround time and effort considerably while maintaining reliability

By Scott Grunwald and Karl Lanes, Emerson Automation Solutions

**SHUTDOWNS, TURNAROUNDS** and outages (STOs) are a stressful time for plant personnel. Because production is halted, management is unhappy, and losses mount every minute the unit remains idle. Avoiding surprises and enhancing STO execution can boost the bottom line significantly while reducing pressure on employees responsible for the work.

Here, we'll describe methods to save time and cut costs during an STO by improving control valve maintenance and repair efforts, with the added benefit of mitigating fugitive emissions.

## STO CHAOS

When a plant begins an STO, normal work practices change drastically. A typical operations crew of a dozen per shift balloons to hundreds of workers; management frantically drives the teams to get the work done as rapidly as possible while still prioritizing safety. This leads to a mad dash to complete the STO.

In the midst of such chaos, the plant's maintenance department usually takes advantage of the downtime to pull and overhaul hundreds of control valves. It invariably finds unexpected damage that requires quickly obtaining

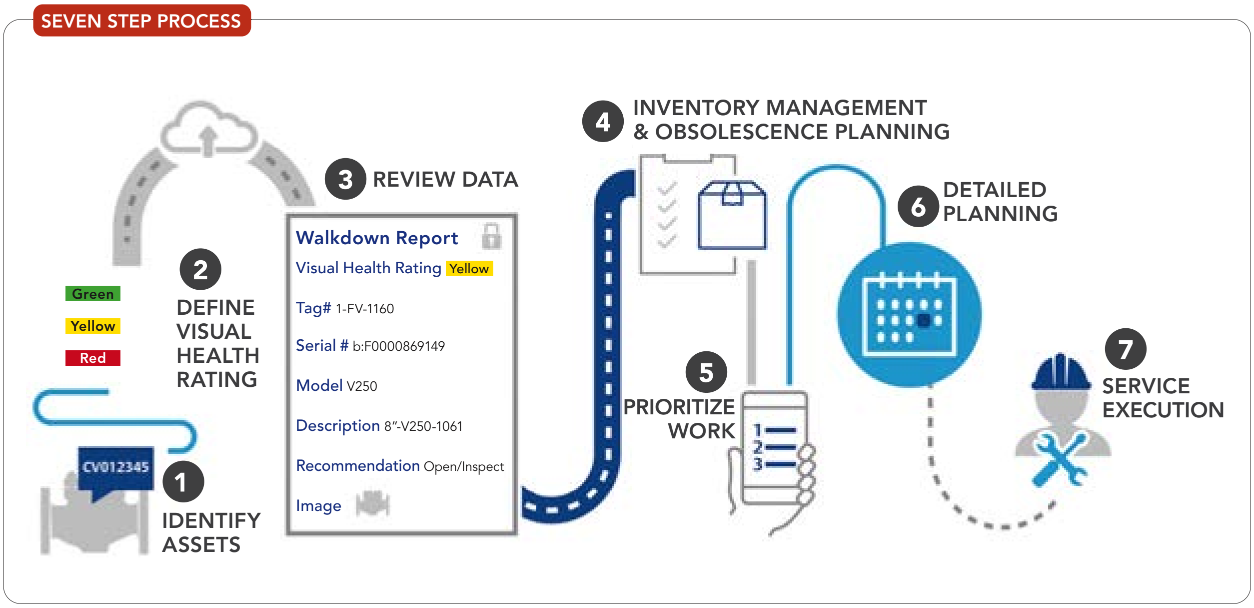


Figure 1. With the right data available, STO efforts become less onerous and can follow clearly defined steps.

replacement parts or even entire valves. These unplanned but common surprises generally create delays and added expenses that extend the STO and cause cost overruns.

Historically, there are three lines of thinking for control valve repair. One option is to simply run the valve to failure and then fix or replace it. Unfortunately, such a strategy usually results in many unplanned events, reducing output and driving up maintenance and repair costs.

A second option is to pull and overhaul every valve during each STO. This minimizes the likelihood of a control valve causing an unplanned event. However, it incurs enormous cost. The logistical difficulty of pulling, overhauling and then returning to service every control valve is daunting. The effort also requires a host of very expensive and limited resources to perform repairs and ensure the valves perform as expected when returned to service.

The third option is repair by replacement, with this decision based on various factors including price, part availability, years in service, valve type and length of the STO. Because this option requires plant personnel to have a replacement valve on hand, it can be quite expensive.

### AN ALTERNATIVE APPROACH

Another method of tackling the STO problem is to only pull and overhaul the control valves that require service. Many valves operate in relatively benign conditions and can go years without any maintenance at all — so, there is no reason to needlessly pull them. Of course, the challenge here is knowing which valves have problems and which do not.

Predicting the condition of a plant's control valves requires reliable valve data and analyses, which too often are hard to obtain. A plant needs to know:

- the complete roster of control valves, including details on all sub-components like actuators, positioners, trim, etc.;
- a history of a valve's operation to date and repairs made; and
- an indication of the valve's performance now and any developing problems.

Armed with that information, a plant fairly accurately can assess which valves need overhaul and which can continue to operate until the next STO.

If these data are available, then the control-valve STO becomes a much more manageable exercise — a multi-step process as shown in Figure 1.

Ideally, the control-valve asset details are readily available and the current health of each valve is evaluated using data and equipment inspection to create a list of valves to overhaul. Because there's always a risk that a valve could unexpectedly fail, it is prudent to add certain critical and severe service valves regardless of their apparent condition. Then, the valve list is re-evaluated to determine what equipment upgrades, e.g., replacing a valve packing with a low-emission style or installing a new valve rather than fixing the current one, make sense to incorporate during the repair.

After establishing the STO scope, the team must plan the logistics of the event. This includes ordering the necessary parts and replacement valves and further defining the details of pulling and repairing each valve.

When carefully planned, STO execution should pose far fewer challenges and incur fewer delays and cost overruns. Invariably, opening valves for inspection will lead to some surprises but these should happen much less frequently.

This alternative means of control-valve STO execution certainly offers a host of advantages. However, its viability depends on the availability of complete valve information along with advanced analyses. Unfortunately, many plants lack the most-up-to-date data history or the means to gather maintenance documentation, making STO planning extremely difficult. Fortunately, ways exist to address this issue.

### START WITH A WALKDOWN

The first step is to understand what equipment the facility has. This most easily is accomplished by walking down every control valve to document specific details of each valve or to verify any available equipment data (Figure 2).

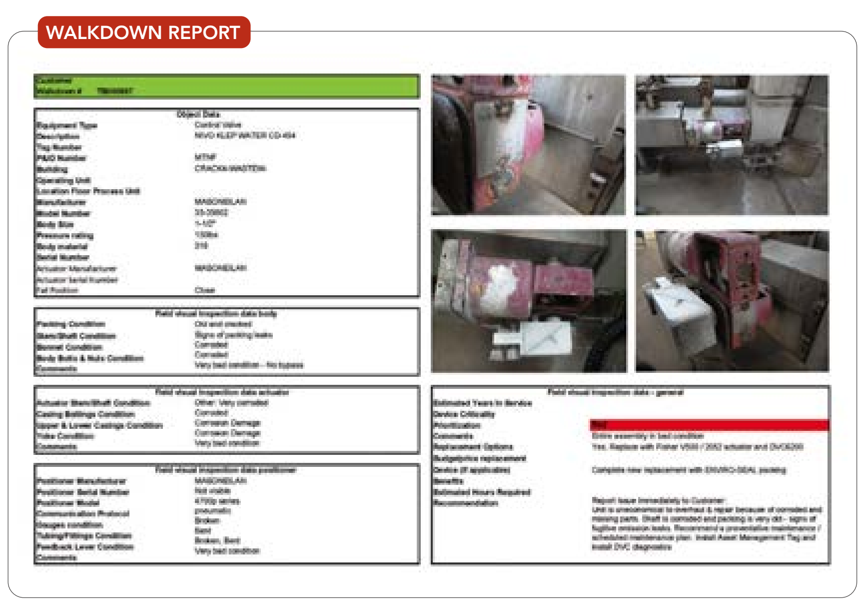


Figure 2. Documenting specific details of every valve in the plant is a crucial first step.

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If this effort is being executed for the first time, it normally happens as much as a year in advance of the STO. If walkdowns have occurred in the past, then the effort required is reduced and the walkdown can take place closer to the turnaround date to obtain the most-up-to-date information. It is wise to place early focus on potential long-lead items, such as valves with exotic alloys or customized internals, to enable ordering replacement parts or valves well in advance.

Plant personnel can perform this effort if they have the time and expertise; partnering with a valve vendor is another option. A critical aspect of the process is to use a method of reporting that encourages consistent and complete data gathering while saving information in a method that can be easily referenced and updated. Some vendors offer applications and handheld devices that aid technicians in efficiently gathering the required information. It also helps to assign each valve a sturdy RFID asset tag to allow easy access to its information as the valve progresses through repair and installation.

Many plants also use the walkdown as an opportunity to address fugitive emissions. Valves handling volatile organic compounds and other targeted or restricted materials are specifically identified and evaluated for emissions during the initial valve review. Then, a check of the leak histories of these valves leads to flagging any valves that have shown persistent fugitive-emission problems.

Leakage results in lost product, generates increased regulatory testing requirements, e.g., per the U.S. Environmental Protection Agency's Leak Detection and Repair program, and, ultimately, can lead to fines. The findings of the environmental walkdown can serve to generate a target list of valves for repair or improvement during the STO.

In some cases, a simple packing replacement may solve the issue. In other cases, the solution may involve upgrading the packing design to better handle the process conditions. For instance, a live-loaded environmental packing design using a combination of polytetrafluoroethylene and graphite rings will substantially reduce fugitive emissions while providing easier stem movement and improved valve performance.

Particularly difficult applications may warrant a complete valve replacement. Lethal service valves might require a bellows-seal arrangement to eliminate packing leakage. A process with high pressure drop and cavitating conditions might call for any of several anti-cavitation valve designs with hardened alloy trims.

### DIAGNOSIS AND OVERHAUL OPTIONS

Most control valves incorporate digital positioners to improve valve response and control. Many of these positioners can gather performance data that can indicate when a control valve is developing problems. There are a couple of ways to obtain this information. One option is to perform a stroke test when a valve is commissioned and then compare that information to current stroke data to identify inconsistencies (Figure 3).

This method, which can be quite effective, does not provide real-time feedback on how a valve is performing while in service. To obtain that level of data, the plant can leverage the diagnostic data that already may be available in the positioners. Recent-generation digital positioners can detect a wide variety of issues including packing problems, air supply troubles, developing trim failures, and a host of actuator and control concerns.

**VALVE SIGNATURES**

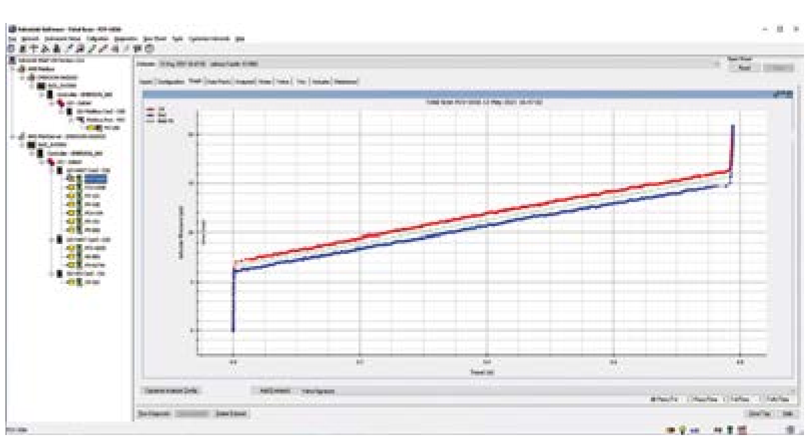

Figure 3. Comparing results of current stroke test with data from initial commissioning can provide insights.

A positioner that communicates to a control asset-management-software package can flag and alarm these issues. Resource-constrained plants can safely transmit this information to external automation experts, who can review the information — highlighting developing problems in periodic reports (Figure 4) and flagging serious problems that require immediate attention.

All these diagnostic data are invaluable for STO planning — enabling flagging valves with developing problems for repair and identifying high performing equipment that can be left alone.

After developing the list of valves needing overhaul, the next step for the STO team is to carefully evaluate those valves to determine the best method of repair. For valves just requiring a simple repair, the solution often is obvious and necessary replacement parts can be ordered. Other valves may offer upgrade opportunities that may make better financial sense.

For instance, a valve may have a history of trim failures related to difficult process conditions. A trim upgrade or even a completely different valve design may provide compelling advantages over simply replacing a part. It may be cost effective to install digital positioners on critical valves to enable partial-stroke testing. Such online testing may allow the plant to extend time between maintenance events, saving significant sums.

REMOTE REVIEW


Figure 4. Outside experts can monitor valve diagnostic data and highlight developing problems as well as serious issues demanding immediate attention.

Another option worthy of consideration for some valves is using repair assemblies offered by original equipment manufacturers (OEMs) rather than single components. For instance, for some Fisher valves, a drop-in trim cartridge replaces up to 20 individual components. Such assemblies minimize the technician training necessary for installation and may make inline valve repair possible, saving time and resources. They also can reduce the cost and number of spare parts that a plant must keep in stock.

When evaluating these options, it often is wise to take advantage of a valve vendor's expertise; a vendor usually can provide a list of alternatives while providing cost comparisons to determine the best solution.

#### PLANNING AND EXECUTION

The last critical step before starting an STO is formulating a detailed plan for executing the repairs. The logistics of pulling, overhauling, re-installing and returning to service hundreds of control valves is not to be taken lightly.

A plant hardly ever has the internal resources to handle all needed valve repairs during the STO, so it almost always will contract with a valve repair company. When utilizing such a firm, it is important to choose carefully because some lack the technical training required to perform the repairs. Others may attempt to use non-OEM repair parts to cut corners. Non-OEM parts can create myriad problems, so all requests for proposal should require the use only of OEM repair parts and products.

It also is critical to accurately enter the details of each repair into the asset management system after the repair is complete. This ensures the valve historical record is up to date, with the internal components of each valve correctly documented.

When planned well, an STO should go smoothly. However, it still requires vast resources to successfully execute the work and commission the repaired equipment. Obtaining "as left" stroke signatures of each valve (Figure 5) for comparison against future performance is especially important.

Plants with limited resources can turn to companies specializing in control valves to help with this work. These firms can provide test equipment and trained personnel to confirm every control valve is ready for startup. They also can manage this portion of the STO itself, coordinating valve repair work, ordering parts as necessary, and ensuring the valve repair data are captured accurately and updated in the asset management system.

#### REAL-WORLD SAVINGS

These techniques for pre-planning and executing STOs can provide substantial economic benefits.

For example, after enduring a plant shutdown of a newly acquired facility where virtually nothing went right, a company turned to an outside firm to first gather valve data via a digital walkdown and then use that information to carefully plan and execute the outage.

CRUCIAL COMMISSIONING STEP

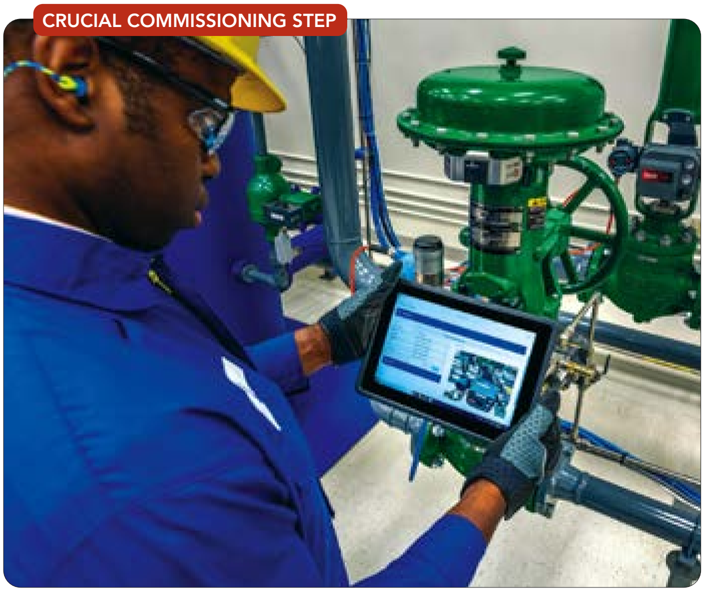

Figure 5. Capturing a post-repair stroke signature provides critical data for spotting developing problems.

The second STO went dramatically better, saving $485,000 and coming in 46% under budget.

In another case, a combined-cycle power plant was reworking every critical valve during every outage to maximize uptime. After installing several upgraded digital valve positioners and implementing diagnostic alert software, the plant could perform its outage efforts more efficiently, saving $68,000 in one STO alone.

Similar programs in other plants have generated average savings of $1,200 per valve by focusing repair efforts on valves that actually have problems and leaving other valves alone.

In each of these cases, the company wisely engaged a knowledgeable specialist firm with trained staff and a successful track record. A less-reputable partner using knock-off parts may save a few dollars during the STO but these apparent savings will disappear as problems develop when the plant is put back into service.

### A MUCH BETTER APPROACH

Data-driven STO valve-overhaul techniques repeatedly have proven successful and saved end users hundreds of thousands of dollars. However, even the best-executed STO planning process may fail to identify some valves requiring repairs. Plant personnel still occasionally will encounter an unexpected valve failure or discover an issue on a valve that was not originally targeted for repair on a unit startup. So, planning for these types of issues remains important.

Furthermore, a well-executed plan not only will significantly reduce STO issues but also will ensure work-scope consistency and safety. These efforts will help keep the plant running reliably between STO events while minimizing events and associated expenses. ●

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# WIRELESS PRESSURE MONITORING **PROTECTS CATALYST**

## Sensors on portable vessels use network that provides straightforward sitewide coverage

By Kevin L. Finnan, Yokogawa

**DURING A** wireless-pressure-monitoring evaluation process, a major petrochemical company found that portable process units presented unique challenges. The company, which manufactures high-density polyethylene and polypropylene at a polyolefin complex in the United States, maintains 100 portable vessels at the site. These store catalyst and are regularly transported to charge reactors throughout the facility.

In storage, the vessels are connected to a header that maintains a constant nitrogen ($N_2$) pressure. The $N_2$ prevents moisture from entering and contaminating the catalyst. Once a vessel is disconnected from the pressurized $N_2$ header for transportation to the charging area, ensuring no decrease in the $N_2$ pressure due to leakage in tubing or valves is critical.

Operators required a compact, lightweight pressure sensor that would easily connect to the $N_2$ fill line on each vessel without additional supporting hardware. The sensor also needed to be installed in a manner that would prevent collision damage during transportation between the storage area and reactor charging areas. Typically, forklifts move the vessels, often through spaces with very little clearance.

Because vessels could be routed or parked virtually anywhere in the complex, the manufacturer required reliable communications coverage throughout. Buildings and an extensive array of process units and piping presented challenges to wireless signal strength. The wireless network also had to tolerate portability. As vessels move throughout the complex, they could require a handoff from one access point to another, much like mobile devices in a cellular telephone network. Typically, a wireless Internet of Things [IoT] network is designed only to accommodate stationary sensors.

Other requirements included Zone 1 hazardous area certification due to the potentially explosive environment in some locations and operation over a wide temperature range as many of the reactors are located outdoors. The outdoor locations also dictated dustproof and waterproof sensor enclosures.

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"Optimize Combustion Using a Digital Twin," https://bit.ly/3mCfRqC

Among the least-challenging requirements for wireless IoT technology was the maximum $N_2$ pressure reading interval of once per hour. Because checking the pressure is critical, the operations team preferred readings actually take place more often. That would allow the operations staff to take corrective action to prevent loading wet, contaminated catalyst into a reactor, thus eliminating a costly production loss and catalyst replacement.

In the existing process, a technician periodically reads a pressure gauge on each vessel. For 100 vessels, that is labor-intensive and poses the risk of too long an interval between manual readings.

The lack of electrical power on the portable vessels mandated self-powered sensors. All the battery-powered sensors under consideration could manage power use in a way that allows multiple-year battery life at the required reading interval. With an increasing emphasis on reducing maintenance spending, the operations team desired the longest possible battery life.

This wireless IoT project is part of company-wide initiatives to improve productivity and safety. A key aspect focused on the evolving workforce. While reducing costs, plant managers are responsible for enhancing workforce safety, incorporating new skillsets and expanding training programs. As veteran staff who perform manual gauge-reading rounds retire, a new generation whose skillsets include the IoT is arriving on the scene.

### THE SOLUTION

Physical size and weight constraints disqualified many of the prospective options. Even today's compact versions of traditional explosion-proof pressure transmitters turned out to be too large and heavy. They not only required additional mounting hardware but also their sizes presented risks of collision damage during transportation. Many wireless HART devices posed the same problems.

The options that did qualify in terms of size and weight presented a wide variety of network architectures and trade-offs. Of those with proven, complex-wide coverage, most required infrastructure such as gateways and access points.



Yokogawa's Sushi Sensor (Figure 1) emerged as an ideal solution for the application. The product is certified as explosion-proof for installation in Zone 1 hazardous areas. The IP 66/67 enclosure is dustproof and waterproof. The operating temperature range is -40–85°C (-40–185°F). Compact and lightweight, the Sushi Sensor enabled a simplified installation via a tee connection to the pressure line and a block valve (Figure 2). No additional brackets or mounting hardware were required.

From October 2021 to February 2022, 100 Sushi sensors were installed in two phases.

The Sushi Sensor network requires far less infrastructure than others, including Wireless HART, the primary challenger. A site survey confirmed that, using only a single gateway, the Sushi Sensor's long-range LoRaWAN network provides complete coverage across the entire complex. All other networks required varying numbers of devices such as access points, repeaters and gateways.

LoRaWAN is among the low-power wide-area (LPWA) network protocols attracting attention in IoT wireless sensor communication systems. LoRaWAN is an open communication standard promoted by the LoRa Alliance, which comprises more than 500 IoT companies and end-users worldwide.

LoRaWAN has excellent sensitivity reception and radio interference resistance. In ideal conditions, LoRaWAN offers a communication distance of six miles (10 km) or more. Even in a facility full of buildings and process infrastructure, LoRaWAN ensures long distance communication over one kilometer between sensors and a gateway. In a "pipe jungle," LoRaWAN provides reliable communication as long as the sensors and the gateway are not completely surrounded by metal or concrete structures.

**COMPACT DEVICE**

Figure 1. The pressure sensor is lightweight and approved for Zone 1 hazardous areas.

EASY INSTALLATION


Figure 2. Hookup of sensor requires only a tee connection and block valve.

LoRaWAN-compliant devices can be installed and operated easily without the need to design wireless routes that require access points or repeaters.

At the petrochemical complex, the gateway was installed in a concrete, explosion-proof control room but the LoRaWAN network still maintained excellent signal strength to all locations.

The Sushi Sensor also offered a battery life that was among the highest of the options considered. The longer the interval between battery replacements, the lower the long-term maintenance cost. The maintenance team also appreciates that battery replacement is a simple process.

The Yokogawa team offered both on-premise and Cloud options. The manufacturer chose to use the Cloud, which allows operations personnel to securely monitor vessel status via dashboards on personal computers and mobile devices. In addition to the dashboard displays, the system will send a live e-mail alert for low pressure in any vessel.

The return-on-investment versus risk was positive. The manufacturer determined that preventing a single incident of loading wet catalyst into a reactor justified the deployment cost of the entire wireless monitoring system.

## A GREAT CHOICE

While the original Sushi Sensor was designed for advanced, predictive asset management applications in conjunction with an artificial-intelligence/machine-learning environment, the Sushi pressure sensor clearly suited the portable vessel monitoring application due primarily to its simplicity. It provided a variety of important benefits. ●

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# Sort Out Seal Pot Snags

A variety of approaches can address issues posed by oil

## THIS MONTH'S PUZZLER

Our pumps use API Plan 53 for sealing. We're having problems with our seal pots: high consumption of very expensive oil, and contamination of the oil in the pot (see Figure 1 online at https://bit.ly/3AG8fKn).

Our young inspector brought this to my attention. He wants to bring in the pump salesperson but I doubt that person has the technical expertise we need. I can't get any help at all from the company that sold us the seal pot or the seals; the salesman familiar with our product suggested a steam seal but that's not our corporate policy. We have trouble maintaining pressure at our air compressors, especially with the use of pneumatic pumps all over the plant. I have seen the psi at the air tank drop to the low 70s; the tank is located 500-ft away from the seal pot. I want to send the sample to a laboratory for analysis because I think it's the seal.

The inspector wants to test the cooling water coil. He thinks it might be leaking into the seal pot. The water is from a cooling tower.

What is the cause of the high consumption of oil? Is there any solution besides continuing to go through \$10/gal oil? Are there any tests we should run?

### EVALUATE THREE OPTIONS

This is a common problem: equipment needs expensive lubrication but consumes a lot of lubricant that contaminates product and causes spills that pose risks of fire or slipping injuries. In addition, failure of lubrication may damage the equipment or even lead to a fire, as in the case of compressors where loss of lubrication is a common cause of fire.

You can approach this problem in three ways: 1) live with it; 2) manage it; or 3) get rid of it.

Continuing to live with a situation involving an expensive ingredient (lubricant is an ingredient whether or not you think it is) adds to the work load of your staff. In engineering, we are taught to put problems behind us so we can face others. I've worked at places that never addressed some problems and, as a result, staff became overwhelmed. Nevertheless, you should weigh this option. Sometimes, the hysteria of a problem diminishes after a time. Indeed, there's a productivity approach called the Napoleon technique that involves deliberately not responding for a while in the expectation that someone will come up with a solution in the meantime (see https://bit.ly/3PJrQNZ).

However, you never should delay addressing certain issues — product contamination and fire risk come to mind. Quantities matter. Spending a few hundred dollars extra on lubricant per year might make sense compared to investing tens of thousands of dollars to reduce this cost slightly.

Now, on to managing. This involves automatic measurement of the oil supply (level) with some assurance that it's getting where it is needed (temperature measurement). If product contamination is an issue, you regularly must sample the product and, if the oil and product interact, identify not only the quantity of oil in the product but any material that evolves by interaction. This analysis could be pretty intense; minor constituents in the lubricant could cause a ripple effect in your customers' products. Customer service will want to you to identify this problem as soon as possible.

So, let's consider what could cause the oil leak: 1) corrosion in the seal pot or pump; 2) poor operation of the pump leading to deadheading or dry-running; 3) faulty selection of the seal pot; 4) low pressure in the backing pressure — with dips in the air pressure eventually damaging the seal separating the oil and process fluid; and 5) an oil incompatible with the seal and, perhaps, the product. The corrosion problem should be the item that scares you: it won't matter what oil you use — this one isn't going away!

Note that I alluded to ensuring that oil is getting where it's needed. Temperature is a clumsy way of doing this because the damage already could be done before overheating occurs. Old fashioned sampling probably is the best way; look for bits of rubber and metal that tell you what's happening with the seals and equipment.

As always, relying on instrumentation doesn't do away with the need for humans. Monitoring the oil requires a disciplined lubrication but also staff to regularly inspect the instruments.

Of course, before you choose this path, weigh its ongoing costs.

If, instead, you decide to try to eliminate the problem, remember that maintaining seals is expensive. So, consider magnetic-drive and canned pumps as well as seal-less equipment whenever possible. If protected against deadheading (from a closed discharge valve or blockage in the line) or dry pumping (i.e., no liquid in the pump bowl), these types of pumps can run reliably for decades. However, compared to sealed pumps, they are hypersensitive to these events; providing redundancy is crucial.

If you don't want to bring in a consultant, coming up with a way to eliminate the problem altogether may take months. You might succeed with smaller equipment but dealing with centrifuges, compressors, grinders, etc., requires specialist expertise — which is why consultants with such knowledge are invaluable.

Also, don't forget about the possibility of substitution. You might find an oil that won't contaminate your product, poses less of a fire hazard, is more compatible with seals, not as corrosive, lower cost, etc.

*Dirk Willard, consultant, Wooster, Ohio*

### CHECK OUT PREVIOUS PUZZLERS

To see all the Puzzlers that have been published over the years, go to: www.ChemicalProcessing.com/voices/process-puzzler/.

## NOVEMBER'S **PUZZLER**

Originally, our column was installed with a large feed preheater. Severe corrosion in that preheater and an increase in throughput required a larger reboiler. Our internal reboiler was replaced by an external vertical thermosiphon using an available bottom nozzle. Now, 30% of the tubes in the preheater are plugged. The trouble is that the nozzle is too small for the thermosiphon.

Our control engineer at the time — he has since retired — set the tower level control as the bottom valve. This worked well enough. A new production supervisor didn't like that arrangement because it was a challenge starting up the plant. He had a contractor create a cascade control scheme where the level controlled the steam flow to the reboiler while the column bottom temperature served as a subordinate controller for the bottom valve.

With the changes, the reboiler stopped working completely. We can hear steam getting to the reboiler but the thermosiphon is working only erratically if at all. Our plant outage has been extended while we unravel this mystery.

A committee of engineers has come up with a range of possible causes: 1) the preheater isn't providing sufficient heat because additional tubes were plugged during the outage; 2) the level reading is faulty because there wasn't time to clean the tank bottoms and fouling has occurred in the bottom pressure leg; and 3) the steam traps aren't doing their job, causing surges of condensate causing control problems.

The corporate engineer suggested contacting the old engineer for some advice. What do you think caused the problem? What is the best way to address it?

Send us your comments, suggestions or solutions for this question by October 7, 2022. We'll include as many of them as possible in the November 2022 issue and all on ChemicalProcessing.com. Send visuals — a sketch is fine. E-mail us at ProcessPuzzler@endeavorb2b.com or mail to Process Puzzler, *Chemical Processing*, 1501 E. Woodfield Rd., Suite 400N, Schaumburg, IL 60173. Fax: (630) 467-1120. Please include your name, title, location and company affiliation in the response.

And, of course, if you have a process problem you'd like to pose to our readers, send it along and we'll be pleased to consider it for publication.

# Are Guarantees Worthwhile?

The comfort they provide can come at considerable cost and complexity

**A supplier's risk of a damaged reputation may suffice.**

**"CAN YOU** guarantee that will work?" For a company employee, a flubbed fix might lead to a poor performance review or even a career dead-end. An external supplier or service provider might face the demand for a refund or even for the cost of damages incurred.

As a consultant and troubleshooter, often I get asked this question. After all, the plant isn't working today, so obviously something the customer got wasn't right. It wants the problem fixed. So, yes, it wants a guarantee the unit will work.

Responding, "Of course, we guarantee it," poses serious perils because the word "guarantee" raises legal issues of liability. Any use demands careful definition of exactly what is being guaranteed, how it is being determined, and what the consequences of failure are.

What the customer really is asking is two-fold. First, are you really sure? Second, because the customer knows it's taking a risk, have you, the supplier, properly evaluated its risk? In other words, the customer would like you to assume some of the risk to show that you're really sure.

What the supplier or service provider is hearing is the dreaded word "liability." Few suppliers of any type could cover the liability that might arise from a failure in a process plant. The word "guarantee" without legalese to limit liability just isn't realistic. Reputable suppliers usually will point out that, no matter what, they put their good name on the line with every recommendation. However, that won't suffice for every customer.

Some specific equipment types have industry procedures and methods for determining performance, e.g., Hydraulic Institute or American Petroleum Institute standards for pumps. Other equipment may have vendor-specific requirements but is tested often enough that standardized procedures are available. An example of this is burner performance testing for fired heaters; all major vendors have specific test methods to demonstrate burners will meet emissions requirements under particular conditions. Of course, your own company may have methods for this testing as well. Then, the seller and buyer must negotiate what the guaranteed performance covers.

More challenging are types of equipment like heat exchangers where testing tends to be service specific. Some services (e.g., steam/water) may be straightforward but others may involve elaborate testing procedures.

Other equipment rarely is tested versus specific performance criteria due to the difficulty and expense involved. Examples include distillation internals. Such testing often demands case-specific procedures. If the guarantee covers both capacity and efficiency, it may require extensive analytic and instrumentation support as well as definition in advance of data methods. The guarantee becomes a very complex document in most tests like these.

The ultimate guarantee is for a process as a whole. Most processes involve multiple steps to get from feed to product. Guarantees may involve emissions, efficiency, capacity, yield, catalyst life and performance, purities, reliability and many other operational criteria. Multiple factors including feed types, compositions, products, environmental conditions, laboratory techniques, calculation methods and other factors must be defined. Also, does the guarantee cover only the overall process or do some intermediate points within the process have specific requirements as well?

In addition, it's important to define what will indicate failure to meet the guarantee. This may include the number of attempts that can be made, who is responsible and to what extent for equipment and process modifications, when the performance test must be performed, and limitations on the type and cost of changes.

All of the defined factors also are subject to legal requirements in the specific jurisdictions involved. For example, no supplier or service provider willingly accepts consequential damage guarantees. However, some countries mandate that the presence of a guarantee includes coverage of some types of consequential damages.

This sounds complex because it is complex. Guarantees increase the amount of time required to negotiate contracts. Someone must pay for the work involved in performance testing. Equipment and services with formal guarantees cost more. So, a provider of equipment or services should make sure it understands the legal implications of providing more than the "industry standard" for a guarantee. Likewise, a customer should carefully decide if demanding a formal guarantee really is worth the extra effort and cost versus simply relying on the reputational risk a supplier carries. ●

**ANDREW SLOLEY**, Contributing Editor
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## Nitrogen Generator Monitors Gas Purity

The NGP+ pressure-swing-adsorption nitrogen generation units offer gas purity from 95% to 99.9995%. The units now include an expanded and enhanced midsize range (27–482 SCFM), and are available in flow sizes up to 4,802 SCFM (for a single unit). The low-ambient-temperature setting allows installation outside (in a covered area) in temperatures down to -10°C/14°F. An Elektronikon Touch controller with easy gas purity selection and advanced connectivity options helps optimize performance and continuously measures gas purity to protect production. It also monitors the feed air to safeguard the integrity of the adsorbent.

**Atlas Copco**
866-546-3588
www.atlascopco.com

## Flow Meter Tolerates Pressure, Temperature Changes

The DOG-6 oscillation flow meter can accurately measure both dry and wet gases. It can handle damp media because of its natural, gravity-induced condensation drainage. The unit offers an optional shut-off valve, calibration software and a flow computer. The sensor is built to withstand aggressive media, moisture and dirt particles. Its lack of moving parts helps to deliver low maintenance and long service life. The flowmeter also works at extremely low operating pressures and has a low pressure drop. It is not affected by pressure or temperature changes, says the company. Units also can be custom made to user specifications, opening the door to wider field applications.

**Kobold Instruments Inc.**
412-788-2830
www.koboldusa.com

## Dust Collector Doesn't Require Shutdown

The modular conveyor disposal (MCD) Whirl/Wet dust collector is engineered for applications requiring a sanitary design that also have continuous or intermittently high dust loadings. Collected particulate is removed continuously from the collection hopper via a removable conveyor system, allowing operation and routine maintenance to go on, free of interruption. The dust collector can accumulate all soluble and insoluble particulate over 1 micron. The sanitary design system is constructed from stainless steel for both clean-in-place and external washdown capabilities without shutdown. Energy generated inside the unit prevents system clogging, meaning the glutinous residues common with some dust collectors are not an issue.

**Tri-Mer Corporation**
989-723-7838
www.tri-mer.com

## Pyrometer Delivers Fast Response

This fiber-optic two-color digital ratio pyrometer, Model PSC-GRF11N, is designed for lower starting temperature measurements. The series offers four temperature ranges: 300 to 1,100°C; 350 to 1,300°C; 400 to 1,600°C; and 500 to 2,300°C. Model PSC-GRF11N operates in ambient temperatures up to 250°C (482°F) and is said to be immune to high magnetic frequencies encountered in manufacturing facilities. Its fast 5-ms response time reportedly suits quick measurement processes. A selection of variable-focus fiber optic lenses provides small spot sizes from 0.7 mm in diameter. The non-contact infrared temperature sensor uses an integrated laser that provides precision aiming onto the center of the target.


**Process Sensors Corp.**
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www.processsensorsir.com

## Refrigerant Dryers Reduce Emissions

The new DT series of refrigerant dryers include intelligent control that reportedly ensures a stable pressure dew point, even in changing environmental conditions. The dryers use environmentally friendly R513A refrigerant for sustainability and lower $CO_2$ footprint. The series offers a constant dew point of 3°C at a free air delivery of between 0.4 and 14 m³/min for maximum delivery capability. An all-in-one aluminum heat exchanger operates in a reverse flow process and contains a proven air/air heat exchanger, evaporator and condensate drain. All models are compliant with EU regulation 517/2014 on fluorinated greenhouse gases. The refrigerant circuit is hermetically sealed, rendering a leakage test by certified refrigeration engineer unnecessary.


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### Peristaltic Pumps Withstand Dry Runs

The PeriPro peristaltic pumps deliver large flow rates at a wide range of pressures for pumping complex and difficult media. They can easily handle viscous and abrasive media even at high pressures. These pumps have a long operating life, are easy to use, and enable 30% energy savings compared to other hose pumps, the company says. The pumps have no valves or mechanical seals, and their only wear part is the hose. In addition, the pumps are insensitive to dry running, require 90% less lubricant than other peristaltic pumps and enable a high metering accuracy.


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### Electric Bulk Unloader Helps Meet Compliance

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# Are PFAS on Their Way Out?

Strategies arise to combat PFAS as more studies reveal the health hazards of the chemicals

**PFAS exposure could lead to risk of liver cancer.**

**THE U.S.** Environmental Protection Agency (EPA) cites many studies on the hazards associated with polyfluoroalkyl substances (PFAS). These risks include decreased fertility, developmental delays in children, increased risk of some cancers, reduced immune response to infections, and risk of obesity.

And the list continues to grow. In August, the Keck School of Medicine at the University of Southern California, Los Angeles, published a study in *JHEP Reports* linking PFAS to non-viral hepatocellular carcinoma, the most common type of liver cancer. It is the first study to confirm the risk of liver cancer using human samples, say the authors. The scientists report PFAS disruption to metabolic processes in the liver can lead to non-alcoholic fatty liver disease (NAFLD) and a much higher risk of cancer. The report also notes a dramatic and unexplained rise in the disease around the globe in recent years; NAFLD is expected to affect 30% of all adults in the United States by 2030.

Also in August, an article by researchers from Stockholm University, Sweden, and ETH Zurich, Switzerland, published in *Environmental Science & Technology*, revealed PFAS levels in environmental media are now ubiquitously above guideline levels.

"There has been an astounding decline in guideline values for PFAS in drinking water in the last 20 years. For example, the drinking water guideline value for one well-known substance in the PFAS class, namely cancer-causing perfluorooctanoic acid (PFOA), has declined by 37.5 million times in the U.S.," says Ian Cousins, the lead author of the study and professor at Stockholm's Department of Environmental Science.

"Based on the latest U.S. guidelines for PFOA in drinking water, rainwater everywhere would be judged unsafe to drink," Cousins adds.

However, as evidence against PFAS builds, so too does research into strategies to counter them.

Chemical and civil engineers at the University of Illinois, Chicago (UIC) have been awarded just over $1 million to further develop their reactive electrochemical membrane (REM) filtration system designed to trap and destroy PFAS. The system converts traditional filtration membranes into a reactive surface. The small pores in the membrane trap contaminants and electricity applied to the membrane causes reactions that break PFAS molecules apart.

The engineers will use the new funding for a three-year project that will characterize and optimize efficient electrocatalysts to successfully remove and destroy PFAS at high levels with low energy consumption. They also will analyze other systems for comparison and best practices in deploying the technology at a large scale in practical, real-world applications.

"While REM filtration is one of the only ways to destroy PFAS, these systems so far work best in a limited number of controlled conditions. Our challenge is to make these systems work in the environment," UIC team leader and professor of chemical engineering Brian Chaplin notes.

Meanwhile, chemical engineers and biologists at Texas A&M AgriLife, College Station, Texas, have developed a new bioremediation material they say is more sustainable and cheaper than commercial applications currently used to clean up PFAS.

The material, called "Renewable Artificial Plant for In-situ Microbial Environmental Remediation," or RAPIMER, adsorbs PFAS and holds them in place for bioremediation by the fungus *Irpex lacteus*. Derived from inexpensive and sustainable lignin, RAPIMER is thermo- and hydrostable, biodegradable and renewable.

"We produced a sustainable plant material that could be used to concentrate the PFAS chemicals," says Susie Dai, associate professor at Texas A&M.

"The plant's cell wall material serves as a framework to adsorb the PFAS. Then this material and the adsorbed chemical serve as food for a microbial fungus. The fungus eats it, it's gone, and you don't have the disposal problem. Basically, the fungus is doing the detoxification process," she explains.

In another recent development, engineers at the University of California, Riverside, Calif., report selective breakdown of fluorinated carboxylic acids (FCA) by common microorganisms. FCA are bioaccumulative and extremely persistent in the environment.

Building on previous work reporting successful microbial defluorination of a fully fluorinated PFAS structure by replacing carbon-fluorine bonds with carbon-hydrogen bonds, the new study, published in *Environmental Science & Technology*, shows the point of entry for the anaerobic microbes was a double bond between carbon atoms located next to the carboxyl group of the FCA molecules.

Trifluoromethyl branches on the double bond could further enhance the biodegradability, they note. This work continues.

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