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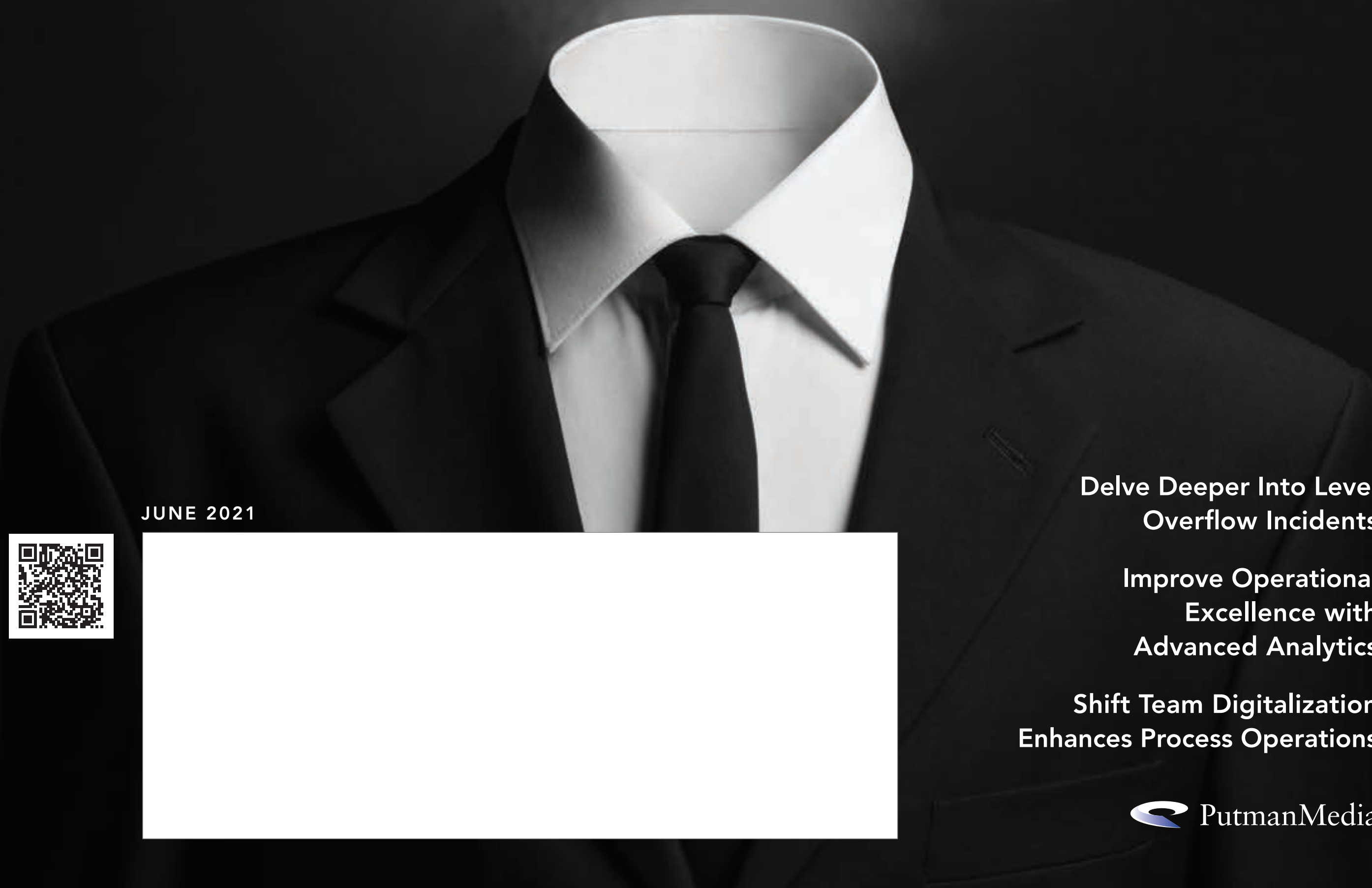

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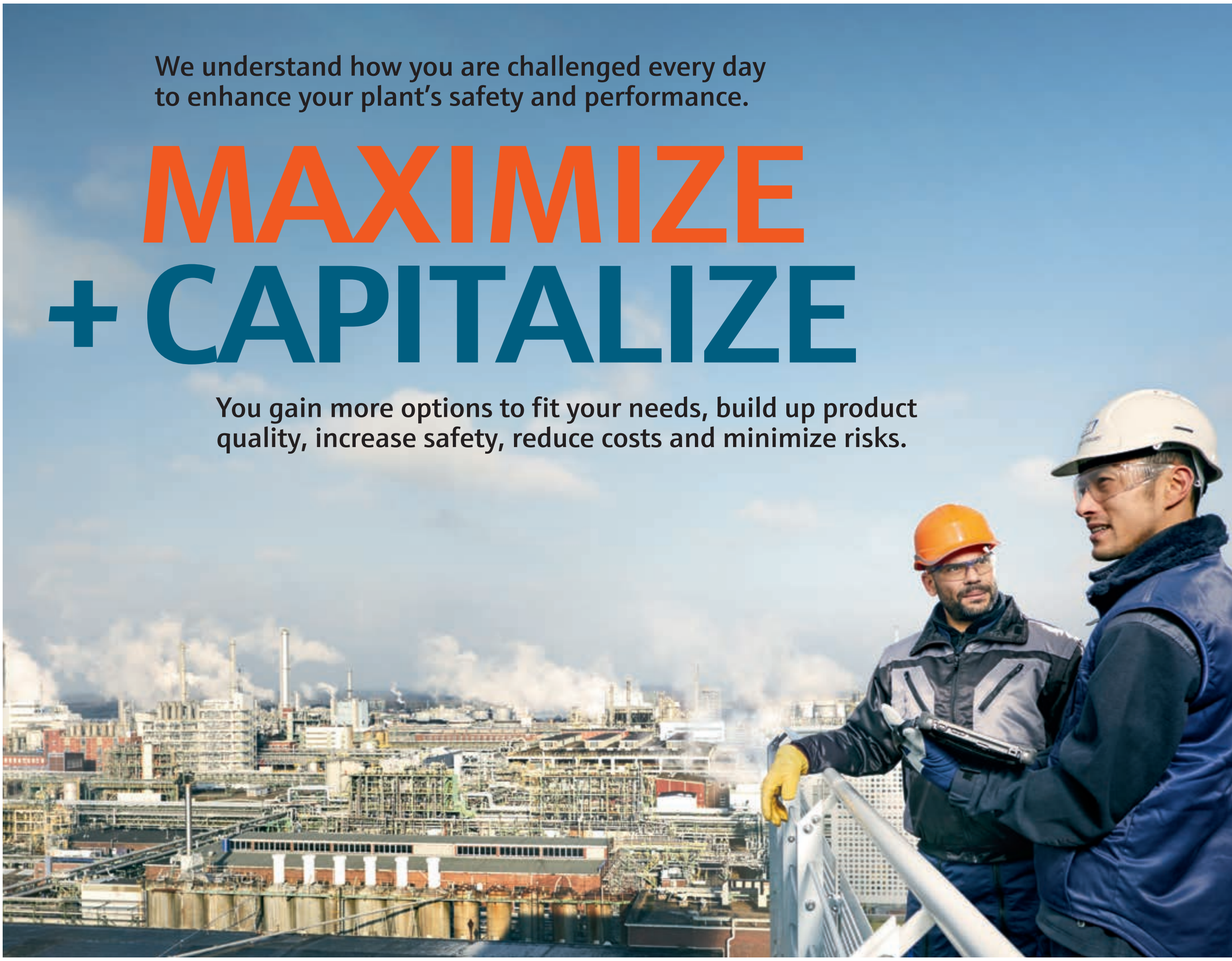

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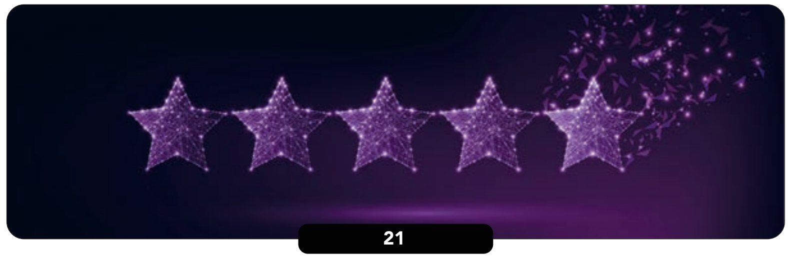

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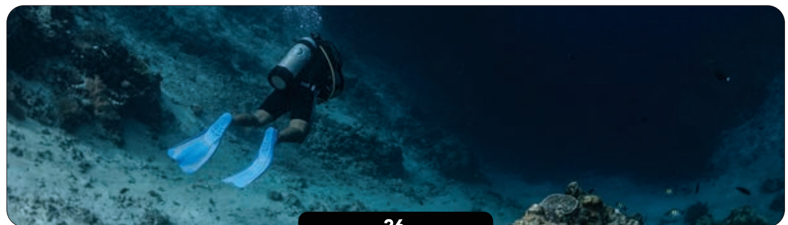

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Process Safety Program Launches

Collaborative initiative aims to boost competency of current workers

The courses devote equal time to online sessions and hands-on work.

LATE MAY marked the debut of the first course in an innovative process safety certificate program developed jointly by the Texas Chemical Council (TCC), Austin, Texas; the Mary Kay O'Connor Process Safety Center (MKOPSC) at Texas A&M University, College Station, Texas; and the LyondellBasell Center for Petrochemical, Energy, and Technology (CPET) at San Jacinto College, Pasadena, Texas. The program's goal is to provide operators, supervisors and engineers with a good backgrounding in process safety. People who successfully take all four courses in the program will receive a certificate from San Jacinto College.

"Students will come away with a greater appreciation of hazards and how to apply what they learn at their plants," notes Bill Efaw, associate process safety director at Dow Chemical and chair of the MKOPSC steering committee. "The courses aren't trying to make the students experts but to impart practical pointers."

The four consecutive courses — Introduction to Process Safety; Introduction to Risk Management; Fire Protection and Emergency Response; and Industrial Safety and Technical Fundamentals — each cost $1,200 and consist of 48 hours of hybrid instruction over three months. Participants will get 24 hours of online sessions and partake in 24 hours of hands-on learning at CPET (one 8-h/d per month over three months). For more details, including specifics on each course, visit https://bit.ly/3vD3agf.

The first online session was scheduled for May 24, with laboratory sessions set for June 18, July 9 and August 13. The Introduction to Risk Management online course is slated to launch in August, with the debut of the other two courses targeted for January 2022.

The online sessions don't have caps on the number of participants. However, each laboratory session can accommodate only about 20 people — but, when necessary, more lab dates can be added.

In 2020, the TCC, whose membership includes about 70 companies with production plants in the state, launched an initiative to improve process safety performance. A survey of its membership showed overwhelming interest in an educational program. This led to the partnership with the MKOPSC and CPET. The MKOPSC is a recognized leader in process safety education. (*CP* jointly publishes with MKOPSC the *MKO Process Safety Journal*; see: www.ChemicalProcessing.com/journals.) CPET, located near the Houston Ship Channel, a key chemicals production area in Texas, features an 8,000-ft^2, two-story propylene glycol unit as well as a variety of laboratories including a multi-functional glass pilot lab.

The program will adapt the existing MKOPSC curriculum for engineering students. The MKOPSC, CPET and subject matter experts at TCC member companies have been working together to develop content for each course. The laboratory sessions will focus on process hazard analysis of actual equipment and likely will include simulated incidents.

The TCC, MKOPSC and CPET deserve our plaudits for this initiative. Here's hoping it succeeds beyond expectations and can serve as a template for such efforts elsewhere in the United States and, indeed, worldwide. ●

MARK ROSENZWEIG, Editor in Chief
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Choose Relevant Content Categories

Use landing pages to quickly find information on a topic

We realize readers have different needs.

VISITORS COME to ChemicalProcessing.com for a wide variety of reasons. Some folks are looking for fluid-handling best practices while others seek guidance on motors. With those differences in mind, we've always utilized a category taxonomy to help you navigate the site and easily get to relevant content.

Selecting the hamburger menu (the three horizontal bars) to the left of the *Chemical Processing* banner at the top of any page takes you to a list of key categories. The top tiers are: Automation, Processing Equipment, Asset Management, Environmental Protection, Safety/Security, and Utilities/Energy. Choosing any one of these brings up subcategories:

Automation: automation & IT, wireless technology, analyzers, control systems, instrumentation, safety instrumented systems

Processing Equipment: design & simulation, fluid handling, powder & solids, reaction & synthesis, separations technology, heat exchangers, and motors & drives

Asset Management: reliability & maintenance, economics, training, digitalization, and sustainability

Environmental Protection: water/wastewater, air, and ground

Safety/Security: security, cybersecurity, fire/explosion protection, physical security, risk assessment, and dust control

Utilities/Energy: energy efficiency, air, electricity, heat transfer fluids, water/steam, and vacuum systems

Each of these sections (we call them landing pages) contains hundreds of pieces of content in the form of articles, white papers, news, products, multimedia and even blogs. It's all packaged together for a complete resource library on topics that matter most to you.

To give you an idea of what we cover, some of the popular content from each section includes:

Automation:

"Process Automation Opens Up." Ongoing effort aims to improve operational flexibility and asset performance. https://bit.ly/3fUAFGa

"Automate Manual Inspection Rounds." Doing so increases worker efficiency and safety and frees time for higher level activities. https://bit.ly/2Z8rZmR

Processing Equipment:

"Improve Your Critical Drawings." Use best practices to foster consistency in P&IDs and PFDs. https://bit.ly/2Ko5vWI

"Build Safer and More Reliable Seal Support Systems." Follow some best practices to enhance operations and reduce overall costs. https://bit.ly/2RgThql

"Motors: How to Convert from Horizontal to Vertical Mounts." Consider key mechanical factors when applying a horizontal ball-bearing motor in a vertical mounting position. https://bit.ly/3yftfnL

Asset Management:

"Maintenance: Drones Fly Higher." Fast payback and increasing capabilities elevate role at plants. https://bit.ly/3bAb0R1

"Circular Chemistry Spins Faster." Developments foster use of renewable feedstocks and end-of-life materials. https://bit.ly/3htiBUF

Environmental Protection:

"EPA Orders Testing For Nine Chemicals." Companies must test for ecotoxicity and skin absorption and inhalation exposures. https://bit.ly/3tTzvOL

"Direct Air Capture Technologies Ramp Up Capacity." Several projects aim to improve direct air capture and storage of carbon dioxide. https://bit.ly/2QqwgAL

Safety/Security:

"Podcast: Fukushima Disaster 10 Years Later — What Have We Learned?" The catastrophic incident 10 years ago started in 1967 when the power plant was built. https://bit.ly/3eThmMN

"Podcast: Focus on the Right Process Safety Indicators." The absence of an incident doesn't mean the presence of safety. Focusing on the correct indicators can help you intervene and potentially change the future. https://bit.ly/3t8y9Q1

Utilities/Energy:

"6 Tips to Effectively Remove Contaminants from Compressed Air." Consider these common myths and tips for filtration that also minimize leakage. http://bit.ly/38AcCWW

"Properly Select Vacuum Pump Motors." Go beyond rated power to find the real energy consumption. http://bit.ly/2NnO34l

Not only do we add content from every print issue into these category buckets, we also complement our coverage with web-exclusive information. As always, our goal is to provide authoritative, practical and impartial technical information as well as best practices, key trends, developments and successful applications to help you be as efficient, safe, environmentally friendly and economically competitive as possible. ●

TRACI PURDUM, Senior Digital Editor
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Keep Cool When Thawing Projects

Changes since a proposal was frozen can pose risks and opportunities

Can you still move equipment around as originally planned?

FILED AND forgotten, that's the fate of too many proposals I've had to work on. Usually, they relate to somebody's pet project, an itch that production wanted to scratch, or a worthwhile concept that proved uneconomic. I'm kept busy for a week or two developing the scope, estimating the cost and laying out the schedule. Then, when eyes pop over the price, the project is entombed in a folder.

However, every so often, a need appears, funding is found, and the fun begins. The situation can become intense where regulators are involved or a project suddenly becomes crucial to the company.

The first challenge is budget. Nobody in management seems to grasp the major dent inflation can make in a project budget developed just a few years earlier. One project I scoped in the early 1980s was revived five years later; the original budget wasn't anywhere near adequate. Inflation has an impact even at 2%/y, the annual rate for the past 20 years. In a hot economy, things are much worse.

The second challenge is that a plant environment seldom is static. Equipment is moved and other equipment is added. There's also the little matter of priorities. Is your project important enough to justify moving a tank, pump, pipe or even a wall out of the way? It's not just the money — plant politics come into play.

So, how do you address these problems and keep your job? Start with a new scope if goals differ from the original ones. If the scope is the same, then skip this step.

CHECK OUT PAST FIELD NOTES

More than a decade's worth of real-world tips are available online at www.ChemicalProcessing.com/field-notes/

Never assume the original design was sound. Spend some time getting to know the equipment or process. Talk to the project originator and the stakeholders. You may find the objectives are unachievable or the project manager or equipment provider stretched the truth on what was possible. Also, check if the plant is okay with the status quo and how it copes with whatever issues the proposal addresses. If so, the project really isn't needed and should go back into the file drawer.

Next, look at the real estate and the technology. Hopefully, you have a detailed schedule showing how the work was to be accomplished. Check access, e.g., for cranes, etc., in the current layout. Can you still move equipment around as originally planned? Has the space for your equipment now been filled? Can you move what's there? Someone must tell you what must stay and what can move. Finding who's really in charge often is hard and likely will blow your donut budget for meetings. If you can't move something in the way, temporarily or otherwise, you may have to reinter the project.

In addition, always keep in mind that other things may have changed, e.g., plant standards for pipe, materials, etc.; utilities, i.e., water, steam, air and nitrogen; and the state-of-the-art in equipment. Is there a better way to accomplish the goals of the project? Remember desalination? Nobody's laughing about it like they did in the 1980s. Advances in instrumentation and control technology occur at a fast pace — does your project take advantage of what's now available?

Don't assume the suppliers are still around. Make some phone calls not just to confirm that but to see if the original people dealt with remain. I try to buy from vendors or fabricators located close enough that I can visit their shops. Every time I've had to rely on inspectors, especially ones overseas, I've found things get missed and some last-minute modifications are required; this is a common problem with pressure vessels.

You also may find that engineering has changed. Years ago, vessel fabricators did the ASME code work. Today, you have to find an engineering shop that still maintains its license. Or, in the case of a non-coded vessel, you can do it yourself if you've got the time. Then, there's what I call equilibrium. Seldom is a project scope the same as it started out in basic engineering. When some manager tells me that projects are sequential, I laugh because that's a recipe for disaster. Equilibrium takes time and buy-in. The most successful projects are ones that bring everyone together during the kick-off meeting and allow the design to evolve until it meets the project goals and makes completion as easy as possible.

DIRK WILLARD, Contributing Editor
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Greener Propylene Production Looms

Tandem catalysts provide record yields and may suit ethylene and styrene manufacture

OXIDATIVE DEHYDROGENATION has long been considered a more-energy-efficient way to make propylene from propane, but the method produces small yields. Now, a new approach from researchers at Northwestern University, Evanston, Ill., results in higher yields while also using less energy. The findings could support more-energy-efficient production processes for many plastics, and could benefit smaller chemical plants where energy consumption is very important and current engineering strategies may not be feasible, say the researchers.

"Instead of searching for the right catalyst, we deconstructed the oxidative dehydrogenation reaction down into two components — dehydrogenation and selective hydrogen combustion — and then designed a tandem material that does both reactions, in a particular order. This produced the highest yields of propylene ever reported," says Justin Notestein, professor of chemical and biological engineering at Northwestern and co-corresponding author on the research.

Tests produced 30% yield from a single pass through the reactor at 450°C, compared to 800°C for traditional propylene production; more than 75% of the carbon atoms in the propane converted to propylene. By comparison, heating propane in the absence of oxygen doesn't produce yields greater than 24%, and the catalysts often are unstable, the researchers note.

The approach uses a platinum-based catalyst that selectively removes hydrogen from propane to make propylene, and an indium oxide-based catalyst that selectively burns the hydrogen, but not the propane or propylene. An article in the journal *Science* contains more detail.

"We found that the nanostructure really matters," Notestein explains. "…This nanostructure is able to separate and sequence the reactions, even though both catalysts can do both reactions."

Optimization of process conditions and independent tuning could yield further improvements, believe the researchers, but they will need the help of partners. The team is open to collaborating and discussing licensing or sponsored projects.

"Our reactors are not large enough to carry out experiments relevant for scaleup," says Notestein. "This reaction is a tightly coupled pairing of an exothermic and endothermic reaction, and heat management will be an issue at larger scales. There are significant composition gradients down the reactor bed. These could be controlled and exploited through staged O_2 addition, for example. With respect to composition, many platinum alloys are excellent for dehydrogenation," he adds.

Making such nanoscale tandem catalysts on an industrially relevant scale poses few issues, Notestein stresses. "The core of our catalysts is entirely generic platinum-alumina. You can purchase these off the shelf at any scale. We use atomic layer deposition (ALD) to grow the indium oxide overcoat. … With careful optimization…the overcoats could be deposited by more conventional means," he says.

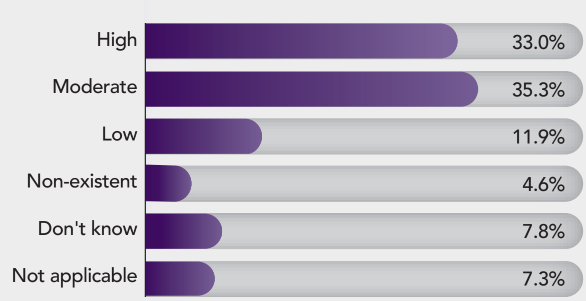
The ALD coating also helps prevent sintering of the metal component. "I would not be overly concerned about hydrothermal stability or mechanical robustness; we actually use spherical, non-porous primary particles that should be fairly robust if formed up into pellets," adds Notestein.

Ethylene and styrene production also could benefit from such tandem catalysts. "These two reactions are already commercial, or close to commercial, and an optimized catalyst based on this design might be well suited," Notestein elaborates. "We hope to look more at ethane dehydrogenation as well as operating on simulated natural gas. We have other reactions that we will be examining with these and related catalysts. For example, we are initiating collaborations to use the intermediate H_2 more productively."

The team will next focus on validating their hypothesis about reaction mechanisms with in situ X-ray absorption experiments and kinetics studies to separately examine rates of dehydrogenation and hydrogen combustion. "Over the next year, we should be able to address most of the fundamental experiments," concludes Notestein.

TO PARTICIPATE IN THIS MONTH'S POLL, GO TO CHEMICALPROCESSING.COM.

How would you characterize your employer's interest in "circular chemistry" (i.e., use of renewables and end-of-life materials)?



More than two-thirds of respondents report at least moderate interest In circular chemistry.

Arenes Synthesis Occurs at Milder Conditions

A NEW catalyst that works at 150°C and ambient pressure achieves the selective hydrogenolysis of a broad range of phenols to industrially important arenes (aromatic hydrocarbons) needed both in the manufacture of fine chemicals and in biorefinery applications, report researchers at the University of Tokyo. The catalyst, composed of aluminum tri-phosphite ($Al(PO_3)_3$)-supported platinum (Pt) nanoparticles, also can handle sterically highly demanding phenols and difficult lignin compounds, they add.

The researchers, led by assistant professor Xiongjie Jin and professor Kyoko Nozaki of the Department of Chemistry and Biotechnology, believe their catalyst could hugely reduce the energy cost of production compared with conventional hydrogenolysis reactions that typically need temperatures exceeding 200°C and pressures above two atmospheres.

"Our 'Pt catalyst' makes use of platinum nanoparticles and an aluminum metaphosphate substrate, which is rarely ever used in catalysts," says Jin. "But the most exciting part for us is not just that the catalyst improves reaction efficiency but that it opens up new options for the kinds of source materials that can now be used in these processes," he stresses.

HYDROGENOLYSIS CATALYST

Figure 1. Platinum/metaphosphate catalyst spurs production of arenes from phenols at mild conditions. *Source: Xiongjie Jin/University of Tokyo.*

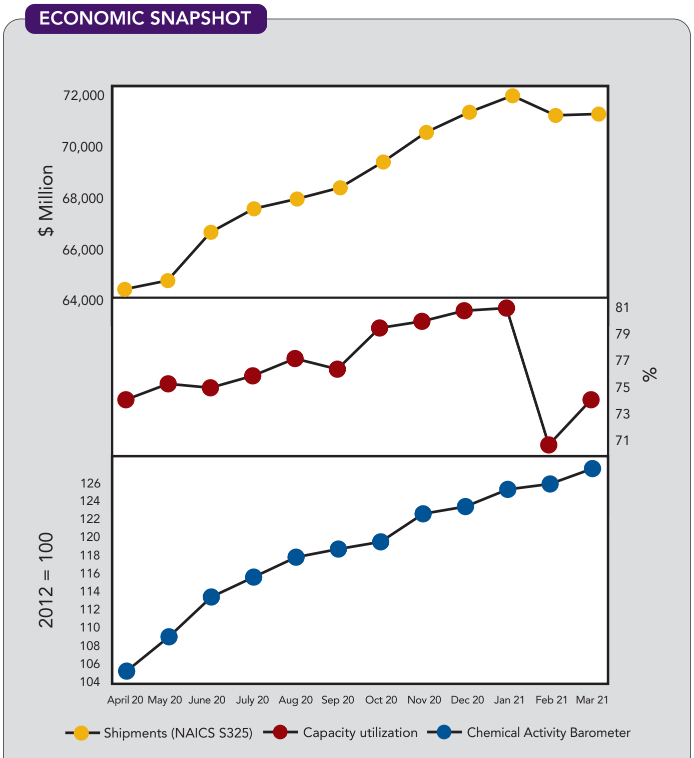
The researchers already are studying ethers as a potential new starting material. "The hydrogenolysis of ethers is also important in the conversion of biomass like lignin or cellulose to valuable chemical compounds or bio-fuels," Jin notes.

Another investigation is looking for ways to extend the activity and lifetime of the Pt catalyst — which already can be recycled and reused several times — and at other potential catalysts capable of carrying out the same reactions. "One possible direction is using 3d transition metals [titanium, chromium and manganese] as the catalysts instead of the precious metal Pt," he explains. As it stands, improvements in both the activity and lifetime of the Pt catalyst are needed before considering any move to pilot scale.

Jin emphasizes that the Pt catalyst developed by the group currently only is applicable to phenols derived from lignin depolymerization, not lignin itself. So, pre-processing of lignin is necessary before use of the catalyst system. "Actually, there are reported catalysts directly applicable to lignin, but energy-consuming harsh conditions are still required. Therefore, if a catalyst could directly be applicable to lignin under mild conditions, it would be very nice."

While the work has yet to attract any industrial investment, Jin and his co-workers believe their new catalyst system has so many benefits that it could lead to a vastly more sustainable way to produce aromatic hydrocarbons on an industrial scale.

ECONOMIC SNAPSHOT



All three metrics rose. *Source: American Chemistry Council.*

Ponder Chilled Water Thermal Energy Storage

Using an insulated water tank can improve the economics of variable cooling loads

Operating savings accrue from reduced peak electric demand.

LARGE, CHILLED water (CHW) thermal energy storage (TES) systems have seen extensive use for over 40 years to manage peak electric demand from air-conditioning loads in industrial applications, and especially in operations where cooling loads fluctuate widely over short time periods (e.g., batch processes, R&D facilities).

CHW TES involves a large insulated water tank, generally installed above-grade using welded-steel construction. The tank remains filled with water at all times. The lower region contains relatively dense, cool, chilled water supply (CHWS), while the upper region contains less dense, warmer, chilled water return (CHWR). A relatively narrow "thermocline" (a temperature gradient similar to that observed in a quiescent lake warmed by the sun) separates the two zones with no physical barrier between the regions. TES charging occurs off-peak, by pumping CHWR from the upper region to a chiller plant, while cooled CHWS flows to the lower region; it discharges on-peak, pumping CHWS from the lower region to the cooling loads, while warm CHWR flows to the upper region. Conventional CHW TES is limited to a minimum supply temperature of 39 to 40°F, the temperature at which plain water exhibits its maximum density. However, modified versions of the technology can operate at lower temperatures.

Operating savings accrue from reduced peak electric demand, and shifting electric energy use from high-cost on-peak periods to low-cost off-peak periods. Capital cost savings relative to conventional (non-TES) chiller plant capacity also occur. This is because non-TES systems require an installed chiller plant capacity to equal the *instantaneous* peak load on a peak design day (plus any necessary spare capacity), while TES-equipped systems merely require an installed chiller plant capacity equal to the equivalent *average* load (plus any necessary spare capacity). The avoided chiller plant installed cost often far exceeds the cost of the required CHW TES system installation. This net capital saving can occur in several situations:

1. New facility construction,
2. Retrofit facility expansion or other load growth, or
3. Retirement of existing aging, inefficient, or unreliable chiller plant capacity.

The following example, from the 2-million-ft^2 corporate R&D complex for Chrysler Motors (now Stellantis) in Auburn Hills, Mich., illustrates both operating and capital savings. CHW TES was built into the facility's central cooling system during its initial construction to serve a projected peak cooling load of 16,000 tons. A conventional (non-TES) chiller plant requires 17,700 tons of capacity (including spare capacity). However, with 68,000 ton-hrs of CHW TES included, the chiller plant capacity was reduced to 11,400 tons. The 6,300-ton chiller plant capacity reduction, offset by two 3.1-million-gal TES tanks, produced a net capital cost reduction of $3.6 million. There was also a $1 million annual energy cost saving due to reductions of 7,600 tons of on-peak cooling, and 5.7 MW of electric demand. The two above-grade, welded-steel TES tanks also provide emergency fire protection.

Facilities that employ combined heat and power (CHP) systems with a combustion turbine (CT) for on-site power generation also can use chilled water TES. TES flattens the daily cooling and electric load profiles, which allows for a larger CT (with a lower unit capital cost in $/kW) operating fully loaded for more hours per year, thus improving CHP economics. Also, CTs lose power during hot weather, just when the power demand and value are highest. TES can be coupled with a turbine inlet cooling (TIC) system to maximize power output at those times, while also minimizing the total unit capital cost in $/kW.

Hundreds of CHW TES applications exist, totaling well over 10 million ton-hours of stored cooling and 2 million tons of peak load shift, equivalent to well over 7,000 MWh of stored electricity and 1,500 MW of peak load shift. Oil and petrochemical industry users include ARCO, Exxon/Mobil, Halliburton, Saudi Aramco, Shell and Texaco; in the pharmaceutical industry, they include Abbott Laboratories, Boehringer-Ingelheim and Wyeth-Ayerst.

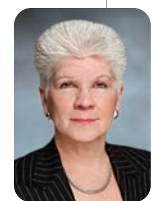
If you own or operate a facility with a large, time-variable chilled water load, or with a CHP gas turbine, you should consider CHW TES!

JOHN S. ANDREPONT and **BRIAN C. CLARK**,
guest contributors

Editor's note: This article was written by colleagues of our regular columnist, Alan Rossiter (pictured). JOHN S. ANDREPONT is founder and president of The Cool Solutions Company, Lisle, Ill. BRIAN CLARK is a regional sales manager for CB&I, Houston. Email them at CoolSolutionsCo@aol.com and Brian.Clark@mcdermott.com.

EPA Expands TRI Reporting Rules

New chemicals added to the list include ethylene oxide



Failure to report, or faulty reporting, are target-rich areas for enforcement.

THE U.S. Environmental Protection Agency (EPA) announced on April 29, 2021, that it will be "taking important steps under the Toxics Release Inventory (TRI) to advance environmental justice, improve transparency, and increase access to environmental information." The EPA plans to expand the scope of TRI reporting requirements to cover additional chemicals and facilities, including those not currently reporting ethylene oxide (EtO) releases. The agency also announced enhancements to its TRI reporting tools, but this article will focus on the chemical expansion effort and why it is significant.

TRI reporting is a core element of the EPA's tracking of industrial chemical production, use and distribution. The EPA considers the chemicals listed under the TRI program as capable of posing a threat to human health and the environment. "Releases," meaning discharges into the air, water, or placed in some sort of land disposal, are reported annually. The agency values the data it harvests from TRI reporting; failure to report, or faulty reporting, are target-rich areas for enforcement. Listing new chemicals on the TRI reflects the EPA's current thinking regarding chemicals of interest for regulatory purposes.

The EPA for several years has focused on the effects of EtO on human health, including cancer, and the environment. EtO serves as a chemical feedstock and a sterilization agent. It's no surprise that the agency is broadening TRI reporting on EtO to include certain contract sterilization facilities that use EtO but that are not currently required to report this information. The EPA states that many contract sterilization facilities are located near areas with environmental justice concerns. Making more information available about releases of EtO will assist it in identifying and responding to any human health and environmental threats they cause.

The agency also intends to make changes to expand the TRI program to protect the health and safety of underserved communities, including:

TRI reporting for natural gas processing facilities. A final rule proposes adding natural gas processing facilities to the list of industry sectors covered under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). This addition to TRI would increase the publicly available information on chemical releases and other waste management activities of TRI-listed chemicals from that sector. Once the EPA issues a final rule, the report for any calendar year must be submitted on or before July 1 of the following year.

TRI reporting for additional per- and polyfluoroalkyl substances (PFAS). The EPA will continue to add new PFAS, in addition to the three PFAS added in reporting year 2021. The provisions included in the 2020 National Defense Authorization Act (NDAA) automatically add certain PFAS to the TRI chemical list when certain conditions are met. The EPA anticipates more PFAS additions, including perfluorobutane sulfonic acid (PFBS), following its recent publication of a toxicity assessment on the chemical.

TRI reporting for TSCA Work Plan and high-priority chemicals. The EPA plans to propose adding to TRI chemicals in the TSCA Work Plan and substances designated as high-priority substances under TSCA. The agency proposes listing chemicals included in a 2014 petition from the Toxics Use Reduction Institute. According to the EPA, many of these substances could be present in communities close to industrial uses of these chemicals where releases to water, air or land could have a greater impact.

The EPA's announcement is yet another reflection of its commitment to environmental justice. Consistent with the Biden Administration's much-publicized claims, the EPA's reliance upon TRI reporting in this regard is no surprise. Stakeholders can expect more of the same. The report for any calendar year must be submitted on or before July 1 of the following year. The previous Administration sidelined the rulemaking to add natural gas processing facilities to the TRI. How the Biden-Harris EPA will proceed with a four-year-old proposed rule remains unclear. For reporting year 2021 (due by July 1, 2022), the NDAA automatically added three PFAS to the TRI list: perfluorooctyl iodide; potassium perfluorooctanoate; and silver(I) perfluorooctanoate. While the reporting requirements will not take effect immediately, stakeholders should review any proposed and final rules to ensure they remain in compliance.

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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. The views expressed herein are solely those of the author. This column is not intended to provide, nor should be construed as, legal advice.

Permanently Installed PdM Solutions Offer Myriad Perks

NOAH BETHEL
Vice President – Product Development
PdMA® Corporation

Having access to experts who just need a computer and a secure internet connection to help the on-site guy look at the data is priceless.

PREDICTIVE MAINTENANCE (PdM) and condition monitoring solutions boast numerous acclaims. Indeed, they enable manufacturers to utilize advanced testing tools; review analyses and reports generated from data gathered; and manage information using an integrated system.

In the case of motors, the lifespan can be optimized. Optimal motor management and maintenance improves reliability, ensures the best return on asset values, decreases downtime, and effectively establishes more cost-effective manufacturing.

To learn more about the perks of PdM, Chemical Processing sat down with Noah Bethel, vice president of product development at Tampa-based PdMA® Corporation, a provider of electric motor testing instruments and predictive maintenance and condition monitoring solutions.

Q: What are some of the main benefits of permanently installed solutions?

A: The number one thing is reliability. Permanently installed technology is being monitored 24 hours a day; you are optimizing the early indication of faults so that you can get ahead of them, minimize the damage to the system, reduce the time to production in the event of an outage.

Number two is safety. With energized gear, there are rules and regulations to follow to keep you safe. When you permanently install a solution, it allows you to look at the same data you used to collect in the vicinity of energized gear from the safety of your desktop. That's hard to argue with.

The third is data reliability. Humans make mistakes. The more variables you can remove, the less likely you'll have human error involved. By installing technology, you have to go through an installation and launch, so you're overcoming all the errors that someone might make on a test-by-test situation when they're connecting the equipment to an asset.

Q: What about the challenges?

A: Challenges are always present but not in terms of installation — that's all pretty straightforward and quite simple. The challenges come from acceptance of the industry.

A decade ago Wi-Fi was unacceptable. People thought it was unreliable and unsecure but it's almost everywhere now. Cloud technology experienced early innovative resistance, too, but it's getting a lot more acceptance.

You have to do your due diligence and make sure that you've got all the security in place to remove people's fears and concerns.

Another challenge is nuisance alarms. A lot of people installing permanent technology don't spend the time to ensure that the machine is learning and reassessing the alarm set points, and as a result, there are nuisance alarms. People stop paying attention.

Q: Do operators take permanently installed solutions for granted; the set-it-and-forget-it mindset?

A: They absolutely do. In a past article we referenced a case study looking at data, alarms and understanding them. A utility plant had a situation where they weren't looking into an alarm. They said, "Oh, it alarms all the time. It's just a nuisance alarm."

The problem was that their nuisance alarm had grown. That one element was an alarm, which happened to be a phase imbalance. But the phase imbalance eventually correlated with a second dismissed alarm showing high temperature on two phases.

Q: What impact has COVID-19 had on the movement toward permanently installed solutions?

A: COVID basically locked people out of the workplace so we got an influx of requests to get permanently installed technology to provide access to technicians who used to go out and feel and touch and listen to the motors. Now they can evaluate the data from their office at home so it has had a significant impact on the increase in demand.

Q: Are there any other influences that lead to permanently installed solutions?

A: Baby boomers retiring. There were an average 2 million-per-year retirees leading up to 2019. In 2020, there was 3.2 million. So, you've got younger workers who aren't quite adept, but you also have people who are retired and willing to work from their back porch in places like sunny Tampa, Florida. Having access to these experts who just need a computer and a secure internet connection to help the on-site guy look at the data is priceless.

Another issue — college kids aren't rushing to get into the maintenance industry. As a result, companies are looking for ways of getting data to third-party personnel, even local service shops, who have some expertise. So permanently installed technology is another answer for that situation.

Q: Are portable solutions still relevant?

A: Without question and for a variety of reasons. Number one, not every asset is going to qualify for 24-hour critical monitoring. That's just a financial decision. Portable solutions enable testing on an annual or semi-annual basis.

The other thing is there is a lot of portable technology that tests motors when they're offline. Specifically, one of our big fault zones, which is the insulation fault zone, is better left to de-energized or portable technology.

Another reason is troubleshooting. There may not be a problem with the motor — it could be operator error. You have this great permanently installed technology waiting to tell you what's going on but there was something unrelated to a maintenance anomaly that caused the motor to turn off. That's where offline portable technology comes in.

Also, there is the case for storage and warehousing situations — when motors are sitting on a shelf and de-energized. So, again, from a motor perspective, there's a lot of places that permanently installed just can't help you out.

Q: How do you decide which approach is best?

A: Criticality is the number one issue. That involves impact on production, impact on the environment, and the impact on cost. Then you consider replaceability. Sometimes motors aren't that expensive but to get a replacement or to get it repaired is going to take so long that it will become critical. Those are the four areas under the criticality that I think most people put into the decision of, "Okay, this is going to qualify for permanently installed."

The other big area besides criticality, in our assessment, is resource availability. Because no matter what, if you do not have the resources to go out and even test the critical stuff, or even the subcritical stuff, you're in trouble in terms of maintenance and reliability. If you have resource-availability issues, you'll have to permanently install a certain number of assets and offshoot the analysis to the local service company.

TESTING TECHNOLOGIES

Figure 1. PdMA® Corporation helps its customers accomplish goals by monitoring the health and condition of electric motors with its advanced electric motor testing technologies.

Q: How do you maintain these maintenance tools?

A: One advantage to permanently installed is that it gets installed and it stays there. It doesn't bounce around in the back of a pickup truck, it doesn't fall down the stairs, it doesn't get dropped into the puddle. Additionally, re-calibration of our permanently installed technology isn't required. That doesn't mean that there's not going to be facilities that, under ISO restrictions, must calibrate their equipment. So, we do have re-calibration services available.

Q: Anything you'd like to add?

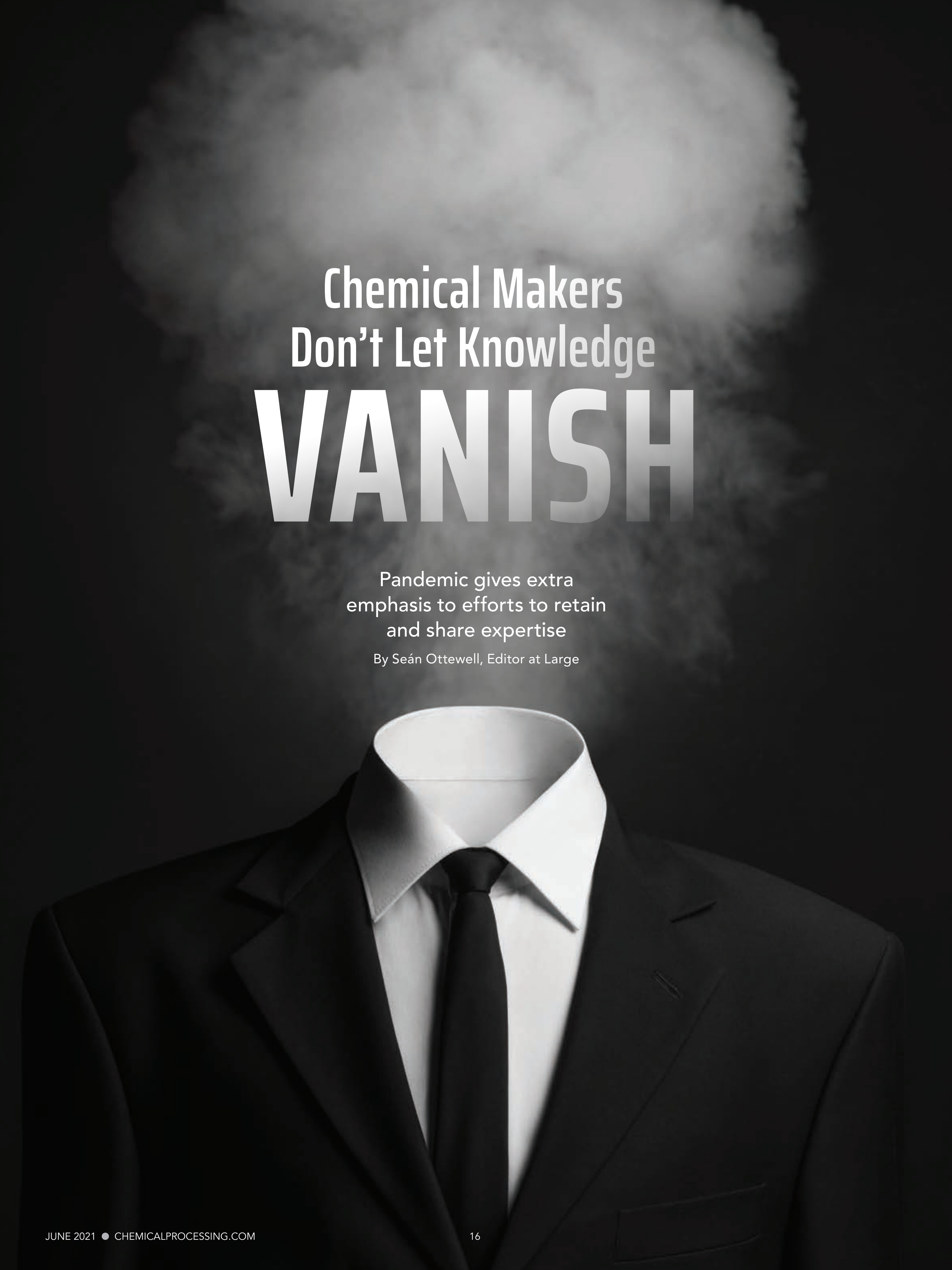
A: We sell a lot of technology to motor repair shops. As a result of them being motor experts, they are heavily equipped with resources and personnel who know motors very well. As a product of the challenges we spoke of earlier (baby boomer/pandemic/younger generation not being interested), the service industry has identified this quite vertical business opportunity for themselves. They are recognizing that they can suggest permanently monitoring motors and in doing so they can extend the warranty an additional year or multiple years because now they're the ones paying attention. So, it's a win-win. Our goal is to help our customers work more efficiently and effectively within an environment of shrinking resources — and this is an interesting way to do it.

For more on PdMA® Corporation, visit: www.pdma.com

Chemical Makers Don't Let Knowledge VANISH

Pandemic gives extra emphasis to efforts to retain and share expertise

By Seán Ottewell, Editor at Large



THE COVID-19 pandemic is spurring changes in the way operating companies and vendors make the most of employees' skills and knowledge. Firms such as BASF, Rockwell Automation and AspenTech now are leaning heavily on the latest technologies.

"Even before the COVID-19 pandemic, training and knowledge management for managers and employees were revised to make them fit for the challenges of digital transformation and a modern working world. On the one hand, new and flexible forms of work are associated with a change in culture. On the other, we are empowering managers and employees in the use of new tools," explains a spokeswoman for BASF, Ludwigshafen, Germany.

A key element of the strategy is retaining knowledge and experience, especially when an employee transfers to another company unit or retires. Hand-in-hand with this is the need to ensure efficient and safe operation of BASF's plants, execution of maintenance work, and implementation of organizational issues in the long term (Figure 1).

"For some time now, this has not been possible without the use of digital tools. For example, collaboration tools such as Sharepoint and WebEx are used for working together. Some units already use videos to document knowledge, and moderated knowledge transfers take place virtually wherever possible," adds the spokeswoman.

To best illustrate how to use these tools for knowledge transfer, BASF has set up a platform called "Digitalization & Me" on its intranet. Here, employees can find, among other things, numerous online training courses, videos and articles on further education. The company also uses LinkedIn Learning to communicate digital content.

"The COVID-19 pandemic has strengthened and accelerated this process. At the Ludwigshafen site, further training courses were converted to digital learning solutions in the shortest possible time, where possible, so that the planned measures could be implemented as far as possible," notes the spokeswoman.

BASF also has launched a digital series specifically for managers called "Leading at a Distance" that focuses on "leading virtually." The aim is to support managers during the particularly challenging times of the COVID-19 pandemic and provide them with the necessary tools for virtual leadership through exchanges with experts and others who might be working off site or getting close to retirement.

A new global campaign entitled "Making remote work, work!" highlights all aspects of virtual collaboration as well as content on virtual leadership.

Onboarding events for new managers, which normally are held in person, have gone in recent months to an online format, and will continue that way for the time being. Similarly, the master craftsman qualification for production and technology employees has been converted to virtual or hybrid training. Part of their work involves gaining knowledge and carrying out assessments made available via a learning portal while the rest entails working face-to-face in small, socially distanced teams.

THE VALUE OF EXTENDED REALITY

Rockwell Automation today is having more conversations with customers in the chemicals and other sectors about knowledge retention and transfer, according to Ramon Farach, a Nashville, Tenn.-based global industry technical consultant for the company, which has a wide automation and digitalization portfolio.

"Workforce turnover has been an ongoing problem in the chemical industry, and COVID-19 has only exacerbated the issue. Physical restrictions made in-person learning especially difficult as companies must limit the amount of people that are allowed in a control room or facility at the same time," he says.

On top of that, companies also must deal with unexpected staff absences if someone becomes sick or comes in close contact with COVID-19.

ACCELERATED ADOPTION

Figure 1. Major chemical maker is fostering greater use of digital tools and providing more online resources. *Source: BASF.*

"When these absences are among experienced workers, it creates an unexpected knowledge gap for the less-experienced workers remaining on site," adds Farach.

As a consequence, onboarding of new talent has become a particularly big headache for companies. "In normal times, new operators would have the opportunity to learn procedures and job tasks face-to-face with experienced employees, which is very helpful for their development and hands-on learning in an operating facility," he notes.

Troubleshooting problems also has become difficult for process or operations support engineers. For the past year or more, subject matter experts (SMEs) who ordinarily would visit plants to provide root cause analysis or troubleshoot complex issues (Figure 2) often haven't been able to address issues in person. Instead, they have had to find other ways to "see" and accurately support major problems, explains Farach.

Other tasks similarly affected by COVID-19 are processes such as hazard and risk analyses and safety assessments. These normally would take place in person and consist of a detailed walk-through of the plant.

"Now, personnel have to rely on technology, so they are performed through a variety of extended reality (XR) technologies to ensure accuracy," says Farach. XR is a catch-all term that includes augmented reality (AR), virtual reality (VR) and mixed reality (MR), he notes.

"These are not necessarily new tools but they have evolved and become more pervasive in the past year. Within this umbrella, there are a variety of technologies that can help more-experienced operations personnel pass down their tacit knowledge."

One of the easiest technologies for capturing knowledge is AR eyewear. Experts can wear the eyewear while performing a technical task or operating procedure, recording the full experience hands-free. After this, the video can be edited and voiced-over to explain the task step-by-step. It's a tool that helps extract knowledge right from the source to equip new personnel with the accurate, easy-to-follow information they need, Farach stresses.

AR-based remote assistance is another technology that's been especially helpful during the pandemic when meeting in person is difficult. It combines AR collaboration tools with real-time video communications to connect engineers with SMEs so all can see the issue in detail from the same perspective and work together to find an answer. "Our partnership with PTC has helped us provide these technologies and solutions to customers at a time where they are adjusting to a new way of work," adds Farach.

Rockwell Automation is discussing these technologies with several of its customers. One application being assessed with a large specialty chemical customer, which will apply in other segments of the chemical industry, is the use of PTC's Vuforia Chalk to provide an effective alternative to bringing resources into a plant because of pandemic-related restrictions. Vuforia Chalk combines advanced AR collaboration tools with real-time video communications to connect a field technician with an expert so they both can see and discuss the situation at hand. Potential benefits include streamlining troubleshooting efforts as well as coordinating and sharing insights relating to project scope definition.

The increased use of XR technologies will only speed up the transition from paper to digital records, believes Farach. "Rather than using PDFs or lengthy documents, we need — and have come to expect — this knowledge to be readily available and accessible through virtual platforms. We have already seen this begin and expect to see most procedural documentation become digital in the long-term."

In addition, chemical companies facing pressures to reduce operating costs in the face of margin erosion

AN INCREASING RARITY

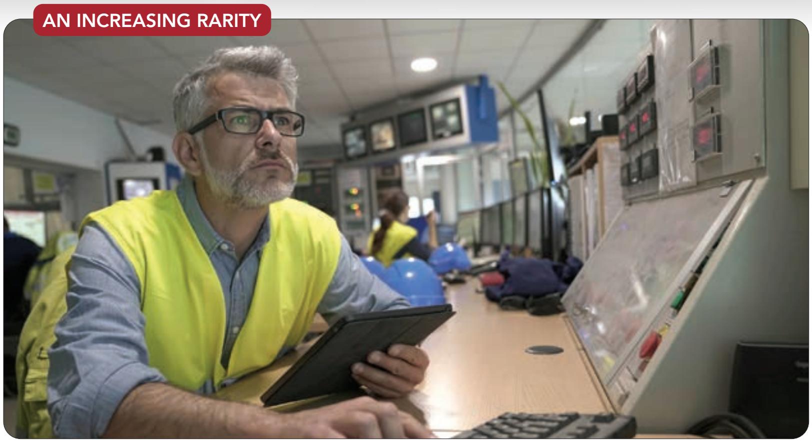


Figure 2. The pandemic has dramatically decreased on-site visits by subject matter experts to troubleshoot problems. *Source: Rockwell Automation.*

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are realizing significant cost savings using XR to provide remote support and knowledge transfer, he notes.

"We believe these new ways of working will become the new normal and continue to play a significant role in the way our customers do business well after the pandemic has finally passed. COVID-19 has shown us just how important it is to be connected in this industry. If this would have happened 20 years ago, it would have been extremely challenging for businesses to survive. Using the right technologies to stay connected is what made it possible for us — and our customers — to keep going during this difficult time," Farach concludes.

GREATER FOCUS ON RETAINING KNOWLEDGE

"The impact of retirements has never really been an attention-grabber, rather an undercurrent that almost always comes up in conversations with customers," explains Laura Stridiron, senior product marketing manager at software company AspenTech, Houston. "However, there's never really been any consideration of the numbers involved with the capture and use of tribal knowledge because it's very hard to assign a value to someone who is about to retire unless you have to double shift for over-the-shoulder learning, for example. I never thought it would take a pandemic to bring these issues right to the surface."

The pandemic has stopped people being able to cross-pollinate ideas in their usual team settings, she notes, adding that now they are asking questions such as: "How is this going to impact our health and safety at work?" and "What do we do if the expert we need is working from home?"

AspenTech has seen some customers move to dedicated work teams due to COVID-19, meaning no intermingling. While remote support still is available, knowledge transfer via phone and with intermittent contact likely is difficult or non-existent.

"Customers who had digitalization efforts underway are realizing that it is not about automating tasks but about ensuring consistent action and decision capabilities and it has brought a new importance to those projects," she explains.

AspenTech has a two-pronged approach to these challenges. The first involves looking at historical data and applying learnings from those data to the future. This is why it's important for the company's technologies to encompass all the process data, Stridiron notes.

So, for example, an impending compressor failure is never a problem in isolation. Other events occur elsewhere in the facility that likely never get correlated back to that compressor issue. At the same time, veteran staff's experiences often have led to their developing their own approaches to tackle such difficulties.

"So, it's a case of making the subjective more objective and trying to put this knowledge and expertise into the heads of process experts," she explains.

The second prong of AspenTech's approach is how to better and more impactfully learn going forward. The idea is to enable broad and ready access to a particular situation and share learnings across the organization.

Here, the company's Event Analytics technology is designed to provide an investigation tool for operators to more quickly assess "bumps in the night" that they either may have ignored or had to seek help with. It allows operators to quantify if the issue is something that occurs frequently and what else was happening at the same time. "They are then able to indicate the corrective action required and monitor for future occurrences, giving other shifts as well as future operators better guidance on actions to take," adds Stridiron.

Being able to capture, retain and then apply such knowledge in a useful way can have profound effects on the bottom line, too. Stridiron cites a project at a chemical company that involved teasing out the "muscle memory" of two and half years' worth of data and then overlaying it with the knowledge of existing engineers on the site. The result was a $1.5-million/y saving in energy consumption by the company's furnaces.

In another example, a polymer plant experienced a sudden drop in recovery of unreacted raw material, which was costing nearly $100,000/week in losses. After trying several methods of analysis with no success, the plant turned to AspenTech's ProMV to analyze the process data. It found that temperature stability was the key factor at play. The company then realized the problem had been known about a decade earlier. However, no current employees on the site recollected that.

"Memory and vague work orders cannot be the source of root cause identification. ProMV saved $5 million/y in this case and, with monitoring and controls, similar issues will be proactively identified in the future before profits suffer," Stridiron concludes. ●

IMPROVE OPERATIONAL EXCELLENCE WITH ADVANCED ANALYTICS

Cloud-based software can optimize data analytics to deliver maximum value

By Allison Buenemann and Megan Buntain, Seeq

AT A time when markets are unsettled, profit margins are slim and all eyes are on corporate sustainability, chemical manufacturers are embracing new operating strategies. Besides traditional spending for equipment or process changes to improve outcomes, many companies now also are investing in data analytics and associated skills, in particular advanced analytics.

These investments enable chemical manufacturers to transcend data silos so engineers and other subject matter experts (SMEs) quickly can analyze data from legacy process historians, relational databases and new Industrial Internet of Things (IIoT) sensors. Cloud-based advanced analytics applications are a key part of this transformation, addressing the issues of time to return on investment, multi-source data access and distributing insights across the organization.

Thanks to self-service analytics, frontline SMEs closest to the assets and processes, instead of spending hours wrangling and aligning data, can use the time to uncover process, quality and environmental improvements. Cloud-based software accelerates the enterprise-wide deployment of these improvements by simplifying collaboration between information technology (IT) and operational technology (OT) leadership. The result is that early adopters of these innovations are moving ahead of their competition, fostering prosperity in a tough market environment.

DEFINING DATA STRATEGY

When crude oil was trading near $100/bbl, chemical makers primarily relied upon capital improvement projects to increase production capacity. This spending to boost capacity has resulted in a chemicals market that is saturated in many sectors, driving down selling prices and forcing companies to rethink how they can eek out an extra $0.05/lb profit margin.

With traditional value-creation strategies no longer generating the return they once did, chemical manufacturers are adopting alternative approaches to drive operational excellence. Many companies now are placing greater emphasis on extracting more value from data through process modeling, optimization, key performance indicator (KPI) calculation and loss tracking.

Making the most of analytics requires strategy and enterprise alignment from the start. It demands answers to questions such as:

- What data currently are being stored?
- Who are the primary users of those data and where are these users located?
- What type of calculations do the data go into?
- What frequency of data is required for the analysis?
- Is analysis based on historical, near-real-time or forecasted data?

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ENTERPRISE SCALE-OUT WITH THE CLOUD

As chemical manufacturers achieve gains from continuous operational improvements generated from the insights created by their employees, the path forward is to extend the use of analytics across more assets and plants, and, eventually, to global operations. This requires use of the cloud.

Cloud-based analytics programs received a large share of IT attention and budget about a decade ago with the emergence of big data technologies. Many industries, from financial services to retail to healthcare, invested to harness the cloud for data collection, data storage, analyses and machine-learning tools to help them solve pressing business problems. The first wave of investment focused on using the cloud to store large volumes of data across the business value chain, including customer, financial, enterprise resource planning and business data.

Bringing access to disparate data sets together across different departments within a corporation provided 360° views of business performance. The emergence of self-service business intelligence (BI) applications connected to these cloud databases — using tools like Tableau, Microsoft Power BI or Spotfire — enabled business users to create analyses without learning to code.

This first generation of big data advances largely ignored operational data. Most manufacturers have generated and collected operational data for decades — and stored the information in supervisory control and data acquisition systems and plant-based historians. However, making these mission-critical data available to cloud-based databases or BI applications was challenging for several reasons.

The design of protocols for programmable logic controllers and industrial machines often didn't have the internet in mind, and cybersecurity is a concern for transmitting operational data to the public cloud. Most operational data are time-series data that create inherent challenges for BI applications as these are purpose-built for business data, which most commonly are relational data.

Today, the big data landscape is much different because corporations now want to include operations data in their enterprise digital strategies. The emergence of industrial data standards like OPC and machine-data message brokers like message queuing telemetry transport are enabling improved connectivity to new cloud-based databases that are purpose-built for time-series and IIoT data. Additionally, advanced analytics now can be deployed in the cloud, providing SMEs with easy access to operational data whether they are working in the plant, in the field, in a remote operations center or from a home office.

The cloud accelerates these enterprise roll-outs by enabling analysis of massive amounts of data at ever faster speeds, with almost limitless computational power at hand. A corporation can take an analysis created by a single engineer at one plant for one asset or one batch and quickly share this insight across the peer group to scale-out to thousands of assets and batches. Specifically, the cloud is well suited for applying machine learning to generate new insights and predictions that simply aren't possible when data are siloed, and users are limited to the constrained computing resources in their company's data centers.

- What data sources are being used together to create insights?

With an understanding for how and where to store data, the focus shifts to what types of analyses to prioritize. This could mean defining a specific set of KPIs to evaluate, periodically report and benchmark across production sites. It could involve standardizing the analysis and monitoring of key process equipment (pumps, compressors, valves, etc.) across the organization, or it could mean incorporating machine learning, artificial intelligence or digital twins to solve predictive maintenance challenges.

One of the most effective ways to crank out analytics at scale is to empower existing SMEs with user-friendly self-service advanced analytics tools. The SMEs, through their process knowledge and awareness, can put the data into proper context, eliminating the contextualization feedback loop often experienced with siloed data science groups in organizations. Chemical manufacturers are embracing this strategy with the understanding that maximum value is created by combining advaned analytics software with empowered employees.

OVERCOMING COMMON OBSTACLES

Despite technology advances spurred by cloud-based software delivery, data access still lingers as one of the most significant barriers to engineering productivity. Live connections to process and contextual data sources are critical for near-real-time analytics and for acting on the results — but these connections frequently are not available. As Figure 1 highlights, traditional, often spreadsheet-based, methods of aggregating data from multiple sources or over long periods of time commonly pose a number of problems. Cloud-based advanced analytics addresses these and other issues to increase productivity and speed time to insight. The combined data are indexed on demand by the SME and displayed in an interactive point-and-click environment, making it easy to perform calculations and get immediate visual feedback of the results.

A user-friendly environment is imperative to make advanced analytics accessible to SMEs, many of whom lack a programming background. Another key factor is the ability to display the visualizations and results of various analyses in a comprehensive dashboard and reporting tool. Reports built in browser-based advanced analytics ap-

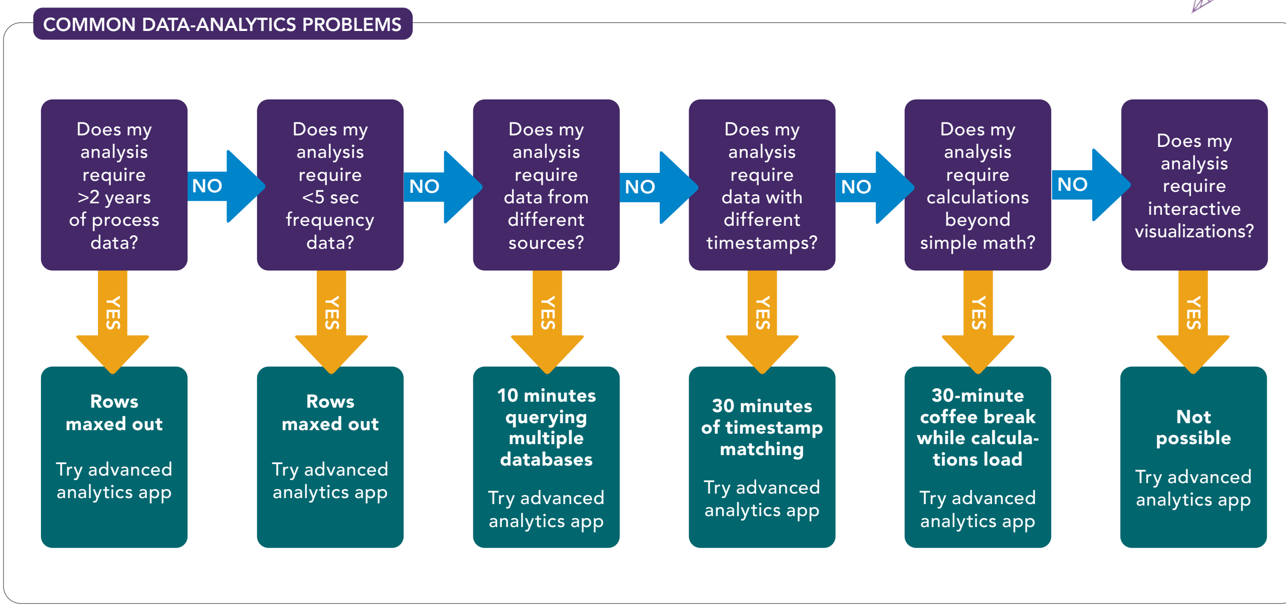

Figure 1. Traditional approach to analyzing process engineering data using a spreadsheet poses a variety of issues.

plications enable easy access to insights and click-through functionality for further investigation.

With the data access and computation challenges addressed, the choke point shifts downstream to how an organization operationalizes the insights gleaned from analytics. Converting an analytics insight into a physical action taken by frontline process personnel requires an advanced network of information flow among systems. The cloud and related services empower chemical manufacturers to do this in near-real-time at scale.

DELIVERING VALUE

Once the proper foundation is in place, a chemical maker can achieve significant improvements. Let's look at three actual examples.

Product quality. Critical measurements like yield, composition and viscosity often are difficult to monitor online; so, instead, samples are taken and sent to a laboratory. An unexpected result from the laboratory analysis initiates a feedback loop, manipulating upstream parameters to achieve the desired downstream quality result. It's important for manufacturers to understand which independent variables in the process most directly link to the desired outcome and to what magnitude because this information is needed to maximize product quality, yield and other parameters.

One large-volume chemical maker pulled the relevant process variables into a Seeq Workbench display, and identified time periods comprising both normal and abnormal operation. Using a correlation matrix algorithm built in Seeq Data Lab, it determined the manipulated variables with the largest impact on the measured quality variable. After removing outliers and downtime data from relevant signals, process dynamics were accounted for by delaying upstream signals by the offset of maximum correlation with the target signal. A predictive model of product quality was built and deployed to control room operators via an auto-updating dashboard.

The deployment of the dashboard has given those closest to the manufacturing process a better understanding of the product quality of in-process materials. Based on the prediction of future laboratory sample data, operators now make proactive adjustments to fine-tune the measured variable to align with the targets. This mechanism of proactive product quality control is saving the company $1–5 million/yr in product downgrade losses.

Sustainability and environmental stewardship. Chemical manufacturers are looking for ways to improve sustainability and drive toward carbon-neutral low-emissions operations. One of the key capabilities needed to reduce emissions is developing an understanding of the quantity of emissions being released, and then tracking those cumulative volumes against annual permit limits. Accurate reporting becomes more challenging when vent stack analyzers peg out at their limits, necessitating use of estimates. The estimation process is complex and highly manual, requiring engineering support at the time of an exceedance.

So, a chemical company used Seeq Workbench to create an automated model of a pollutant detector's behavior during the time periods when its range was exceeded. Model development required the use of capsules to isolate the data set for the time periods before, during and after a detector range exceedance occurred. Regression models were fit to the data before and after the exceedance, and then extrapolated forward and backward to generate a continuous modeled signal; this is used to calculate the maximum concentration of pollutant. Scorecards provide a quick summary view of maximum concentration and total pollutant released during an exceedance event.

The visualizations developed were compiled into a single auto-updating report displaying data for the most recent exceedance event alongside visualizations tracking year-to-date progression toward permit limits (2). Retrospective application of the model revealed pollutant volumes likely were underreported in previous years; so, the company decided to make proactive process adjustments when it became clear that the current year was on a similar trajectory.

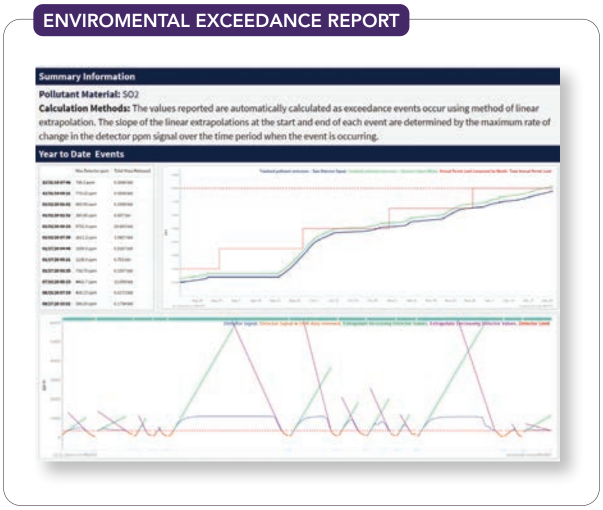

Figure 2. Auto-updating report shows year-to-date events as well as cumulative emissions against permit limits.

Worldwide roll-out via the cloud. Global chemical manufacturer Covestro, Leverkusen, Germany, launched a digitization initiative called process data analysis and visualization (or ProDAVis) for process monitoring. The aim is to provide employees at all its sites worldwide with process data access and analytics tools to achieve digital transformation.

One of Covestro's key objectives was to achieve sustainable solutions, not short-term quick fixes. This meant that OT and IT leadership had to create a shared vision that didn't require ripping and replacing the existing operational data infrastructure — but, rather, building on and evolving that infrastructure to gain greater value from their data. An essential element was providing cloud-based analytics tools that each employee could use to drive both immediate and longer-term operational improvements. This approach accelerated Covestro's time to value by leveraging what already was in place while including its employees in the technology selection and usage, and by using the cloud to scale-up more quickly.

BEST PRACTICES AND POTENTIAL PITFALLS

For chemical manufacturers, the fastest path to value is starting with use-cases and data that already are accessible, instead of leading with technology and then searching for a problem to solve. Common use-cases that self-service advanced analytics can quickly address are batch cycle time, golden batch, energy consumption and process monitoring.

To move ahead quickly, many companies are choosing software-as-a-service applications that offer rapid deployment in the cloud (sometimes within hours) and include secure connections to data — enabling users to begin work quickly. A common mistake at this juncture is to first move all data to one location, often the cloud, before beginning any work. This delays implementation and often results in abandonment of projects due to long periods between investment and results.

As mentioned earlier, it's important to put employee knowledge to work and ensure that SMEs are at the heart of any analytics program or investments. SMEs understand the industrial process, data and context best. Choosing "black box" machine learning or analytics tools not only precludes capturing the insights of these experts but also can result in a lack of SME engagement. Easy-to-use and flexible analytics tools create new opportunities to gain value by marrying the best of people, process and technology.

Finally, you must begin with the end in mind. Adopting operational analytics across the enterprise eventually will require the global scale and reach of the cloud. However, this doesn't mean you can't do work until all data are in the cloud. Choosing cloud-based tools that can access both cloud and on-premise data sources ensures insights from data can be readily generated, starting with one employee and scaling out to thousands. ●

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DELVE DEEPER INTO LEVEL OVERFLOW INCIDENTS

Simply blaming human error doesn't address the true cause

By Nicholas P. Sands, DuPont, and Todd Stauffer, exida

TANK LEVEL overflow incidents are one of the most common scenarios for a loss of primary containment at a process plant. Effective alarms, as a first layer of protection, are critical to preventing tank overflows. Often the initial question after an incident is: "Did the operator get an alarm?" Immediately the focus goes to "human error" as the likely cause (the "what"). This article instead will explore the sources of human error related to alarming — with a goal of exposing the "why" and the "how" (to do it better). It provides guidance on investigating an alarm incident, including relevant questions and a "Why Tree" for determining root cause. It also offers recommendations for how to prevent or minimize human error by the operator.

First, though, it's important to understand that human error is common and costly. Medical errors in hospitals and clinics result in approximately 100,000 deaths each year in the United States and cost the healthcare industry between $4 and $20 billion annually. In the petrochemical industries, operational error can cost upward of $80 million per incident. "Operator error" is a significant causal factor in 60–85% of industrial accidents.

WHAT IS HUMAN ERROR?

Let's start by emphasizing that very rarely is the "human" in "human error" the true source of the problem. The explosion in data generation — some suggest that more data have been created in the last two years than in the entire previous history of the human race — certainly shows in the amount of data presented to the operator in a modern chemical plant. Increasing levels of automation (and system complexity) don't eliminate human error, they increase the likelihood of errors.

Human error is a function of people, technology and context. Actions only can be judged as erroneous with the benefit of hindsight and when there's an expected behavior or performance benchmark for comparison. The root cause of human error often is a design focused on technology instead of optimizing human performance; consequently, "design-induced error" probably is a more accurate description. Technology should be organized around the way users process information and make decisions.

Technology also should reinforce the user's mental model, which captures the understanding of how a system operates and behaves. Mental models guide the operator on what information to expect and what information to look for (e.g., if vessel temperature is increasing, so should pressure). The richer and more complete the mental model is, the greater the chance of successful response to an alarm.

TYPES OF HUMAN ERROR

To address human error, we must understand the different kinds of error and the cause of each. Errors can stem from issues with diagnosis, planning, accessing memory or with executing an action. Types of error include slips, lapses, mistakes and violations (Figure 1). Some types of errors occur more commonly with novice operators while others afflict experienced operators more. Consequently, remediation actions differ depending upon the type of error.

Slips and lapses, also known as skill-based errors, are failures when the person had the correct intention but performed an incorrect action because of lack of the appropriate level of attention. An example of a slip is inadvertently changing a control valve output to 5.0% instead of 50.0%. Slips may result from confusing links or displays of information in the human-machine interface (HMI) or not error-checking inputs. Slips are common for expert operators who are performing a task without paying close attention; they may be multi-tasking.

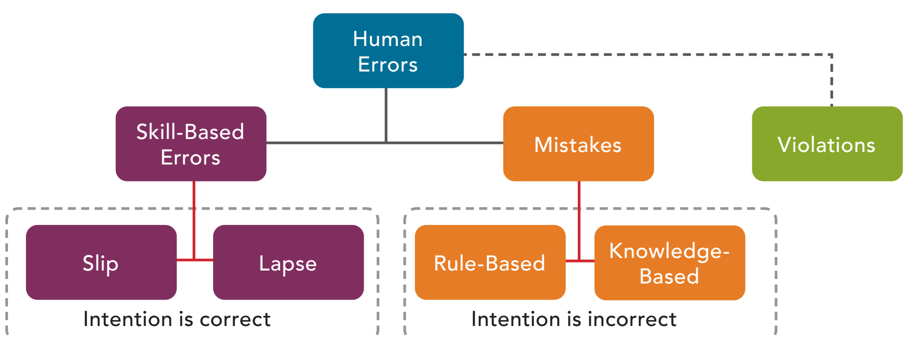
A lapse (memory failure) occurs between the formulation of an intention and the execution of an associated action. An example is when a maintenance technician fails to tighten a screw after completing a procedure. The use of checklists or explicit reminders helps prevent lapses; this is why experienced pilots still use a checklist for walking down an airplane before takeoff. Additional training typically won't correct slips or lapses.

A mistake (intention failure) occurs when the person initiates the wrong plan of action for the task at hand. Mistakes, which typically involve a problem-solving activity (like the operator responding to an alarm), fall into two categories: rule-based errors and knowledge-based ones. Rule-based errors can arise through misapplication of a good rule or use of a bad one. An example is when the operator misinterprets a valve command status as position feedback, thinking the valve is closed when it's not.

Knowledge-based errors, which include failures of understanding (errant mental models) and perceptual errors, typically arise due to a lack of experience and because the person doesn't have all the knowledge required to perform the task at hand. Most mistakes reflect a lack of knowledge, so training and better displays can help address them. Mistakes are common for the novice operator.

A violation (non-compliant action) is when the person intentionally does something inappropriate. It doesn't always indicate a malicious act or devious employee. Instead, it

TYPES OF HUMAN ERROR



Error Types		Description
Skill-Based Errors	Slip	Failure of attention where an action is carried out that is not intended or planned.
	Lapse	Memory failure resulting in the omission of an intended or planned action.
Mistakes	Rule-Based	Using the wrong rule for the situation. Incorrect application of the correct rule. Failure to apply the correct rule.
	Knowledge-Based	Failure resulting from insufficient or incorrect knowledge. Misapplication of existing knowledge to new situations.
Violations		Deliberate deviations from standards, safe operating practice and procedures.

Figure 1. Errors fall into several categories, each with distinct characteristics.

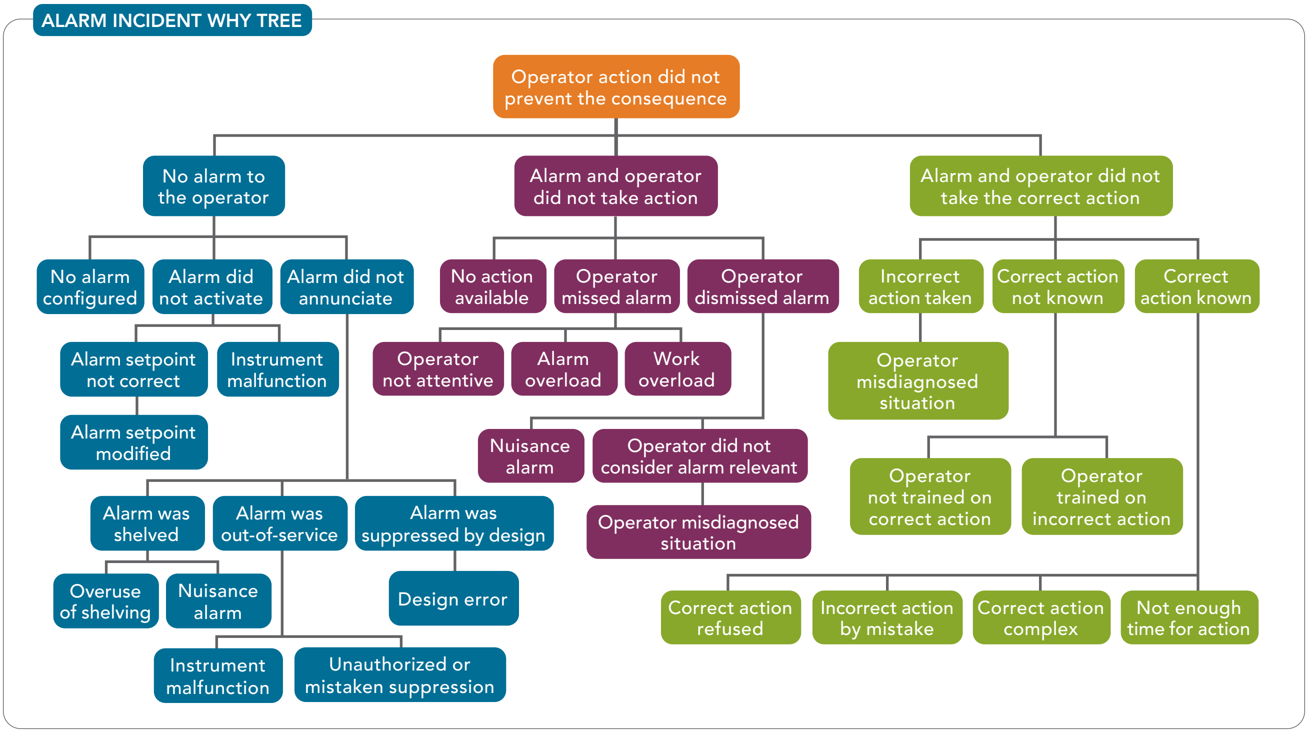


Figure 2. This includes branches for three groups of causes, with two particularly relevant to human error.

could exemplify the "law of least effort" in action, which says that if a task appears overly difficult, the operator over time will find an easier way to do it. Scenarios where production is emphasized over safety (the operator isn't "authorized to shut down production for safety") also can foster violations.

Analysis of human error may take place during an incident investigation when evaluating the operator's role. It should focus not on identifying what the person did wrong but instead on understanding why acting that way seemed to make sense. Identification of the type of human error can improve the quality and effectiveness of recommendations.

INCIDENT INVESTIGATION

The investigation team typically gathers the information to analyze. For incidents involving operator response to alarm, the team should collect some often-overlooked information, such as:

- the history of alarms and operator actions preceding and during the incident;
- the annunciation frequency of relevant alarms, i.e., how often the operator gets the alarm;
- the shelving frequency of the relevant alarms, i.e., how often the operator uses a function to hide the alarm annunciation;
- the history of setpoint changes to the relevant alarms;
- the history of out-of-service suppression of the relevant alarms, i.e., how often an administrative process is used to hide the alarm annunciation;
- the rationalization information for the relevant alarms, including probable cause and corrective actions;
- training materials related to the relevant alarms; and
- the alarm system performance metrics, particularly the average alarm rate per operator position and the percent time in alarm flood for the operator position.

Analysis of this information helps identify the factors that contributed to the operator not taking the action to prevent the consequence. Identification of the incident root cause is important so the recommendations address the cause. It's not uncommon for investigations to stop at the operator did not take action to prevent the consequence and blame the operator. Often, it takes more questions to get to the real causes — including understanding the operator's thought process.

A Why Tree can generate possible causes for the incident or failure of protections and, once the cause is determined, to develop recommendations. Figure 2 shows an example Why Tree.

The Why Tree is divided into three groups of causes at the second level:

1. Why did the operator not get an alarm notification about the situation?
2. Why did the operator not take action in response to the alarm?

3. Why did the operator not take the correct action in response to the alarm?

(The first group of causes doesn't relate as much to operator error but we've included it for completeness.)

Figure 3 shows the feedback model with the usual steps in alarm response. A disturbance causes a deviation or abnormal condition indication or alarm that the operator detects. The operator diagnoses the situation and then takes action in response to the alarm.

The causes at the top of the Why Tree address issues in the alarm indication, detection and diagnosis, and response.

The investigation team can work through the Why Tree using the information listed above to identify the likely causes behind the failure of the response to the alarm. Frequently, causes include instrument malfunction, operator training, and misdiagnosis of the situation related to the operator's mental model. The data should guide the investigation, for example:

- If no alarm was annunciated, the team should review the instrument, alarm configuration and alarm suppression history.
- If no action was taken in response to the alarm, the data can indicate if the alarm was a nuisance alarm or if the operator was overwhelmed with alarms during the event.
- The history of alarms and operator actions will answer if there was an alarm to indicate operator action was needed, if the operator took action, and if the action was correct. Multiple alarms and actions may require review.
- The team should check rationalization information to see if the correct action and probable cause were documented.

To fully process the Why Tree, the operator has to share his or her thought process at the time. This is easier to do when the investigation isn't seen as an attempt to blame the operator but one to improve the systems. Useful recommendations only result when there's an earnest attempt to understand the mechanisms and factors that shape the operator's decision-making and behavior.

ANALYSIS OF INCIDENTS

Let's now look at three actual events that led to serious consequences.

Gasoline tank overfill. At a Buncefield, U.K. site, operators failed to prevent a tank from overfilling; this resulted in a vapor cloud explosion. Reviewing the Why Tree shows there were two instances of "no alarm to the operator." The alarm from the tank level gauge didn't activate because of "instrument malfunction." The level gauge also gave the operator misleading information. The alarm for the independent high-level shutoff failed because "alarm was out-of-service" due to "mistaken suppression" as a result of maintenance.

There are other relevant human error lessons to be learned. Managing the incoming fuel transfer should have been viewed as a safety critical task, meaning if performed incorrectly, it could lead to a major accident. The investigation showed that operators didn't have sufficient visibility or control over the pipeline to properly manage storage of

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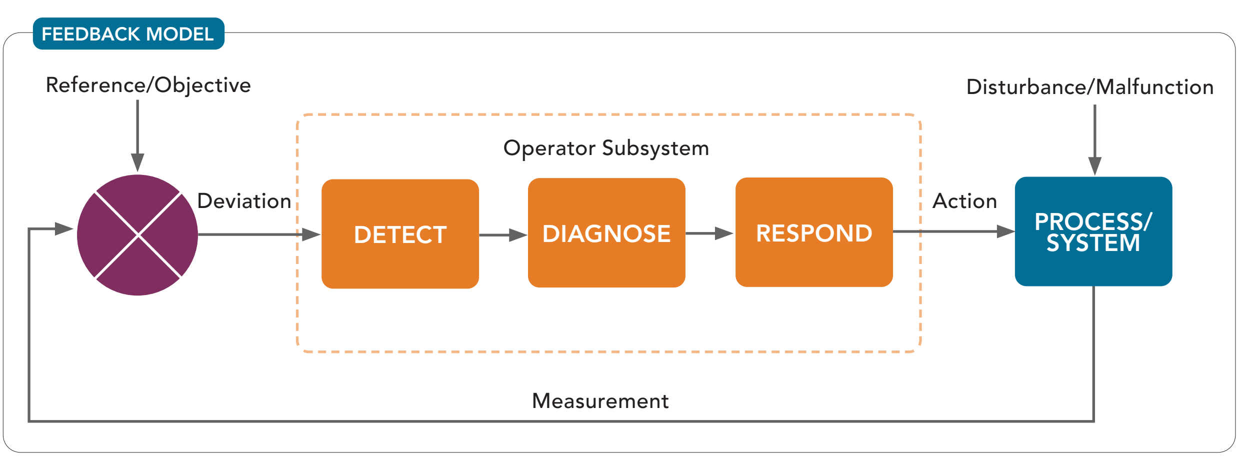

Figure 3. Detection of an issue should prompt proper diagnosis and then appropriate action by the operator.

incoming fuel or to address developing abnormal situations. Performing a human reliability assessment of this safety critical task would have identified this insufficiency.

Loss of treated water (utility) in winter. A Canadian process plant had a level control valve freeze closed on its treated water tank in January. When the frozen controller alarmed high (spuriously), the operator lowered the setpoint to 75% from 80%. When a redundant level indicator alarmed low a few minutes later, the operator thought it was another high alarm and reduced the setpoint to 70%. The operator took no additional action for eight hours. When the treated water pumps began to cavitate, the operator realized that no more water was available to feed the plant's boilers. The plant lost steam in the middle of winter.

The Why Tree indicates a failure resulting from "incorrect action taken" caused by "operator misdiagnosed situation." With redundant level indications available, the operator, before taking action, should have confirmed the validity of the level controller high alarm by looking at theother measurement. The operator made a slip by failing to provide sufficient attention to notice that the second alarm was for low level instead of high level. The system design also contributed to the diagnosis error. Only the level controller provided visual indication of an alarm on the process graphic; the redundant level transmitter didn't. A dozen stale alarms clouded the alarm summary display, hindering the operator from recognizing the new information. The summary display presents information in a series of columns, such as time, tag, tag description and alarm condition. There was minimal difference between the high and low alarms; the distinguishing characters ("PVHI" vs. "PVLO") only appeared at the end of a long string of characters.

Interestingly, the company's response to the incident was to add a low-low level alarm to both instruments. Yet, the use of the Why Tree clearly indicates the problem was not "no alarm to the operator."

Batch sent to wrong equipment. During a batch campaign, a piping modification intended to deliver product to a designated tank instead sent it to a different tank. After several days of production, the high level alarm on the second tank triggered. The next day the high-high level alarm on the second tank activated. Production continued until material overflowed the second tank. Eventually, a field operator investigated and identified the loss of containment. The release finally was contained after more than 1,000 gallons of material was spilled. In this example, the failure "operator dismissed alarm" occurred because the alarm wasn't considered relevant. The situation was misdiagnosed because it didn't square with the operator's mental model (mistake).

Errors (slips) associated with performing actions on the wrong equipment are common in industry and often also include violations. A 2007 explosion at Formosa Plastics' Illinois plant occurred when an operator turned the wrong way at the bottom of a stairwell, leading the person to mistakenly open a running reactor (after bypassing a safety interlock) instead of one that was being cleaned. The investigation showed that this type of error had taken place in the past, indicating the design wasn't sufficient to prevent human error. (See: "Explosion at Formosa Plastics (Illinois)," https://bit.ly/3tcaqhK.)

For additional information on this topic, check out the webinar "Impact of Human Factors on Operator Response to Alarm: Lessons from Process Industry Incidents," https://bit.ly/3ebV4Fu.

BAD RECOMMENDATIONS

Often an investigation team is so focused on a particular incident — looking at a tree rather than the forest — that its recommendations are inconsistent with the alarm philosophy. The following all-too-common recommendations damage the effectiveness of the alarm system over time.

- *Add a second alarm.* If the operator didn't take action when there is one alarm, add a second for the same action as a reminder. This creates redundant alarms, one of the enemies of a good alarm system. Often, the operators stop taking action at the first alarm, knowing they can take action at the second alarm.
- *Re-alarm.* If the operator didn't take action soon enough, annunciate the alarm again and again and again, until the person takes action. This increases the alarm rate to the operator and can distract from more urgent alarms.
- *Raise the priority.* If the operator didn't take action, increase the priority for the alarm. This makes sense if the priority wasn't correct. However, artificially upping the alarm priority will degrade the meaning of priority over time and conflicts with the priority system set out in the alarm philosophy.
- *Put flashing text on the display.* If the operator didn't take action, make this alarm visible in a special way that can't be missed. This creates a unique human-machine interface (HMI) view of the alarm, breaking the HMI philosophy. Over time, the displays become filled with special alarm indications until nothing seems special.

GO BEYOND "OPERATOR ERROR"

Tank level overflow incidents continue to be a significant issue at process plants. Minimize the

chances for human error by designing the system around the way that users process information and make decisions. Analyze near-misses and incidents thoroughly to get to the root cause. If "operator error" is your root cause, then chances are you haven't investigated deeply enough. Use of a Why Tree can help identify the contributory root causes. History has shown that if you don't get to the root cause, then remediation steps (such as putting in another alarm or forced training) won't prevent a repeat incident.

Consider these specific recommendations to minimize the potential for human error in operator response to an alarm:

- Identify situations that can lead to human error or where human error could prompt an incident. Put mechanisms in place to prevent or mitigate them. Include error-checking and confirmation within the HMI to minimize slips.
- Beware of hindsight bias, i.e., the tendency to perceive past events as having been more predictable than they actually were, for it will impact how well the organization can learn from the event.
- Watch out for bad recommendations that would make the situation worse (see sidebar).
- Design process graphics to help reinforce the operator's mental model of the process and to ease diagnosis of the cause of an upset.
- To develop better diagnosis skills (to prevent mistakes), implement a training program that practices recognizing cues, expectations and operator actions. Also use pre- and post-mortem discussions to facilitate knowledge transfer within the operations team. ●

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SHIFT TEAM DIGITALIZATION ENHANCES PROCESS OPERATIONS

Taiwanese complex gains important benefits from two-phase initiative | By Dave Loubser, Yokogawa

DIGITALIZATION EFFORTS at process plants can boost efficiency and profitability. Based on our experience, shift handover and routine follow-up of high-priority tasks are prime areas for efficiency improvements from digitalization. That's certainly what Formosa Petrochemicals Corporation (FPCC), Mailiao Township, Taiwan, has found.

The company operates a 500,000-bbl/d of refining and petrochemicals complex in Mailiao Township. It employs more than 5,000 people at the three production plants there. Founded in 1992, its work processes have developed and adapted to different cultures particular to individual shifts. FPPC management, in its quest for operational excellence, reckoned that improving of shift team effectiveness could enhance the company's performance.

Through a seminar facilitated by a joint KBC and Yokogawa team, FPCC saw that the execution of its production and maintenance plan was sub-optimal. Internal investigations and information gathering showed that its shift execution approach had not grown in line with best practices and digitalization tools.

This was especially evident in shift handovers. These suffered from data and communication gaps — including incomplete information; missed or unknown work item status; illegible handwritten log sheets; and data limited to operators' written notes, hindering further analysis and troubleshooting.

The company also found that certain shifts had more efficient handovers. Because of this inconsistency, FPCC realized that a change-management program would be another important aspect of a successful implementation of digital tools to support the shift- and plant-team improvements.

FPCC's vision is to continuously adopt best operating practices and implement these across its site. The company chose KBC's Shift Team Effectiveness Standard because it consists of 14 discrete elements built on best practice experience (Figure 1).

As a non-prescriptive standard based on KBC's extensive industry

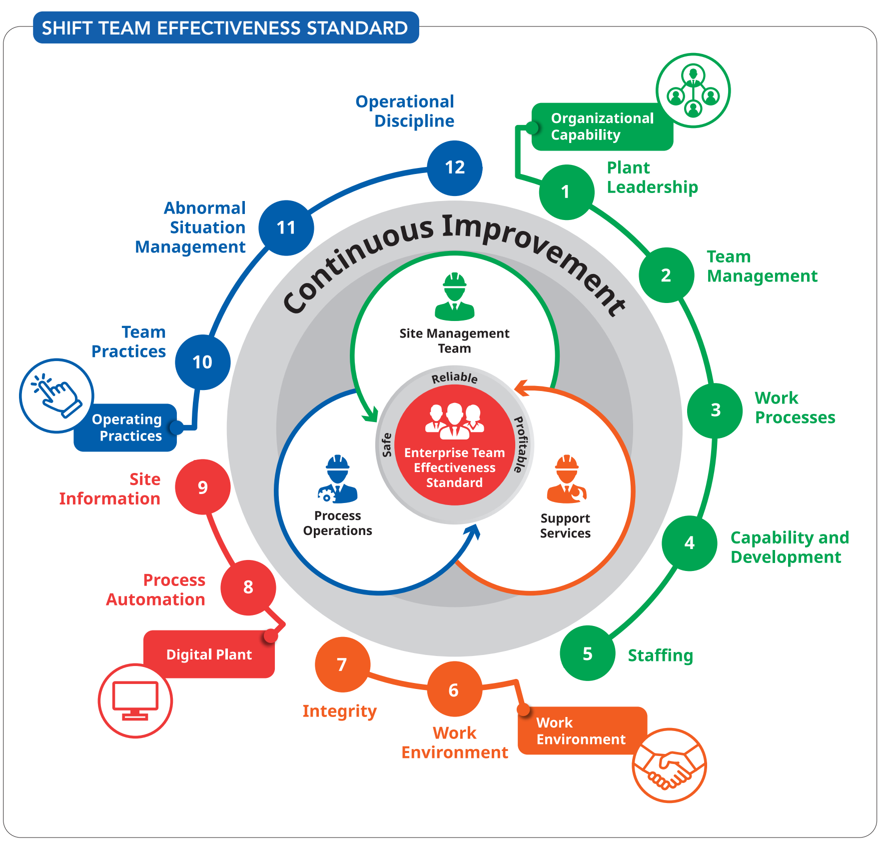

Figure 1. KBC's standard includes 14 discrete elements that take into account best practices.

experience and the benchmarking of process industry best practices, the standard offers flexibility. FPPC plant leadership and the project team were able to adapt these best practices to suit their needs, resulting in superior plant shift-team performance.

FPCC's drive toward using the latest digital technologies led them to implement the Logbook and Shift Handover modules from the Yokogawa RPO Operations Management Suite (Figure 2). That integrated suite provides the shift team as well as area- and plant-wide teams with digital tools that help streamline safety and shift-team management practices.

OPERATIONS MANAGEMENT SUITE

Figure 2. Shift teams initially took avantage of the Logbook and Shift Handover modules.

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PROJECT IMPLEMENTATION

FPCC's management recognized that its vision to improve safety and the performance of shift teams would require a multi-phase, multi-year program. It decided to execute the project over two distinct phases.

Phase One. FPCC selected a particular process plant area to initiate the project. This would allow for ease of assessment as well as implementation. The project team could monitor and adjust the results before rolling out the tools more widely. This phase ran from January to October 2018.

A combined KBC/Yokogawa team assessed current shift operations' practices against KBC's Shift Team Effectiveness Standard. The team focused on Element 11 — Shift Team Practices, and Element 4 — Capability and Development.

The project team includes internal change management agents selected by plant management. These people have the necessary authority to drive behavior change as well as an intimate knowledge of plant personnel and operations. Their participation contributed significantly to project success. They continue to take part in all project meetings and activities.

The result of this approach was the development of a close working relationship with project stakeholders. They were on board with the new shift-team working approach.

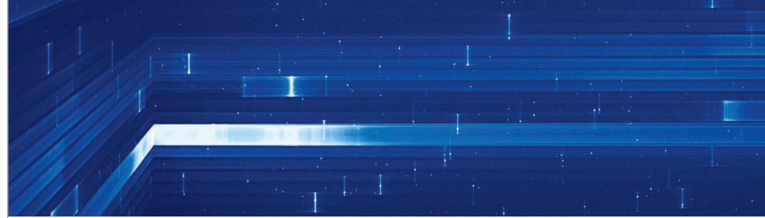
The site assessment took the form of a series of one-on-one interviews, field observations, and workflow discovery sessions with the shift teams and shift and plant management. The workflow discovery sessions involved the FPCC operations team mapping out its current shift-handover and daily shift-management activities on a wall. In addition, the team had to support each of the posted activities with evidence of actual documents or reports to demonstrate compliance with the activity.

The wall map helped the FPCC change agents, operations team and the KBC/Yokogawa team visualize the shift team's daily activities. More importantly, it enabled identifying areas of excellence as well as areas needing improvements.

The project team, including the change agents, indicated where they thought improvements or adjustments were possible. Once FPCC management approved the proposals, the working relationship with the change agents helped get support for the project approach and delivery methodology.

The project team installed and implemented the Logbook and Shift Handover modules from Yokogawa's Operations Management Suite. This customizable software allowed the project team, in collaboration with FPCC, to design the shift log layout and set content requirements. These closely align with the shift workflow, which guides the shift teams in optimizing their shift structure and ensures their execution of the production and maintenance plan.

The KBC/Yokogawa team worked closely with the FPCC change agents, shift teams, and shift and plant



management to understand their specific shift operations' challenges and to develop a practical workflow. The change agents conducted a series of training sessions on implementing structured shift-handover protocols.

The project team recognized that automating part of the workflow was possible. This would further advance FPCC's goal of digitalizing its assets. So, the team installed and implemented Yokogawa's procedure automation tool (ExaPilot) on one specific process.

Phase Two. In this phase, which started in June 2019 and is ongoing, the project team supported FPCC with the installation and implementation of the Work Instruction module of the Operations Management Suite. It links with the Logbook and Shift Handover tools that the team implemented in Phase One. The combination of these three modules provides shift management with a versatile and holistic shift- and plant-team communication tool.

The Logbook, Shift Handover, and Work Instruction tools went over so well that FPCC is increasing their use across the site. To further support the FPCC team, KBC/Yokogawa further customized the tools so they now are accessible via a smartphone.

COMPELLING RESULTS

FPCC management is happy with the results of the phased program. The company now benefits from:

- a structured shift log and handover template for complete information; (FPCC expects to see up to a 90% improvement in shift-handover completeness after the program ends.)
- process-specific related information that supports data analysis and eases troubleshooting;
- much better task tracking that reduces outstanding work items; (KBC's client group reports a greater-than-95% improvement in the follow-up on high-priority work instructions.)
- legible log sheets (compared to handwritten ones) that deliver a 90% improvement in the capture of shift log information; and
- supporting information that now includes pictures and documents, which directly upload to the workflow.

The implementation of digital shift-management tools and best practices, coupled with the change-management program, has provided the management team with a sustainable improvement in shift-team effectiveness. The KBC/Yokogawa project team and the change agents continue to deliver this multi-year program along with the benefits of digitalization. ●

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Take the Strain Out of Sampling

Several issues afflicting new sample station need attention

CHECK VARIOUS FACTORS

Consider the following points:

1. As the problem statement indicates, plugging and corrosion are among the key issues with this system. Typically, particulate content of the process (and, hence, sample) and its viscosity will prompt plugging problems. Catalyst attrition, corrosion and erosion are some of the factors that will cause plugging. Because the sample inlet piping is plugging frequently, straining or filtering the sample close to the reactor (at the sample tap at the reactor) will help minimize clogging of the inlet piping to the sampler. Particulate distribution will govern the mesh size of the strainer screen or that (pore size) for filters.

2. Although an inlet strainer or a filter are desirable, you have severe space limitations. So, consider an alternative location, including outlet piping, that does not have a space constraint and still can get a representative sample. If you opt for outlet piping, install the sample tap on the top or side of the pipe. Avoid bottom entry. In addition, if the outlet pipe is large, say, 3 in. or more, ensure the sample tap is not flush with the pipe but extends into it. Spare nozzles on the reactor could also be potential spots for the sample tap.

3. If viscosity is a contributing factor to plugging, you must consider keeping the piping and the sampler at proper temperature.

4. The issue of erratic sample results, as pointed out by Quality Control, could have numerous causal factors including, for example, the sampler and sample system, automatic sampler controls (timing, sizing of individual samples as part of the composite sample), flow pattern in the reactor, and analyzer issues. First, focus on the issues you can resolve quickly (such as plugging of the sample inlet) and then, if the problem (of erratic results) persists, look deeper into other factors.

5. Because the auto-sampler is relatively new, it is not possible to say if the corrosion issue is solved. Check that piping and tubing materials (e.g., Type 316 stainless steel) and seals are adequate for long-term corrosion-free service.

6. Although relatively unlikely, if, after implementing all corrective steps discussed above, the problem of erratic sample results continues, there may be a bigger issue — the flow distribution in the reactor itself. Obviously, this will directly and adversely affect your product quality. You may need to open the reactor for inspection/repairs.

7. Manual rodding frequency should be minimized; with proper inlet filtration and corrosion control, its frequency will go down. Consider adding proper isolation valves so an operator can do rod-out safely, and requiring personal protective equipment, e.g., face shield and appropriate skin and respiratory protection. Have the operators, operating engineers and safety folks review the revisions.

GC Shah, consultant
Houston

INVESTIGATE THE BACKGROUND

Blowing down, as it's being done today, isn't working. Keeping the sampler clean is bringing your

THIS MONTH'S PUZZLER

We installed a new automatic sampler in our catalyst bed reactor (see figure online at https://bit.ly/3ylOZyn). It replaced an old corroded manual station that was fouling. The manual station worked but some of our new operators warned it posed a burn risk; veteran operators had developed a knack for avoiding that risk. So, the safety department mandated putting in an automatic sampler.

The sampler manufacturer insisted on the installation of a Y-strainer but the pipe layout didn't have space for one. Our project engineer downplayed the need because the sampler had a built-in strainer; he had a drain valve installed to blow nitrogen into the strainer to clean it.

I checked the boneyard and the old station had a Y-strainer but, on closer examination, the screen was corroded with extra holes in it. I noted that someone had welded a finer mesh into the strainer.

The constructor installed the ball valve at the inlet but the vendor insisted on a needle valve.

Quality control is complaining that the sampler results are erratic. Operations doesn't like the blowdown procedure, saying it's unsafe and messy; an operator already has been hurt when his safety glasses were blown off his face. We're blowing down the sampler twice a shift. Blowing down doesn't help as much as expected; operators still have to rod out the inlet piping.

What can I do to improve operation of the automatic sampler? How can we improve safety? What do you think?

operators closer to, instead of further from, the dangers of the process. Talk to the project engineer or whoever suggested blowing down to find out why the person thought it would work.

In addition, the quality of the sampling has degraded. The question you must ask is: Is there a way to clean the sample after it's taken that won't degrade the sample.

Here's another thought. If straining was necessary, does the sample truly represent the product in the bed? Investigate this issue to decide if sampling here really is productive.

A ball valve won't provide good isolation so operators safely can clean the inlet of the sampler by hand. Therefore, perhaps the first move is to replace the ball valve with a twin-seated plug valve or a spectacle blind if space is limited. A twin-seated plug valve has a narrow width and can ensure tight shut-off; however, the internal relieving port drain, between the seats, must be carefully designed to prevent fouling.

Also, ask the sampler supplier why it specifies a needle valve. You likely will gain some insight into the vendor's past experience. In addition, change the piping to enable its disassembly as needed.

Because fouling has been a long-term problem with samplers, perhaps you can use this opportunity to identify the material causing the fouling. Catalysts tend to degrade and even become finer; this investigation might spur a look for a longer-lasting catalyst.

As a last resort, consider replacing the sampler altogether. Find out the supplier's competitors and start the bidding again. Let the current vendor know and give it a chance to fix the problem before you go elsewhere — a little incentive is helpful.

Dirk Willard, consultant
Wooster, Ohio

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AUGUST'S **PUZZLER**

We're finally fixing some of the steam problems that have plagued our plant. The boiler failed and we're replacing it.

Of course, our first challenge was obsolete drawings. Our boiler room and many plant pipe racks are a rat's nest of active and abandoned pipe. Corporate is funding the boiler replacement project and has hired a firm to complete a fresh set of piping and instrumentation diagrams, rack drawings and isometrics. That firm is finding a lot of overloaded racks as well as thermal expansion issues that someone thought were easily solved with expansion joints that now leak unexpectedly.

And then the fight began. Corporate wants all the condensate returned to avoid an expansion of the make-up water. I hate this idea because half our users operate below 1,500-lb/h steam. A survey shows that 20% of the users consume 300 lb/h or less. Corporate also would like to reduce our blowdowns for the cooling tower and boiler although the city isn't pressing us about our water consumption — we use river water from the city — and the area hasn't suffered a drought in 20 years.

Then, there is the tendency to oversize our steam traps. I see 1-in. traps where the control valve is 1-in. or smaller.

Lastly, I would like the boiler replacement project to include a review of our boiler feedwater treatment. We use Type 316 stainless steel but still see rapid corrosion of our pipe; typically, pipe lasts only 8–12 years before it rusts away from the inside out.

We're concerned that available funding won't allow us to address all the problems. What is the best approach to make the most of the expansion?

Send us your comments, suggestions or solutions for this question by July 16, 2021. We'll include as many of them as possible in the August 2021 issue and all on ChemicalProcessing.com. Send visuals — a sketch is fine. E-mail us at ProcessPuzzler@putman.net 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.

Free Up More Tubular Exchanger Area

Consider options besides changing bundle pitch when debottlenecking

DESIGN MARGINS incorporated in most plants and equipment often offer a cost-effective way to increase asset utilization. Over time, a site can use design margins to raise plant capacity or improve product quality. However, constraints posed by just one or two items frequently hinder overall improvements — and make debottlenecking that equipment important.

One recent example was a plant that wanted to raise product yields at its current capacity. Key to that was heating the feed to a higher temperature. The feed was heated by a combination of heat integration followed by a fired heater. The plant already was using all the spare duty capacity of the fired heater. So, the most straightforward approach to get the additional duty required was to modify the heat integration system.

The heat integration exchangers were installed in a multi-level structure. Code limitations precluded adding significant weight to that structure. In addition, the site only had limited open area suitable for new equipment.

Modifications targeted two elements. First, pinch analysis showed that one exchanger in the existing heat integration was nearly completely ineffective. Removing that exchanger would open up both space and weight capability for installing a much-more-effective heat integration unit. Second, minor changes — even as little as 5–6% more duty in specific services — would provide significant benefits. So, here, we'll look at how the plant got this extra duty from a heat exchanger.

Figure 1 illustrates the tube-sheet layout of one exchanger in the plant. It is a partial-condensing exchanger with hot fluid (vapor) on the shell side and cold fluid (liquid) on the tube side. The exchanger is a TEMA E-type shell with eight passes on the tube-side, and downward shell-side condensing flow. The pinch analysis showed that nearly all exchangers in the plant, including this one, were surface area limited. Adding surface area would increase exchanger duty most effectively.

Perhaps the most obvious change would have been to switch the bundle pitch from rotated square to triangular. This would have allowed more tubes, increasing surface area. However, because the exchanger was in a fouling service, the benefits of easier cleaning of the rotated-square pitch outweighed the additional surface area possible with a triangular pitch.

Immediately downstream of the exchanger's inlet nozzle is an open area with no tubes and an impingement plate. If tubes are too close to the inlet nozzle, they block a large fraction of the flow area, creating pressure drop and high inlet velocities. The open area between the inlet nozzle and tube bundle allows the vapor to flow along part of the shell length before entering the tubes. Effectively, this increases the inlet area for vapor flow into the bundle.

The impingement plate prevents high velocity vapor from jet-impinging onto the tubes. The vapor contains some liquid droplets, so high velocity impingement could cause erosion or other mechanical damage.

Providing open area under the inlet nozzle is a conventional approach in exchanger design. Open area also is used next to the outlet nozzle if high velocities are expected there as well. In this case, the tube removal reduces the area possible in that shell diameter by approximately 6%. So, decreasing the inlet velocity another way would allow replacing the exchanger bundle with one having 6% more area.

Two other methods of inlet velocity reduction are possible: a dome at the inlet; or a vapor belt that circles, or partially circles, the shell to allow vapor into the bundle at multiple locations. Both increase the inlet area open for flow and decrease inlet velocity.

Other methods of inlet velocity reduction are possible.

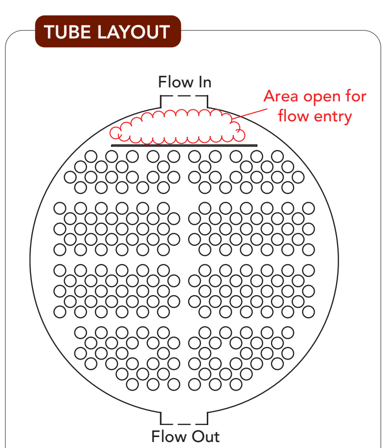

Figure 1. Open area under the inlet nozzle for velocity reduction robs area available for the exchanger bundle.

Here, the plant opted for a vapor belt because it required fewer external piping modifications. Both the vapor belt and the extra tubes added weight to the exchanger. Keeping the weight within the allowable limit required making the tubes and tube sheet of thinner material.

While the modifications may seem extreme for just 6% more duty, the extra feed heat was critical and allowed for more product recovery.

ANDREW SLOLEY, Contributing Editor, ASloley@putman.net

Cloud Dashboard Monitors Equipment in Real Time

The Chesterton Connect Cloud is a web-based dashboard and analytics platform for viewing and analyzing data collected from Chesterton Connect equipment monitoring sensors. The cloud-based software provides 24/7 access to process and operating conditions of pumps or other equipment being monitored to easily recognize and solve issues before emergencies occur. From any remote location, operators can view overall performance, explore variances and trends, add notes, and focus maintenance efforts where needed. The analytics dashboard enables reliability teams to build reports and corrective actions to increase equipment performance and uptime, and easily overlay and compare measurements for up to three sensors.

A.W. Chesterton Company
781-438-7000
www.chesterton.com

Enclosures Suit Outdoor Operations

The KASE compressed air system enclosure units come in several standard configurations, including for two 100-hp, one 250-hp, or three 100-hp rotary screw compressor

units with refrigerated dryers. Other configurations can be designed to meet specific requirements. The units feature a full walk-in design, and are rated for 110-mph wind loads and 50- lb/ft^2 snow load. They include fully insulated, sound dampening paneling, entry doors and removable access panels for major service. Each unit arrives completely assembled with all piping and electrical connections ready to go. The remotely monitored systems mean service providers don't need access to production areas, improving plant safety and security.

Kaeser
877-417-3527
us.kaeser.com

Twin Screw Pumps Handle Low Flow

Designed for process flexibility, these twin screw pumps are built to meet stringent hygienic standards. The models reportedly excel at multi-duty applications, handling both product transfer and cleaning duties. This eliminates the need for a separate cleaning-in-place pump and bypass piping. A front-loading cartridge seal simplifies maintenance and extends process uptime. The new compact, lower-flow pumps reportedly are ideal for low-shear transfer of sensitive, abrasive and high- and low-viscosity fluids with high content of large solids. Their low pulsation characteristics and solids handling capability reduce the risk of product damage, thereby improving product quality, the company notes.

Alfa Laval
866-253-2528
www.alfalaval.com

Surge Dampeners Extend Equipment Life

Integrated SD series (ISD) equalizer surge dampeners are now available in a bolted metal option, which helps minimize vibration and control pipe hammer to protect the system piping and downstream instrumentation. The dampeners are installed at the pump's discharge and engineered to reduce fluid pressure and flow fluctuations for a smoother discharge flow. This protects and extends the life of system equipment, decreases noise and increases the efficiency of Wilden air-operated double-diaphragm pumps. The stainless-steel metal dampeners are available in 25-mm (1-in.), 38-mm (1½-in.) and 51-mm (2-in.) sizes. The bolted-construction design and PTFE, Buna backed, integral piston diaphragms offer maximum process fluid containment.

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wildenpump.com

Software Watches Tanks, Pressure

BinCloud takes inventory in bins, tanks or silos and organizes it in one simple software package. It does away with climbing vessels, manual measurements and spreadsheets. Users log in

to view current levels, place orders and generate reports. New features include PropaneView for checking LNG and NH_3 tanks. The software also monitors pressurized vessels. Integrated ordering lets users create and place orders by site, vendor, vessels, material and amount. Vendors and the materials they provide are set up in the user interface and orders are placed directly from the software. View order history by vendor, material, delivery date and more.

BinMaster
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www.binmaster.com

Steam Trap Checking Gets Easier

Batteryless Eversensors connect to a wireless gateway to deliver predictive maintenance for large-scale steam system applications. The sensors use harvested energy to deliver wireless non-line-of-sight communication up to 250 m (820 ft). With the extended

range and a gateway capacity of 1,000 sensors, plants can check a larger percentage of steam traps with far fewer gateways. An auto-pairing feature and QR code provisioning help users install a single sensor on a steam trap and setup in the cloud in less than five minutes. With real-time insights across an entire steam system, operations and maintenance personnel can address failures as they occur and bank significant energy and CO_2 savings.

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This ⅛ NPT no-drip siphon-fed air atomizing spray nozzles provide

consistent and even flow of non-pressurized liquid for applications like marking, lubricating, rinsing, cooling, quenching, wetting (moistening), dust control and humidification. The nozzles suit situations where no post-spray drip is permissible. The design allows for the absence of liquid pressure. The nozzles use gravity fed liquids or lifted liquids from a siphon height of 36 in. (91cm) and positively stop liquid flow when compressed air is shut off. The nozzles are available in round and flat fan liquid patterns. The volume of liquid flow depends on either the gravity or suction height coupled with air pressure.

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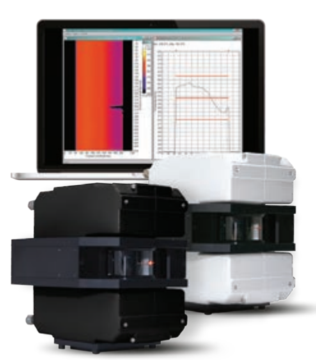
https://exair.co/108-smndsf

Scanner Provides Fast Temperature Readings

The MP Linescanner series delivers continuous, edge-to-edge thermal images and temperature measurements for



high-speed manufacturing processes. The new imagers deliver real-time imaging at scans speeds up to 300 Hz and feature a wide selection of spectral and temperature ranges to accommodate a variety of industrial applications. Rotating optics and a 90° field of view quickly render a 2D image on a PC. Other features include high-quality brushless motor (MTBF 40,000 h), built-in Ethernet TCP/IP communications, and PC independent 4–20-mA interfaces (3 outputs). A rugged, waterproof IP65 enclosure helps withstand industrial environments and air purge keeps the window free of dirt and condensation.

Fluke Process Instruments
800-227-8074
www.flukeprocessinstruments.com/mplinescanner

Transmitter Suits Wide Variety of Gases

The Polytron 6100 EC WL wireless gas-detection transmitter can handle measuring tasks in loading or inspection areas and serves plant expansions, upgrades and new installations. Wireless detection reduces the planning effort required while retaining the same safety levels provided by a wired transmitter, says the company. The SIL2-capable unit covers a spectrum of 140 different hazardous gases in a temperature range of -40°F to 149°F. Industrial wireless standard ISA100.11a ensures safe transmission of measured values. Users can access the transmitter via a Bluetooth interface on an explosion-protected tablet, laptop or desktop PC in the workshop. Transmitter data and the event log can be transferred as a data set and evaluated when necessary.

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Europe Targets 50 Bio-Based Technologies

Report highlights attainable and innovative solutions to emerging challenges

"These bio-based innovations have a high potential to improve EU citizens' quality of life."

A STUDY has identified the top 50 technologies that could drive bio-based innovations in the European Union (EU) forward by 2030.

Called *Life and Biological Sciences and Technologies as Engines for Bio-based Innovation* and funded by the European Commission, the 266-page study looks at four fields: industrial biotechnology, environmental, plant and marine. The report consists of a broad review of existing literature, analysis of first-hand patent data, an EU-wide online survey, stakeholder consultations and three expert workshops.

Dr. Sven Wydra, coordinator of the project and senior researcher at the Fraunhofer Institute for Systems and Innovation Research ISI, Munich, Germany, notes the wide impact possible from investing in life and biological sciences and technologies. "These bio-based innovations have a high potential to improve EU citizens' quality of life and the environment by making industrial production more resource efficient and sustainable, reducing emission of greenhouse gases, recycling plastic and other waste, replacing fossil-based resources with bio-based ones, and providing strategies against emerging diseases," he explains.

Decision-makers in the EU and member states as well as regional policy makers, companies, associations, and research institutions are encouraged to develop tailor-made strategies to address "these great societal challenges."

Each technology includes a description of the innovation needed, an explanation of its importance, and the priority issues it faces.

For example, multi-enzyme bio-catalysis promises one-pot synthesis of complex products. The priority issue identified is the financing needed to encourage more systematic and rational approaches to academic/industrial cooperation.

Another is process modeling. Dynamic, advanced process models can adapt control strategy in real time using feedback loops and, so, contribute to more-consistent product quality and better decision-making by process operators. The study highlights cooperation between industry and academia as a priority issue, citing the need for industry to provide bio-production relevant data to generate accurate models.

Biorefineries adapted to new feedstocks also make the list — in particular, their development and optimization to handle what the study describes as under-exploited, non-food biomass feedstocks such as grass, algae and organic municipal waste. Priorities include substantial R&D, financing for pilot and demonstration facilities and cross-sector cooperation between feedstock-providing and -converting industries.

The study also surveyed novel feedstocks, and using side and waste streams. While it notes there are many valuable carbon-containing components in both municipal and bio-waste, their production, separation and purification remain problematic. Both categories require appropriate regulations to support enhanced value for waste, together with investment in infrastructure and logistics.

Microbial bioconversion of CO_2-based chemicals to industrially relevant ones such as carbon monoxide, methane, and various organic acids and alcohols is another innovation examined. Here, the authors call for interdisciplinary and cross-sector cooperation of CO_2-emitting industries with specialists in industrial biotechnology, electrolysis and green hydrogen production.

The study also reviews dedicated bio-based chemicals, i.e., those that don't have a direct fossil-based equivalent and are produced by a synthetic route. It cites succinic acid and itaconic acid as examples of promising bio-based building blocks and platform chemicals obtained by fermentation. These, say the study, need creation of market opportunities via regulations and standards.

"We must make every possible joint effort to tackle climate change and reduce our environmental footprint. Therefore, we need to make optimal use of the benefits of life and biological sciences and technologies and promote a strategic enabling approach. This study is a very good starting point for developing such a strategy," says Martijn Vis, senior consultant at BTG Biomass Technology Group, Enschede, The Netherlands, who led the study's policy analysis.

"The EU-27 is among the world leaders in innovations for sustainability shifts and a circular and bio-based economy, and shows a strong research base for bio-based innovations in general. At the same time, market conditions still need to be improved to guarantee a successful uptake of bio-based products as valuable alternatives of the fossil-based ones," he adds.

To download the full report, including fact-sheets outlining the top 50 innovations, go to https://bit.ly/2Q6yq8l.

SEÁN OTTEWELL, Editor at Large
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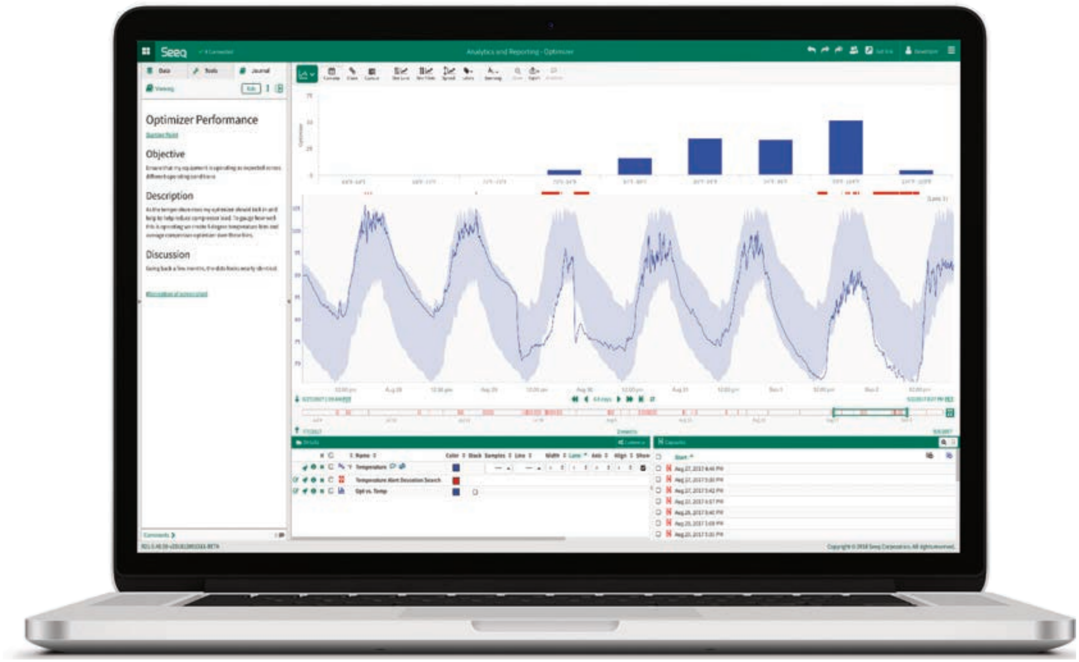
Spreadsheets aren't designed for time series data analytics. Seeq is.



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