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Remote Working Takes Hold

Increased acceptance spurred by the pandemic is leading to a lasting role

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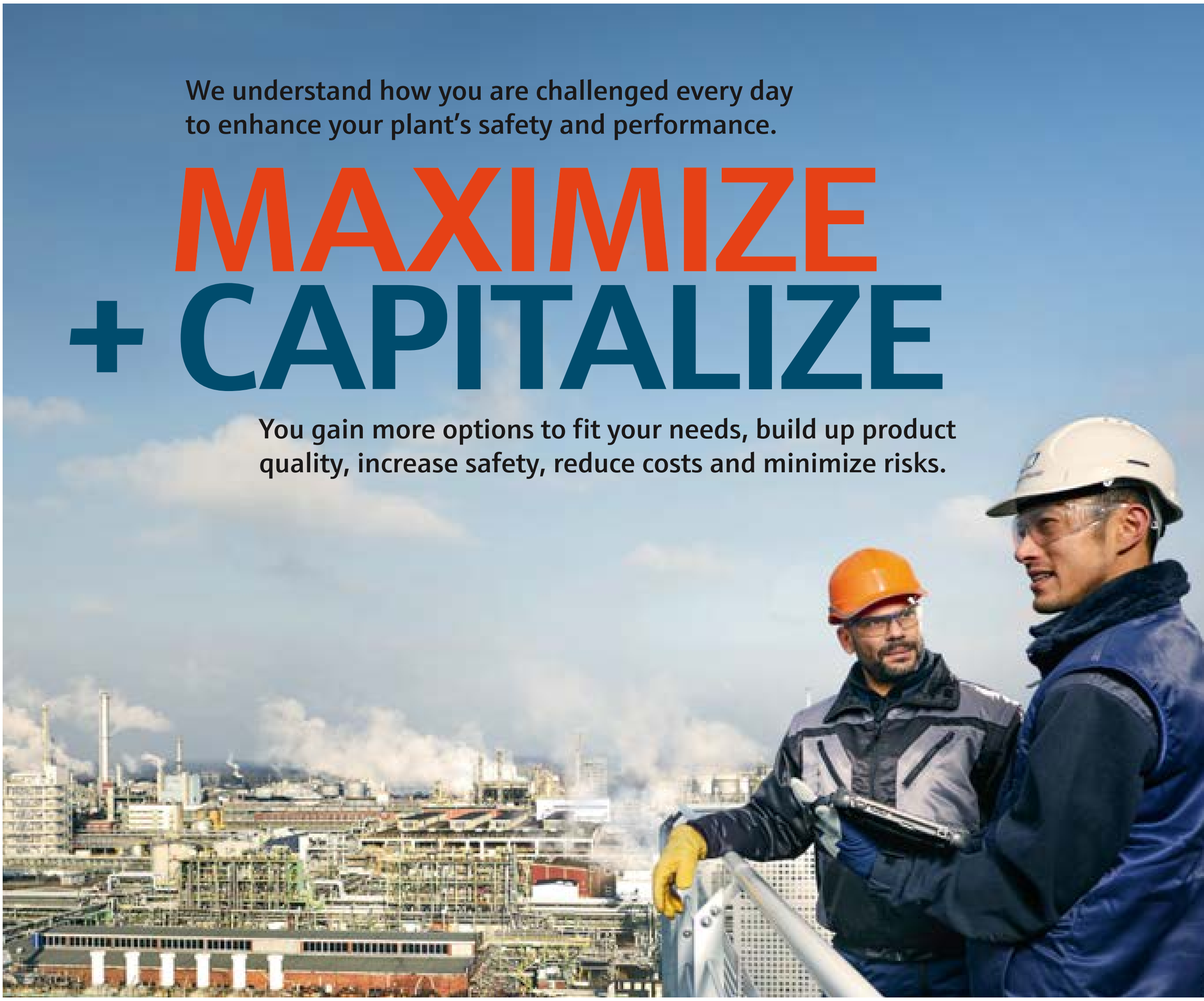

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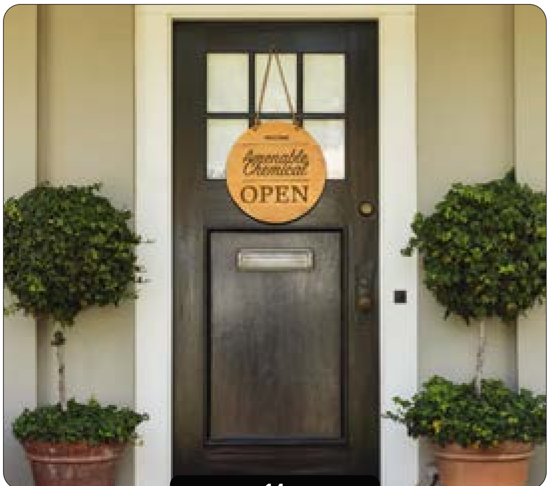

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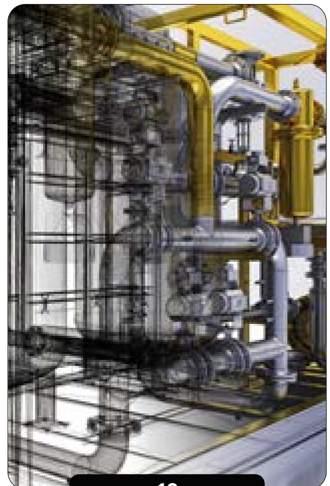

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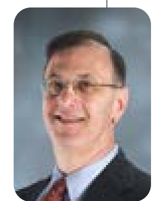
Work From Home Wisely

Take some tips from a veteran of doing a job remotely



I got calls late Friday afternoon to check if I was working.

THIS MONTH marks 19 years I've been working from home! Back in 2003, such an arrangement was rare in publishing as well as elsewhere. As a matter of fact, I can't think of any editor in chief back then who didn't routinely work from the head office.

However, *Chemical Processing* then was based in suburban Chicago (and still is), while I had roots and a house in New York City. The company that published this magazine, Putman Media, was a small family-run outfit that wasn't mired in detailed procedures. Indeed, management prided itself on its lack of rigid policies and ability to be flexible. So, we struck a deal. I would work from home in New York City but regularly visit headquarters. Initially, that meant spending a week each month in Illinois but my trips to headquarters became far less frequent within a few years.

Working from home was much more of a challenge back then. Most input — manuscripts, press releases, photographs, etc. — came on paper via the mail. So, forwarding materials to the editors and production staff at headquarters wasn't a fast or easy process. The Internet wasn't that much help. Perhaps you remember dial-up access and the slow speeds available in 2003! Teleconferences still were relatively rare and videoconferences largely were the stuff of science fiction.

Besides the functional difficulties, my remoteness led some more-suspicious people to check if I was working when I should be. I received more than one telephone call late on a Friday afternoon, supposedly to inquire about something but actually to see if I was there.

Fortunately, working remotely today no longer poses most of these challenges. As our cover story "Remote Working Takes Hold," p. 14, points out, employee preference and the productivity shown by those working from home during the pandemic have spurred some chemical companies to actively encourage remote work.

So, for those of you relatively new to or now contemplating working from home, let me share a few tips. Some of these may seem obvious but they are important.

If you have space, set up a dedicated office or area in which to always work. Ideally, locate it where you can minimize distractions and interruptions from family and pets. Likewise, avoid having a radio or television close by (and refrain from using your computer as a continuous source of background music or news feeds).

Cultivate a set routine. Start work and end work at relatively consistent times. It takes discipline to quit when there are one or two more things you could do fairly quickly. Be warned, after you've done them, you very well might think of a couple more. Likewise, take lunch at about the same time each day, and eat it away from your work area.

Make sure to back up your work to the extent that you can. I have two external drives — a large conventional one for automatic full backups, and a smaller solid-state drive to which I manually back up working files and save updates to other ones I regularly use. For more pointers about backups, see: "Back Up Your Remote Work," https://bit.ly/2yzhpuf.

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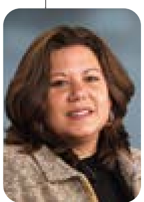
Observe Online Offerings

Our website features a wide variety of web-exclusive material



Our online presence offers complementary resources to the magazine.

CHEMICAL PROCESSING is much more than a magazine. In fact, chemicalprocessing.com houses a great deal of web-exclusive content besides the articles and columns that appear in our monthly publication.

While the backbone of the brand is the magazine that lands on desks every month, our online presence offers complementary resources from our Ask the Experts feature, to Comical Processing cartoons, to podcasts. Here's a glimpse into some of what we offer:

Ask the Experts (https://bit.ly/CP_Experts): We have 29 experts on deck to field questions on anything from combustion to steam and thermal systems.

One category that draws a lot of inputs is mixing, which is moderated by David Dickey, senior consultant for MixTech Inc., Coppell, Texas, which focuses on mixing processes and equipment.

Dickey boasts broad experience in the field of mixing and scale-up; he has had exposure to both the theoretical and practical aspects of real problems. Prior to starting MixTech, he had more than 25 years of experience with process equipment manufacturers. He has built pilot-plant reactors and systems and spent 16 years working directly with manufacturers of liquid mixing equipment. Dave has also engineered dry-solids mixing equipment, static mixers, heat exchangers, pumps, distillation and other process equipment.

The library of questions Dickey and our other 28 experts have addressed is impressive and may prove helpful to others with similar questions.

Comical Processing cartoons (https://bit.ly/CP-Cartoon): Now in its 13th year, our caption contest features cartoons by award-winning artist Jerry King. For the 10-year anniversary, I chatted with King about his career ("Comical Processing Celebrates 10 Years," https://bit.ly/3yULAsM). King shared that a kind teacher realized he didn't have a knack for the electrical engineering coursework he was taking at the time and introduced King to the world of art. "He knew I was struggling but he also knew I was good at drawing. He said, 'Maybe we can get you in a class about art because that's where you belong,'" recalls King.

From there, a career was launched. He's illustrated children's books, worked at numerous greeting card companies, spent 20 years as a cartoonist for *Playboy* magazine and currently creates between 200–300 cartoons per month for myriad publications including ours. He credits the diversity to his longevity in the business.

The Comical Processing Gallery features over 180 cartoons all aimed at the *Chemical Processing* audience. If you need a quick break, check out King's work and the funny captions your peers have submitted.

Podcasts (chemicalprocessing.com/podcasts): We have two podcast series. The first, Process Safety with Trish & Traci, is hosted by yours truly and features Trish Kerin, director of IChemE Safety Centre, as the safety expert. The podcast shares insights from past incidents to help avoid future events. We just wrapped up Episode 34 with a guest, Tony Bocek, a process operator at bp Cherry Point refinery in Blaine, Wash. The topic was a unique process-safety program that empowers operators to become safety champions via two-year programs. Listen to the podcast (https://bit.ly/3P4QKrB) or read his case study, "Refinery Drives Engagement in Process Safety," https://bit.ly/3QhSqz7.

Our other podcast, Distilled Podcast, covers various topics, with new episodes added often, to create a robust library of short, informative material. A subset of Distilled is our sponsored Solutions Spotlight podcasts that offer an industry perspective from vendors in the chemical industry.

Rounding out the major sections of web-only content is industry news (http://bit.ly/2vgZ6po). We focus on news that matters to folks in the chemical industry with coverage on emerging trends, acquisitions, regulations and achievements.

Whether in print or online, our goal is to provide authoritative, practical and impartial technical information as well as details on best practices, key trends, developments and successful applications to help you be as efficient, safe, environmentally friendly and economically competitive as possible. ●

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2022 SALARY SURVEY

Chemical Processing's annual salary survey is awaiting your participation. As a token of our appreciation for completing the survey, you can enter a drawing for a chance to win one of ten $50 Amazon gift cards. (Your privacy is important to us and we only will use this information to contact the winners.) Ready to take the survey — scan the code and begin. https://bit.ly/CPSalary2022

Prevent Dust Explosions During Processing

Many plant operations pose under-appreciated risks

The cause of too many explosions is unknown.

THE PLANT floor at the West Pharmaceuticals facility in Kingston, N.C., was kept spotless to meet hygiene requirements. However, combustible polyethylene dust accumulated in the suspended ceiling. This led to a dust explosion on January 29, 2003, that killed six workers, injured 38, and destroyed the plant. The U.S. Chemical Safety and Hazard Investigation Board (CSB) couldn't identify the ignition source.

As I noted in last month's column "Get Fired Up About Combustible Dust," https://bit.ly/3NAVkfR, the CSB blames dust explosions for numerous fatalities at many plants. That column provided some basic information on what constitutes a combustible dust. Here, we'll get into how to identify the risks of dust fires and explosions.

Many plants face risks of dust explosions. Indeed, according to G. Vijayaraghavan, more than 70% of the powders handled by industry are combustible and a vast majority of plants with powder-processing equipment are susceptible to dust explosions ("Emerging Emergencies Due to Dust Explosions in Process Industry," *J. of Eng. Res. and Studies*, Vol. II, 2011).

Checking material safety data sheets (MSDSs) isn't the way to identify risks. Unfortunately, many MSDSs lack necessary details; the MSDS for polyethylene didn't warn the people at West Pharmaceuticals about possible combustion of dried dust. Indeed, the CSB found that 41% of MSDS forms don't mention risk of combustible dust.

There are many risks to consider and they are highly situational. Studies in the United States show that 42% of explosions occur in dust collection systems; 9% in grinding and pulverizing; 9% in conveyors (e.g., screw conveyors); 7% in silos; 6% in dryers and ovens; less than 3% in mixing operations; and a stunning 23% from unknown sources. Oddly, however, these percentages differ markedly in other countries: the U.K. reports only 18% of explosions arise in dust collection while Germany cites 17%. Still, dust collection appears to be one of the most dangerous activities in handling powders.

I am surprised by the lower risk in grinding and drying. These activities seem to epitomize high risk; they can be deadly — an engineer I knew died during a fire at an ammonium perchlorate grinding facility in Nevada. My pet theory is that because these processes are extremely dangerous, companies and workers are especially cautious in their operation.

Identifying the actual causes of explosions instead of taking the easy way out by simply labeling them "unknown" clearly demands far greater emphasis. Of course, pinning down the culprit can be hard. Sometimes several factors that weren't adequately considered conspire to cause an explosion.

Let's consider what triggers a primary dust explosion. According to one study: 11% stem from welding/cutting; 9% from friction; 8% from fire; 5% from static electricity; 4% from an electrical short; and 3% from lightning. "Unknown" accounts for a whopping 60%. Obviously, there's more work to be done here!

One thing you won't find discussed much is how particle properties affect risks in handling dust and particles. The National Fire Protection Association, Quincy, Mass., has established >420 μ as a relatively safe powder diameter; read the fine print — test. Also, it notes that generally $>{}^{1}/_{32}$nd of an inch of dust over more than 5% of room area poses a combustion risk.

The real risk is particle distribution: more than 10% fines is enough to ignite the rest. When I was doing research on rockets in the U.S. Air Force, we studied the relationship among fine, medium and coarse oxidizers, like ammonium perchlorate. There is an optimum balance of sizes needed to promote combustion. So, in this case, our safety analysis didn't focus on the mean particle size or shape but instead on the weighted average distribution.

Another factor is friability, i.e., can coarse particles be ground easily into fine ones. Then, there is shape, defined by aspect ratio (small diameter/large diameter); long particles rub together and stick, so they don't flow well — making them move creates friction and breaks them up into fine particles.

Surface porosity is important. If a powder is hydroscopic, water can get in pores and dissolve material that may recrystallize somewhere else, perhaps in a much finer, lethal form. Porosity poses another risk: a powder may absorb a flammable vapor creating a hybrid hazard that is far more dangerous than either the vapor or solid alone. ●

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Milder Method Makes Ethylene

New photocatalytic process offers several important advantages

CONVERTING ACETELYNE into ethylene, a key ingredient in plastics, typically requires high temperatures and pressures, flammable hydrogen and expensive metals. Now, chemists at Northwestern University, Evanston, Ill., have developed an environmentally friendly process that uses only water and visible light. The photosynthesis-like method also performs extremely well — converting 99% of acetylene into ethylene; current industrial process results in 90% selectivity.

"This is important because it's a commodity chemical with high economic value," notes Northwestern's Luka Đorđević, a postdoctoral fellow and co-first author of a study published in *Nature Chemistry*. "The more you can produce without waste, the better."

To convert acetylene to ethylene, the chemists replaced the traditional palladium catalyst with cobalt, a less-expensive, more-abundant alternative. They ran the reaction at room temperature and ambient pressure. In place of heat, they used visible light, and plain water instead of hydrogen became a source for protons (Figure 1).

The researchers also discovered the system can convert propyne to propylene with extremely high selectivity. "For now, we do not expect to explore this further as we would rather focus on optimizing the acetylene reduction conditions and overcome some issues."

Those issues include high selectivity that decreases slightly after about 24 hours of illumination because of degradation of the catalyst and its $[Ru(bpy)_3]^{2+}$ sensitizer.

PHOTOSYNTHESIS-LIKE PROCESS

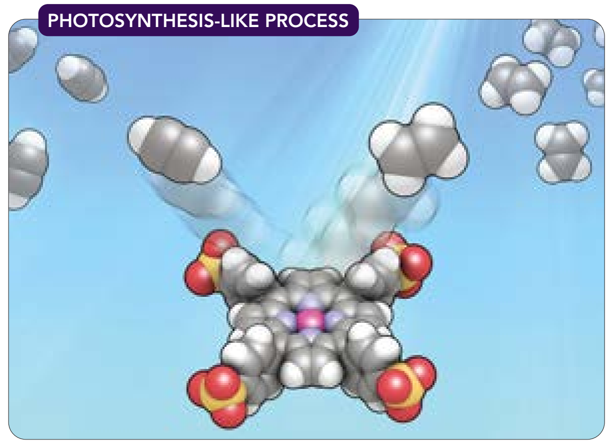


Figure 1. Catalysis driven by light and water produces polymer-grade ethylene. *Source: Northwestern University.*

"$[Ru(bpy)_3]^{2+}$ is certainly not ideal," acknowledges Francesca Arcudi, a postdoctoral researcher at Northwestern and co-first author of the study, "it is known to have the issue of photodegradation. Because we were set on developing the new photochemical acetylene to ethylene reaction, we decided to use a known cobalt complex and a benchmark photosensitizer such as $[Ru(bpy)_3]^{2+}$. Therefore, there remains a very large space to be explored with known cobalt catalysts and (in)organic, photostable, photosensitizers."

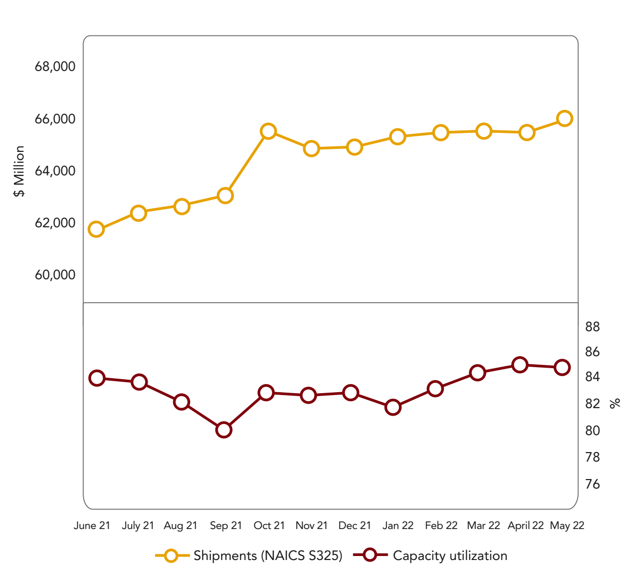
"We believe the degradation issue, as well as the efficiency of the reaction, will greatly benefit by exploring new catalyst/photosensitizer couples. In particular, one avenue that could be worth exploring is the use of semiconductor photosensitizers such as the metal-free organic semiconductor carbon nitride that we also report in our study (although in our reaction conditions it did not perform as well as $[Ru(bpy)_3]^{2+}$)," adds Đorđević.

Expanding on the catalyst/sensitizer systems also would allow the team to have a recyclable catalyst or a photosensitizer that can take advantage of a wider portion of the visible spectrum, they believe. "Another important aspect to consider in future work is to eliminate the need of a sacrificial donor, for example with the development of a photoelectrochemical cell," they add.

"Another avenue worth pursuing would be devising systems with better acetylene solubility: acetylene is poorly soluble in water and we believe the reaction would be faster in other organic solvents, possibly preventing photodegradation pathways at longer irradiation times," explains Arcudi.

Photodegradation also poses a challenge for scaling up the catalytic system. "The photodegradation is certainly

ECONOMIC SNAPSHOT



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

not helpful for implementing the system on a larger scale. Even scaling up the system will suffer from the same drawback," admits Arcudi. "But we are confident that the right catalyst/photosensitizer couple, in the right reaction conditions, will also allow the system to be implemented on a larger scale," adds Đorđević.

"This work opens up novel and exciting developments by addressing issues of safety and sustainability of state-of-the-art industrial hydrogenation reaction; we therefore hope that next steps focused on scaling up our photochemical strategies will bring these kinds of technologies [to] chemical plants in the near future," they conclude.

Iron Catalyst Creates Carbon-Carbon Bonds

RESEARCHERS IN Japan have discovered an iron-based catalyst suitable for the industrially important olefin metathesis reaction that is used to produce new carbon-carbon double bonds by swapping carbon atoms.

A transalkylidenation reaction, olefin metathesis first was used in petroleum reformation for the synthesis of higher olefins; today, fine and commodity chemicals manufacturers widely use it for carbon-carbon bond formation.

With its desirable economic and biocompatible qualities, the iron-based catalyst is seen as a potential replacement for expensive transition metals such as ruthenium (Ru) currently used by industry.

Up to now, however, its use has posed numerous problems.

In a recent article in *Nature Catalysis*, researchers based at the Okinawa Institute of Science and Technology Graduate University (OIST), Okinawa, Japan, report the discovery of and mechanistic studies into a three-coordinate iron (II) catalyst for the ring-opening metathesis polymerization of olefins.

The catalyst's reactivity enabled the formation of polynorbornene (Figure 2) with stereoregularity and high molecular weight (>107 g/mol), a result described as remarkable by OIST researcher Satoshi Takebayashi. However, the iron catalyst is unstable and less active when exposed to air and moisture than its Ru-based counterparts.

"Our mechanistic study showed that we need three coordinate iron (II) complex, and this low coordination number and oxidation state of (II) make it very reactive towards oxygen and water. I think if we can make a catalyst with a higher coordination number and/or Fe (III), it will have more tolerance to both," he explains.

One answer to the air and moisture stability issues could be using a new technique that embeds catalysts formulated as pellets in paraffin tablets, Takebayashi notes.

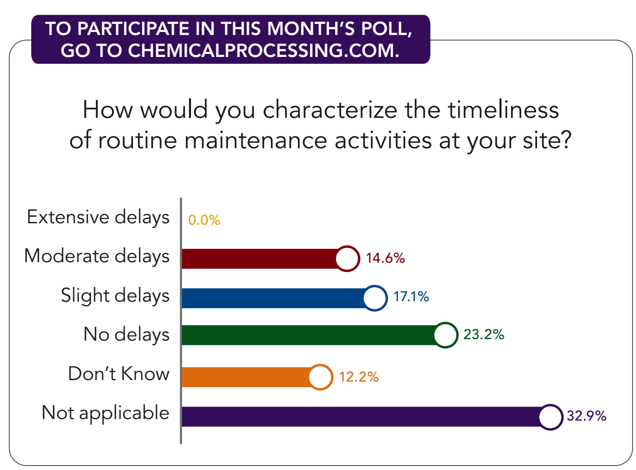
Any potential scale up of the reaction — currently carried out in a 20-ml vial — would require a cheaper ligand because the current catalyst loading, now a minimum of 0.5%, is too high, he cautions.

Takebayashi points out that other research groups also are looking to use first-row transition metals such as vanadium rather than the second- and third-row metals normally relied on for catalytic olefin-metathesis reactions.

Figure 2. The amount of the white solid polynorborene produced varied with catalyst loading. *Source: OIST.*

"This study can be useful to other researchers in the field. I hope that iron-based catalysts can be developed further using this knowledge," he says.

Meanwhile, the next step for the OIST researchers is not to refine their new iron catalyst but rather to develop a catalyst with other base metals to replace Ru.



Maintenance work is taking place in a reasonably timely manner, say most respondents.

Beware of Energy Efficiency Lifecycles

Sustained energy efficiency programs help prevent loss of cost-saving methods

Over time and with reduced scrutiny, efficiencies decline, and relative costs go up.

IN 2016, I took a job in Saudi Arabia. The reason for going was simple: my industrial energy efficiency consulting business in the United States had dried up. No one was interested. Natural gas prices were at historic lows. U.S. refiners and chemical manufacturers had much more to gain focusing on other opportunities. The Saudis, on the other hand, had recognized exporting their hydrocarbons was better than burning them in-country. That gave me the opportunity to turn a painful business failure into a fascinating three-year stint in the Middle East.

My experience in 2016 is an example of a cycle that has been going on for decades. Attention to energy efficiency rises and falls in corporate priority with the rise and fall of energy prices as well as manufacturing margins. The lives of corporate energy managers and energy-efficiency consultants track those corporate priorities. If energy costs are high and margins are slim, you are the man or woman of the hour, but if times are good and natural gas supplies are booming, no one will return your calls. Bad times and poor prospects for capital spending create a need for new ideas from external consultants, and free up lots of personnel to look for opportunities for more-efficient operations. When times are better, companies reallocate those human resources and consulting dollars to opportunities with higher expected returns.

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Check out previous Energy Saver columns online at www.ChemicalProcessing.com/voices/energy-saver/.

A well-thought-out energy management program can mitigate this on/off prioritization. A good program identifies opportunities, sets the bar for ongoing performance, and maintains improvements with minimal resources. Otherwise, over time and with reduced scrutiny, efficiencies decline, and relative costs go up. A few years later, the cycle repeats itself and a new team re-learns all the lessons from the last cycle.

My coauthor Beth Jones tells an interesting story that illustrates this phenomenon: Several years ago, a technician received the company's highest "attaboy" award from its then-president. His achievement: tuning all the company's huge olefins furnaces and saving millions of dollars per year in energy costs. The president's comment: "Great job rediscovering what we already knew! Next time, maybe we'll just punish the people who stopped doing it." The technician took the comment to heart and wrote a "Furnace Manifesto" to preserve and institutionalize the knowledge. (See: Alan P. Rossiter and Beth P. Jones, "Energy Management and Efficiency for the Process Industries," pp. 3–24, Wiley-AIChE, 2015.)

Energy efficiency increasingly is being integrated into the drive for decarbonization, which is part of an even larger ESG (environment, social and governance) movement in the process industries, and across industry in general ("Drive Energy Efficiency with Decarbonization," July 2021, https://bit.ly/35YKCwk). Some evidence exists that this integration has reduced the focus on energy efficiency, rather than increasing it, and contributed to a slowing of improvements in energy intensity in the process industries. Why might this be?

Sustained improvements in energy intensity historically have been relatively slow — 2–3% per year, at best. Other strategies can achieve greater decarbonization much more rapidly with lower capital investment and less effort on the part of refiners and chemical companies. Renewable energy credits (RECs) are a good example. These are certificates that represent the clean energy attributes of renewable electricity. The electric grid transports electricity produced from both renewable and non-renewable energy sources. When "Company A" buys RECs together with electricity from the grid, the "renewable" aspects of the electricity transfer to Company A. This happens without Company A having to install any renewable energy systems at its facilities; it creates a compelling case for companies under pressure to reduce their carbon footprint quickly, overshadowing the undeniable benefits of energy efficiency.

Despite this, it is clear we must stay focused on energy efficiency in plant operations to prevent backsliding, as the "Furnace Manifesto" story illustrates. There is also a compelling case for increased energy efficiency in all new plant designs, as efficiency is cheaper and easier to build in from the start than to implement as an afterthought.

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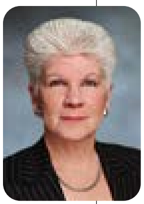
EPA Seeks Input from Small Businesses

Participation could drive development of a proposed TSCA data reporting rule



Chemical information is mission critical for the EPA.

THE U.S. Environmental Protection Agency (EPA) invited on July 6, 2022, small businesses to participate as Small Entity Representatives (SER) for a Small Business Advocacy Review (SBAR) panel. The EPA seeks self-nominations directly from entities that may be subject to the rule requirements; self-nominations were due July 20, 2022. The panel focuses on the agency's proposed rule to collect data to inform each step of the Toxic Substances Control Act (TSCA) risk evaluation and risk management process. Participating in the SBAR, or at least tracking its activities and engaging as much as possible, is encouraged. The reasons for engagement are discussed below.

BACKGROUND

Chemical information is mission critical for the EPA. Data-gathering provisions, however, must be carefully calibrated to elicit useful information and not unnecessarily burden small businesses. This balance is tricky, given the growing complexity of chemical regulation, EPA's enhanced authority under TSCA, and its requirement to complete risk evaluations to establish risk management controls.

The proposed rule would create a framework of reporting requirements based on a chemical's status in the TSCA Section 6 risk evaluation/risk management lifecycle. The new data reporting rule also would enhance the exposure-related data collected through the TSCA Chemical Data Reporting (CDR) process. According to the EPA, collecting data geared specifically toward prioritization, risk evaluation, and risk management would help ensure it has relevant and timely data to inform each step of the process for reviewing potential risks from existing chemicals.

The data reporting rule, including changes to CDR, is tiered to specific stages of the TSCA Section 6 existing chemicals program and covers:

- Identifying a pre-prioritization pool of substances as potential candidates for prioritization;
- Selecting candidate chemicals and completing the prioritization process; and
- Assessing high-priority substances through a robust risk evaluation that may be followed by risk management actions (depending on the outcome of the risk evaluation).

According to the EPA, tying specific reporting requirements to the activities that make use of reported data also will reduce the burden related to data collection efforts while ensuring the EPA has the information needed for its risk evaluations. The proposed rule will help to obtain information about potential hazards and exposure pathways related to certain chemicals, particularly occupational, environmental, and consumer exposure information. TSCA Sections 8(a) and 8(d) authorize the EPA to require:

- Manufacturers and processors to provide known or reasonably ascertainable information, including chemical identity, production volumes, uses, byproducts and worker exposure; and
- Manufacturers, processors, and distributors to submit health and safety information.

The EPA states the potentially regulated community consists of entities that manufacture, import, or process chemical substances, including when the chemical substance is manufactured as a byproduct or is part of a formulated product or article (including import and processing). This collection activity will affect manufacturing sectors, including chemical manufacturing; petroleum and coal product manufacturing; chemical, petroleum, and merchant wholesalers; paper, plastics, paint, and printing ink manufacturing; electronic product and component manufacturing; or other activities, including utilities and construction.

The panel will include federal representatives from the Small Business Administration, the Office of Management and Budget, and the EPA. Panel members will ask a selected group of SERs to provide advice and recommendations on behalf of their companies, levels of government, or organizations to inform them about the potential impacts of the proposed rule on small entities.

DISCUSSION

The ongoing TSCA Section 6 risk evaluations significantly impact stakeholders in the industrial chemical community. The risk evaluations and subsequent risk management results will make or break the chemical substances being reviewed. The EPA is required by law to assess the chemical, its attributes, conditions of use, and potential for human health and environmental exposure. CDR information will be a critical component of the analysis. Stakeholders are urged to work closely with the EPA to ensure the correct information is submitted and that small business entities' interests are well served.

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Heat-Transfer Tech Cuts Costs, Promotes Productivity

Seek expert advice to stay on top of evolving technology.

GREGORY C. BECHERER, senior vice president, CG Thermal.

We try to help our customers avoid common and uncommon mistakes.

FLUIDS IN a chemical process often must undergo either a temperature or phase change — via either heating or cooling — to bring them to a temperature that enables an operation to occur at its optimum point from an efficiency or safety standpoint. Properly selecting, designing, deploying and operating the equipment that heats or cools the fluids are crucial.

For corrosion-resistant heat-transfer materials in harsh and high-temperature processes, there are additional requirements to consider. To help explain existing and emerging technologies to meet specific process and plant conditions, Chemical Processing spoke with Gregory C. Becherer, senior vice president of Twinsburg, Ohio-based CG Thermal.

Q: *What are your areas of expertise?*

A: Our design teams include mechanical and chemical engineers with expertise in specialized heat and mass transfer systems and design. Originally, we focused solely on ceramic and graphite heat exchangers (the CG in CG Thermal). The industries where we can be found include chloro-alkali, vinyl chloride monomer, fertilizers, titanium dioxide, ethylene dichloride, color additives, specialty chemicals, herbicides and pesticides. Our newer markets include high temperature gas recuperation for syngas and carbon-dioxide capture and other green energy technologies, including heat recovery, energy storage and incineration.

We are a good resource for bigger companies but we really like working with medium-sized to smaller-sized companies that have limited engineering resources. We support their engineering team.

Q: You mention both corrosive environments and high temperature environments. Is there ever an overlap between the two?

A: Historically, the simultaneous need for high temperature resistance and corrosion resistance are not typical. The chemical plants built back in the 60s did not have the materials we have today. They had to limit temperatures in order to stay within the working range of what was available. Most of the corrosive chemical processes are below 200°C. However, in the newer emerging markets, corrosion at high temperature is a real consideration. In these high applications, mechanisms such as metal dusting and cold-end corrosion need to be considered.

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The other problem you get with high-temperature applications is a lot of expansion and contraction. When the unit bundle grows because of the temperature, it is important that the tubes expand at the same rate in order to avoid stress failures at the tube joints.

Q: What about maintenance?

A: This is a very important design aspect. In general, it is important to address access for any heat exchanger or process component that is susceptible to fouling, to allow for inspection and cleaning.

Some fouling can be avoided by proper equipment design. It was very typical for high-temperature applications to replace the heat exchanger every five to seven years. And it was very common to clean these units out once a year. But with advanced design concepts and modeling tools (FEA, CFD), units can be designed for 20-year operating life with infrequent downtime for cleaning.

Can you eliminate fouling? In many applications, it cannot be avoided because of process fluid composition and process parameters. But you can definitely reduce maintenance from a yearly cleanout to a 5- or 10-year cleanout cycle, reducing it to the point where it should no longer be problematic. The key is to design a heat exchanger that's user friendly — one that you can easily get inside of without disturbing a lot of components, take the ends off, clean it, put it back together in three hours. It's ignorant if you don't design for some type of easy access to clean it. I can't tell you how many times we have looked at existing towers and we can't understand why they don't have two, six-inch clean out holes here. Why don't they have a manway there?

Q: What are the materials of choice for acid processing and when would you recommend one over the other?

A: Hydrochloric acid is the reason graphite process equipment was introduced. You're not using graphite, you're using impervious graphite. The graphite substrate is porous by nature. We introduce a phenolic resin into the graphite to make it non-porous so you can use it as a heat-transfer material. Impregnated Graphite was invented in the 1960s. Up until the late 70s, early 80s, graphite was really your only choice for hydrochloric acid and sulfuric acid at lower concentrations. But beginning in the 80s, mill technology advanced leading to the introduction of nickel alloys, and the mills learning how to make them economically. So, nickel-alloy metal materials became the common choice for lower concentrations of sulfuric acid. However, for concentrations above 25%, either impervious graphite or silicon carbide (SIC) are required. But when you talk about hydrochloric acid, graphite is still the only way to go. So that's what I would recommend there.

Now there is a new kid in town — a graphite material that is bonded with a PPS material. We've been doing all kinds of corrosion testing and this is my recommendation for hydrochloric and sulfuric acid. It's cost effective — about one-third of other materials. Its smooth surface reduces the propensity to foul, and it is easy to clean.

As for high-temperature applications, the recommendation is stainless steel and other high-nickel alloys. One really needs to be well versed on those materials in high temperature environments in order to make the proper material choice

Q: Is there ever a disconnect with what customers think they need and what you know they need?

A: We try to help our customers avoid common and uncommon mistakes. We take ownership, listening very carefully and making sure we understand. An example: We're working on an abatement issue for a sulfuric acid plant in Columbia. When the customer first came to us, they wanted to put an exchanger between two of their catalyst beds. They thought that was the best way to reduce the temperature and the pressure in order to reduce the sulfur-dioxide emissions. After discussing, we suggested adding one smaller, additional catalyst bed, moving the exchangers past the main operation and using air-cooled and air-heated heat exchangers to treat the gas and put it into the other bed. We took them from an $800,000 project to two heat exchangers with a total price of under about $185,000. We are very firm believers in bringing in the best technology.

On the flip side, we've suggested an upgrade to our ceramic heat exchanger. In this case it is more expensive than graphite but it has a lifetime guarantee against corrosion and erosion. Customers have recognized the benefit and have been switching over. And the reason we do that is because if we don't bring the best technology, somebody else will. We want that heat exchanger we're selling you to last 15 years.

TURNKEY HCL CONDENSER AND SCRUBBER SYSTEM

Designed to condense HCl entrained vapor for a soil remediation project in Sweden.

Q: What about high-temperature applications and the maximum temperature limits?

A: The highest that we have looked at to date is about 2,400°F. It is really not the maximum process temperature we are concerned with. It is the tube-wall mean metal temperature. We use computer simulation including computational fluid dynamics and finite element analysis to determine mean metal temperatures so we know what the maximum allowable stress of the materials will be, and design accordingly. This can then be ASME SEC VIII Div 1 certified.

Q: What happens if temperatures go higher?

A: When you're putting in a new piece of equipment, you perform a HAZOP and we are involved with that. We will sit in with you and go over the scenarios. We help you decide what type of safety mechanisms you need to put in. For example, if we're designing for a 1,200°F maximum tube wall temperature and you have a 2,400°F process stream in the tubes, you must be sure to always have the cold fluid on the shell prior to introducing the hot stream. So you need to make sure there is an interlock to insure that the 2,400°F stream does not see the heat exchanger unless the other cold stream is actually flowing. You have to design in safety and redundancy so that if there is a failure, it will fail safely.

Q: Do you have anything you'd like to add?

A: We specialize is mass and heat transfer of harsh and corrosive process streams, and have gained a lot of expertise from operational expertise over the years. But technologies are continuously changing and evolving. When we need additional resources to tackle these challenges, we are not afraid to seek out others with the required expertise and learn new tricks.

For more information, visit: www.cgthermal.com.

Remote Working Takes Hold

Increased acceptance spurred by the pandemic is leading to a lasting role

By Seán Ottewell, Editor at Large

MORE THAN half of the respondents to a recent *CP* online poll (https://bit.ly/3P0qA9C) indicate they want to do their jobs from home at least half the work week. While the pandemic has prompted companies to allow, if not foster, remote working, prospects for continuing such flexibility longer term seem strong. Companies in the chemical industry are taking note of employee desires as well as the productivity provided by remote working. For example, Evonik, Chemours, and BASF are refining and expanding hybrid working initiatives established during COVID-19 lockdowns, and building upon the benefits such schemes bring.

CATALYZING CHANGE

Evonik, Essen, Germany, prides itself on having a family-friendly human resources policy that is geared to different phases in employees' lives.

"More than 95% of our employees worldwide have access to respective initiatives. Flexible worktime models are an essential part of this approach. However, before the pandemic, homeworking in the traditional sense was used only sporadically and in consultation with the respective supervisors," says Thomas Wessel, chief human resources officer and labor relations director of Evonik Industries. "COVID-19 has had a profound effect on this thinking and acted as a massive catalyst for using home offices and mobile and flexible working," he adds.

In North America, for example, most of the company's employees work in production. Before COVID-19, the majority were expected to do their jobs at an Evonik location. For the most part, only people in sales had fully mobile positions.

Since then, Evonik has increased use of mobile working and home offices for administrative employees, quickly setting up the information technology [IT] conditions to make that possible.

"We thinned out shifts for production employees in the plants and created reserve shifts. At times, more than 16,000 of our approximately 33,000 employees worldwide worked on a mobile basis — not all from a home office, but still mobile," notes Wessel.

The company encouraged mobile working for all employees for which that was a viable option, including those in technical departments. This applied to engineers, chemists, chemical laboratory technicians and mechanics.

"By mid-2020, we realized that a 'new normal' was developing, and there was little performance or productivity loss associated with remote working. In an internal survey, 85% of managers agreed that the productivity level of their employees is the same or better using virtual collaboration," he explains.

MODERNIZING MONITORING

Figure 1. Company expects digitalization to reduce the need for workers to physically visit equipment. *Source: Evonik Industries.*

Figure 2. Staff at Ludwigshafen are developing on-site and mobile working models. *Source: BASF.*

Many teams, managers and employees had more flexibility, a better work-life balance, and more time without commuting. The company saved on travel and office costs. In addition, hybrid working allowed for the introduction of new, modern office-space concepts.

"Negative aspects, however, included a lack of social interactions and challenges in implementing some processes and workflows virtually," cautions Wessel.

TAILORING THE APPROACH

Besides strongly spurring use of home offices and mobile and flexible working, the lockdowns accelerated development of a modern way to collaborate that better meets the requirements of multinational teams spread across myriad time zones or locations.

A global survey of more than 2,000 Evonik staff in early October 2020 resulted in a global framework for hybrid working called #SmartWork.

This aims to optimize and institutionalize virtual collaboration to benefit both employees and the company. It includes a mix of physical presence and remote access that is tailored for each individual and that balances the specific needs of disparate workplaces. It is well adapted to the different experiences and ways of working in all regions, believes the company.

"We are a specialty chemicals company. We have production. We have laboratories. We have research and development. We have administration. 33,000 employees are spread across 170 sites in over 100 countries worldwide. This requires a basically uniform but flexible approach that works worldwide, rather than a rigid program," stresses Wessel.

In the United States and Canada, Evonik began the rollout and implementation phase of #SmartWork in the summer of 2021. Managers evaluate productivity, effectiveness and efficiency, and regularly look at employee satisfaction, commitment and engagement in connection with the flexible working models used.

"#SmartWork in North America is about more than just where you work. It involves a genuine shift in mindset about how we will work and interact in the future," he notes. So, mobile working is linked to individual job profiles. Managers are asked to examine job profiles and create alternative flexibility options wherever possible.

For on-site personnel, this could include flexible shift models, influence on upcoming shift schedules, shift swaps, job sharing, and home days for administrative tasks.

Depending on the job profile, process engineers at Evonik can work "regular" (<40% remote) or "alternating on-site" (>60% remote) hours. They often can perform planning and calculation tasks from home.

Meanwhile, the company is testing new digital options in plant control such as remote control and improvements in plant monitoring to make work easier and more flexible. It expects digitalization to significantly reduce the need for workers to check equipment in the field (Figure 1).

"At Evonik, entire units are working on digitizing plants, enabling remote control/wireless technology and remote maintenance. The potential is great, and much can be achieved technically through automation and sensor technology," Wessel concludes.

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OVERCOMING INITIAL HESITANCY

Chemours, Wilmington, Del., introduced its "flex for your day" initiative for office employees in 2019 on the premise that employees should be able to work wherever and whenever it makes the most sense. Since the Wilmington office reopened without restrictions on April 4th, "flex for your day" remains the guiding principle.

"The 'flex for your day' initiative, and our overall commitment to be policy-light regarding how and when our people come to work stem from our principles of fostering autonomy and choice at Chemours. We trust our employees to make choices that work best for them, and which enable them to be their best and most productive selves when, where and how they are working," says chief people officer Susan Kelliher.

The same thinking applied in the company's approach to managing COVID-19, she adds; protocols regarding masks, social distancing and health checks are based on local threat levels.

"We empowered people to do what they felt was best for their personal health and safety. That relationship of mutual trust is extremely important to us and what has driven our flexible approach to reopening and managing our workforce without the boundaries of strict policy dictating their decisions," notes Kelliher.

COVID-19 has played a major role in how the company's flexible strategy has evolved.

The launch of "flex for your day" prompted some concerns about how effective people would be in a remote environment, admits Kelliher. However, the experiences during and since COVID-19 lockdowns showed that team members found value in remote work. This has softened fears around lost productivity or lack of connectedness with fellow workers, she stresses.

"Once we announced the opening of our Wilmington office building, we realized our people wanted to maintain the ability to choose their environment and schedule, whether in the office or at home. Our guidelines are simply that people do what works best for them," she adds.

"In functional groups like finance and procurement, for example, many of those jobs are not on the clock, allowing teams to base their schedule around the timing that works best for them. On the manufacturing floor and in our labs, we are looking at other options such as part-time work and job sharing, if that's what our teams need to make their jobs work for them. We feel strongly that schedule flexibility should exist for everyone," Kelliher emphasizes.

Even so, after the uncertainty brought about by COVID-19, employees came back to work with many questions about hybrid working, not least about what it really meant and what Chemours' expectations were.

"Interestingly, many were concerned about whether Chemours was genuine about 'flex for your day,' or if we would actually enforce a certain quota for time spent in-office. We realized that we needed to reinforce that we are a company founded on trust. We learned we needed to have more informal and very open dialogue with employees than we thought we needed to. 'Fireside chats' are now regular touchpoints for our employees to ask me and my team questions and for us to listen to the needs of our people," explains Kelliher.

As a result of this dialogue, the company has taken steps to increase the quality of and access to physical and mental health resources for all employees. For example, Chemours recently upgraded its care provision so that both physical and mental health services are managed through one group, which lowers the hurdles for employees to access the care they need and provides better comprehensive management of care.

Other actions include access to qualified childcare and online ergonomic assessments by the company's occupational health team to ensure staff have the right equipment to work in a safe and healthy way. The company offers a home office stipend to offset set-up costs, too.

FORGING A FLEXIBLE MODEL

Meanwhile, BASF, Ludwigshafen, Germany, is developing a hybrid work model that allows employees to choose between in-person meetings and virtually connecting with their co-workers.

Based at the company's Ludwigshafen headquarters, the Flex Work @ LU project focuses on the shift toward greater flexibility as well as practical answers on how to maintain and strengthen connectedness in an increasingly hybrid working environment. It includes everything from new office concepts to IT technologies and tips for teamwork.

"The Flex Work @ LU project has created a digital toolbox with comprehensive answers to all these questions and is available online for everyone," says a spokeswoman. "From team charters to desk-sharing concepts and the Flexikon reference book, the intranet now has numerous practical solutions," she notes.

Designed to be a helpful and practical source of information, the toolbox can be used by employees, teams and units to implement the entire flexible working process — from an initial cautious approach, up to analyzing eventual success.

"The project team will continue to consult and accompany teams while, at the same time, our comprehensive toolbox is also a self-service portal which everyone can access. In addition, units who share a desk can now use a booking tool for workspaces," explains the spokeswoman.

The toolbox has four main sections.

The first is a consulting option that offers advice on how different units within the company can optimize flexible working for their own situations. Point people on the Flex Work @ LU project team help find the right approach for each team. Recordings of training courses show how to structure workshops. The Flexikon reference book contains an A-to-Z of key points on the topic of flexible working.

Next, there are specific workshop concepts designed to strengthen users' understanding of flex working generally, how to identify the right working model for a team, and then how to develop its own charter.

Another section covers how the "new office" works, with a step-by-step guide to the concept of desk sharing, plus details of different furnishing options and guidelines on BASF's booking system.

Finally, specific templates allow employees to give feedback on their flex work experiences. "Employee opinion is decisive for the acceptance of new working models," stresses the spokeswoman.

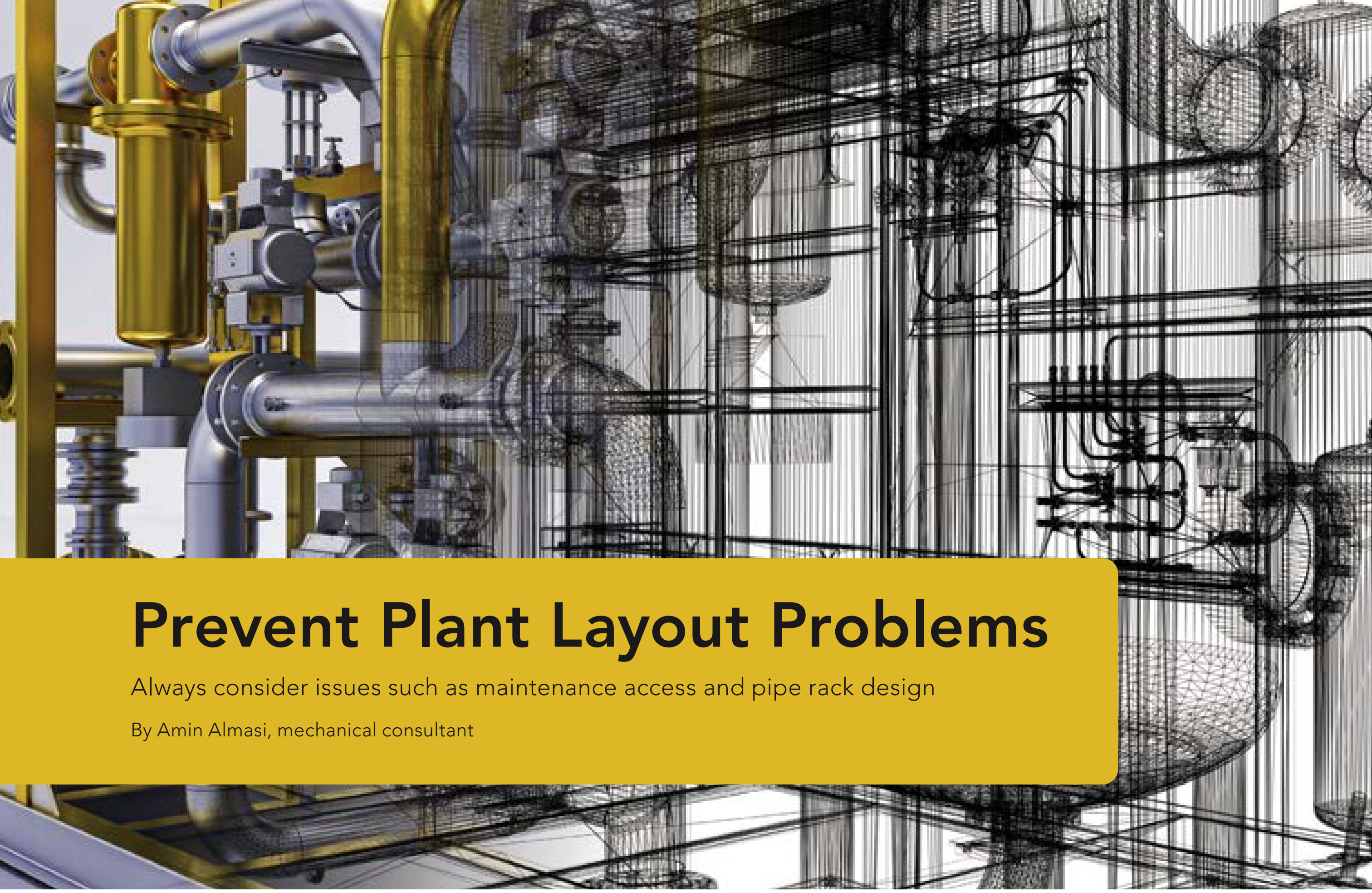
At the same time, however, flexible working models do differ from job to job within the company. "At the moment, our pilot teams at Flex Work @ LU project are still in a transitional period due to the COVID-19 situation, but we are sure that the switch between working on-site and mobile working will work well," she adds.

Although developed and piloted at Ludwigshafen (Figure 2), BASF is applying the Flex Work @ LU guidelines globally to all employees and teams who want to and can work flexibly.

On a broader level, members of many major German companies — including two senior representatives from BASF — have been involved with a report published by the Human Resources Working Group of the German National Academy of Science and Engineering. "From a Presence Culture to a Culture of Trust — Seven Theses on Mobile and Hybrid Working" proposes seven ideas on how digital transformation can serve to promote productivity, innovation and good working practice in German industry.

Many of the ideas focus on building trust and collaboration between managers and employees. However, the report cites as indispensable an ability to handle digital technology and media confidently.

"Given the increased amount of work being done using hybrid working models, being able to handle digital tools to make virtual and international collaboration possible is becoming ever more important. Key competencies, which will become increasingly important in future, continue to include creativity, problem-solving skills, the ability to collaborate and a capacity for self-management and self-directed learning, a willingness to embrace change, and independent thinking and decision-making," notes the report. ●



Prevent Plant Layout Problems

Always consider issues such as maintenance access and pipe rack design

By Amin Almasi, mechanical consultant

LAYOUT MISTAKES continue to plague chemical plants. Deficiencies in design and engineering cause overcrowding and poor access to equipment. So, in this article, we will look at some key failings as well as lessons learned.

Thorough simulations underpin many current designs of chemical plants. However, numerous projects still require adequate and reliable tests to obtain the information necessary to develop elements of the basic design including flowsheets, design criteria, etc. Often, getting essential data calls for operation of a pilot plant.

Unfortunately, many things can go wrong with tests. Samples, methods and details of those tests need great care. Non-representative samples have caused a multitude of issues and problems. The test results only are as reliable and dependable as the sample tested. Small-scale laboratory work often doesn't provide definitive results.

While the quality, details and methodologies of tests always are important, so, too, is the interpretation of the results; this requires close examinations and sound judgment.

In too many cases, the design for a large expensive unit has been based on poor and ill-conditioned tests and inaccurate reports. This has led to serious problems during commissioning and start-up such as the inability to meet product quantity, quality or specification. Sometimes, the severity of problems has necessitated completely redesigning a unit and ordering additional equipment as well as extensive new piping or material-handling units — resulting in considerable delay and financial losses. Such mistakes also can significantly affect the layout and configuration of the unit or facility.

OVERCROWDING AND ACCESS

There has been an unfortunate tendency to use the smallest possible footprint. A variety of motives can prompt this, e.g., the desire to decrease the amount of piping; to cut frictional losses and, hence, overall power consumption; and to have smaller structures to reduce the cost of foundations and footings. However, adopting such an approach makes installation, operation and maintenance far more difficult.

Overcrowding of equipment and machinery has led to many problems, such as operational issues, maintenance difficulties, safety risks and others. Another major challenge often comes when the installation of additional equipment, piping or other items is desired, say, to improve product quality, increase capacity, or as part of a broader revamp or expansion. Too many facilities find they lack sufficient space to make the wanted alterations.

Adequate access, i.e., the space required between components and equipment to permit operations such as operating valves, viewing instruments, and safely actions in an emergency, maintenance activities, etc., is an extremely important consideration. It not only is essential for installation, operation, inspection and maintenance but also for safety, e.g., to enable plant personnel to exit a potentially hazardous area and for fire fighters to work effectively. Access

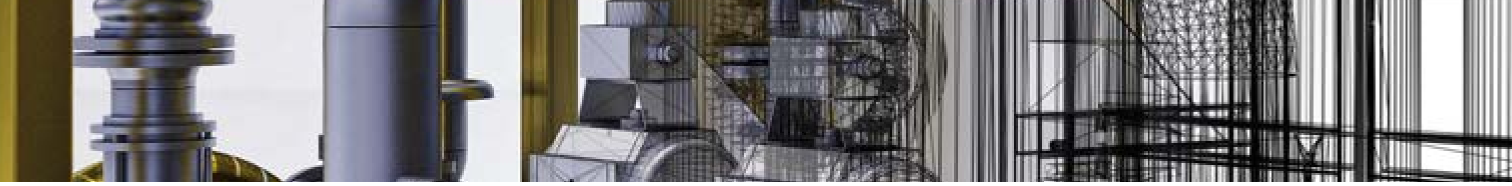


Figure 1. Such an arrangement covers less land but can pose accessibility issues.

also encompasses providing ladders, stairs, platforms, etc.; meeting safety requirements usually includes providing a sufficient number of ladders and stairways.

A common shortfall in numerous facilities is that frequently inspected platforms and areas such as busy pipe racks with many valves or units with lots of valves and instruments only have access with ladder(s). I strongly recommend providing stairs for access to frequently inspected places such as facility levels, major platforms, etc. Of course, ladders still will suffice for many less frequently inspected places (such as equipment platforms).

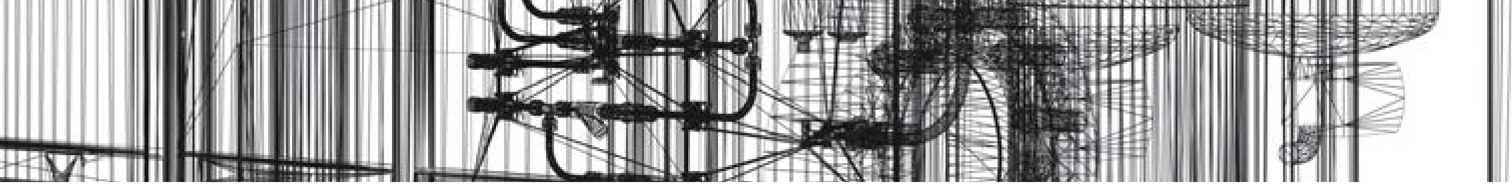
MULTILEVEL VERSUS HORIZONTAL LAYOUT

To save space and cost, some designs adopt a compact multilevel layout, locating equipment at different elevations but close together and with minimum lengths of piping. Often referred to as a structure-mounted vertical arrangement, this puts the equipment in a rectangular multilevel steel or concrete structure (Figure 1). The structure can be several bays long and either open-sided or fully enclosed (depending upon, e.g., operating company preference, climate conditions, etc.). Stairs or elevators provide access. Piping, cabling, utilities, etc., often enter and exit the structure at one level and gain access to each floor by chases (or similar). It often is difficult, expensive and challenging to provide desired clearances and access. Equipment maintenance usually requires use of hitch points, trolley beams or traveling cranes. Ideally, each item should have an adequate open area around it as well as a clear drop zone at grade for equipment removal. Theoretically, designing and building such a multilevel facility with desired access, clearances and safety is possible. However, doing so is very expensive and challenging. In practice, to save some money, contractors may not strictly adhere to some requirements.

In contrast and still preferable for many applications is the traditional concept of using a horizontal wide layout with ample clearances and excellent access. This usually involves locating a horizontal inline unit within a rectangular area, with equipment and machines arranged adjacent to a central pipe-rack network. Such horizontal layouts obviously incur higher costs for land and connecting piping. However, they far better address and manage issues of access, maintenance, safety and operation.

The land available always has been a major consideration. When space is scarce, such as in a renovation, or when special requirements demand an enclosed building, then the only option is multilevel compact installation. However, I've observed several cases where ample land was available but the designer still opted for a congested multilevel facility that used under 60% of the available land and provided less-than-desired access and clearances. Why? Because such a multilevel compact installation was cheaper to design and procure. However, over the long term, such an installation is expensive to operate and maintain, and poses more difficulties and risks.

This points up a crucial lesson. If sufficient land is available, deciding upon an optimum layout requires considering all factors including operation, maintenance, access, etc.



Many modern plants and facilities use a combination of both multilevel and horizontal concepts as appropriate.

KEY FACTORS

The layout reflects the design team's ability to incorporate and anticipate design, operational safety and maintenance requirements while providing the required access and clearances. Layout of an area heavily depends on piping.

So, final layout and arrangement should not proceed before review of a sketch with an overview of all major piping (i.e., above 3–4 inch or DN80) and all alloy steel and expensive piping in a given area. This review should check that all major piping can be routed, supported and designed in an orderly and cost-effective manner with the proposed layout. Considering all piping lines at the same time is recommended, as is routing and supporting them together as much as possible. This approach saves fittings and requires fewer supports. It is cost-effective and efficient as well as easier than the alternative, one-line-at-a-time approach, which always has been problematic and wasteful, and has led to many issues and reworks.

The effective use of available land is key for success. For example, a good strategy is to use a vertical piping configuration, if possible, rather than a horizontal one. Arranging valves, instruments, control devices, inline items, etc., in a vertical piping line with proper access rather than in a horizontal run can avoid wasting a considerable area of land. Obviously, such a vertical configuration might not suit some valves or instruments, leading to the use of a combination of vertical and horizonal runs.

To start the layout, it is best to locate equipment and machines in process sequence to minimize interconnecting piping. Exceptions exist to this rule, such as when there is an operational, maintenance or safety requirement. In addition, it makes sense to group equipment within common areas to suit independent operation, shutdown, etc., or when there is a common utility, maintenance facility, or other shared resource. In some cases, equipment location should facilitate in-place maintenance by mobile equipment (such as a mobile crane) or overhead crane in a shelter or building. Some examples include grouping all water-cooled heat exchangers together in an area and locating pumps together in a unit. Of course, some equipment must be located in a specific position due to process or operational requirements, for instance, pressure drop, line pocketing, gravity feed, etc.

SPACING AND CLEARANCES

Many pieces of equipment and machines require routine maintenance for reliability and safe operation. So, the layout should facilitate the removal of equipment or parts of items for maintenance. It should provide unobstructed space for service equipment and personnel to access and remove components without having to take out unrelated items, equipment and piping. One case that should be considered is the pulling of tube bundles from shell-and-tube heat exchangers. Other examples are the removal of internals from distillation columns, and catalyst loading/unloading of reactors.

It is very difficult to provide general rules for spacing and clearances. As a very rough indication, for typical drums or vessels, the minimum spacing might be half the diameter plus 1.2 m (½D + 1.2 m). Because usual diameters are 0.6 m to 3 m, this works out to minimum spacing of 1.5 m to 3 m. Identical equipment such as matching heat exchangers or horizontal vessels (for instance, those in "1+1" configuration) might be located closer, side-by-side, with, say, a minimum spacing of half the diameter plus 0.5 m (½D + 0.5 m). The spacing between each row of equipment often exceeds 3 m. All piping, auxiliaries, accessories, etc., should be arranged in this spacing while ensuring sufficient clearances still remain after everything is installed. Carefully consider all factors that affect spacing and clearances before finalizing the layout. For instance, locate furnaces, boilers and heaters with fired burners away from potential sources of gas leaks. For these major items, spacing from other equipment typically is 14–20 m depending on details.

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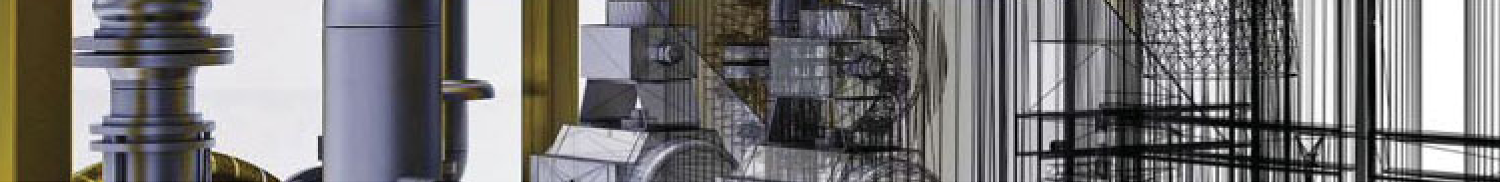
PIPE RACKS

These play a major role in the layout and overall configuration of facilities. Pipe racks are located in the middle of most units. It makes sense to erect them first before they become obstructed by other items or equipment. Multilevel pipe racks commonly are used, most often with process lines on the lower level(s), utility lines above them, and instrument and electrical trays on the highest level.

Pipe racks also often serve secondary functions — such as to provide a protected location for auxiliary equipment, pumps, utility stations and manifolds as well as firefighting and first-aid stations. Air-cooled heat exchangers often are supported above pipe racks for economy of plot space. Do not locate piping over columns as this will prevent adding another level. Place large, heavy liquid-



filled pipelines near columns to reduce bending stresses on pipe-rack beams.

Designing and finalizing pipe racks demand close cooperation among civil, structure, piping and mechanical specialists. A key point is the load estimation of pipe racks. Often, ample margins are needed.

In one project, the initial estimation at the early stage of the detail design was that two-level pipe racks were needed; based on this, the civil team finalized the piling layout. Immediately afterward, piling and civil works began. Later, the piping and instrumentation diagram was updated with the addition of more piping lines requiring three levels of pipe rack. This changed the entire loading, civil design and piling layout — and led to many discussions, problems and reworks. The lesson learned here is: always consider the potential for a sharp increase in the number of piping lines on pipe rack and loadings, and even an additional pipe-rack level. Keep more than 25% of the final width of each level free for accommodating potential future piping lines.

Another concern is the spacing of the pipe-rack supports and the method of intermediate support to prevent pipe sagging. Electrical and instrument trays are best placed on outriggers or brackets to prevent interference with pipes leaving the pipe rack.

Mobile lifting equipment needing access often determines the minimum clearance under the pipe rack. Long lengths of rack piping may require expansion/contraction loops, especially in extreme hot or cold temperature services.

The best way to alter the direction of a pipe in a rack usually is by a change in elevation rather than a flat turn. This will avoid blocking space for future lines. In this way, each line can be routed to change elevation and direction with only two elbows and without obstructing other lines. Using this method, it is easy to move a line from one side of a pipe rack to the other side of the next pipe rack (when it turns) without obstructing other lines. This is important, for example, if you must route a large and expensive alloy steel line to move fluid from a critical piece of equipment on the left side of a pipe rack to a machinery package on the right side of the next pipe rack. ●

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Avoid Alarm Management Blunders

Nine misconceptions can undermine safety and effectiveness | By Darwin Logerot, Emerson

THE SITUATION at today's processing facilities differs markedly from that five or ten years ago. Operators are younger and less experienced, and there are fewer of them. Yet, those small teams are expected to shoulder more responsibility than ever before. Maintaining safety remains a prime consideration, with alarms as one of the most important lines of defense.

"Management of Alarm Systems for the Process Industries," standard 18.2 of the International Society of Automation (ISA), defines recognized and generally accepted good engineering practices for alarm management. Many plants have striven for decades to reach these goals, only to fall into the trap of repeating the same ineffective processes over and over without obtaining the desired results. By recognizing and avoiding nine common misconceptions about alarm management strategy, chemical companies can close the gap between their desired alarm functionality and actual practice in their facilities.

NINE MISCONCEPTIONS

Let's look at each of these misconceptions, what they lead to, and how to properly proceed.

1. *We just need to reduce our alarms.* Alarm floods are the bane of any operations team and have become even more of a stumbling point as today's operational groups have gotten smaller. When tens, hundreds or even thousands of alarms flood in a short time — whether during an emergency or a less-critical aberration — operator attention is drawn in many directions at once, making isolating, defining and solving potentially safety-critical problems difficult.

As a result, alarm management teams often adopt a "zero alarm strategy," i.e., one that aims to configure as few alarms as possible.

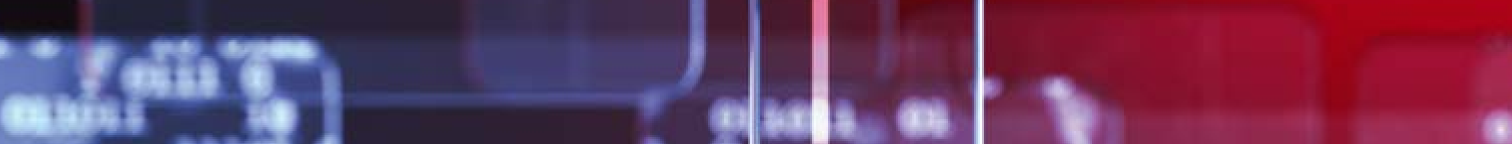
While optimized alarm systems will result in fewer configured alarms, thinking in terms of quantity rather than quality is a mistake. The goal of effective alarm management is to identify quality alarms and keep them in service while improving or eliminating nuisance alarms. At the heart of this strategy is one key rule: the quality of an alarm is negative if it does not conform to all five of the following keywords and definitions:

- abnormal — not planned or expected, a surprise to the operator;
- actionable — operator response to the alarm is required and possible;
- consequential— lack of or incorrect/insufficient action likely will lead to an undesirable result;
- unique — only one alarm sounds to announce an abnormal deviation; and
- relevant — understandable to the operator and pertinent to the current operating state.

2. *We should alarm everything just to be safe.* Alarms differ from status information. Most pieces of equipment in the plant only have a few statuses that conform to all five keywords and, therefore, require an alarm. Identifying, evaluating and then deliberately ignoring an inconsequential alarm squanders an operator's precious attention; so, elimination of these alarms is important.

Status information might draw more attention when configured as an alarm but doing so clutters the operators' alarm interface. This not only distracts operators but also conditions them to ignore alarms, creating a dangerous situation when a true alarm needs attention.

A common example of status information inappropriately appearing as an alarm is an inactive pump. If two pumps are installed in parallel, with only one expected



DISTILLATION SYSTEM

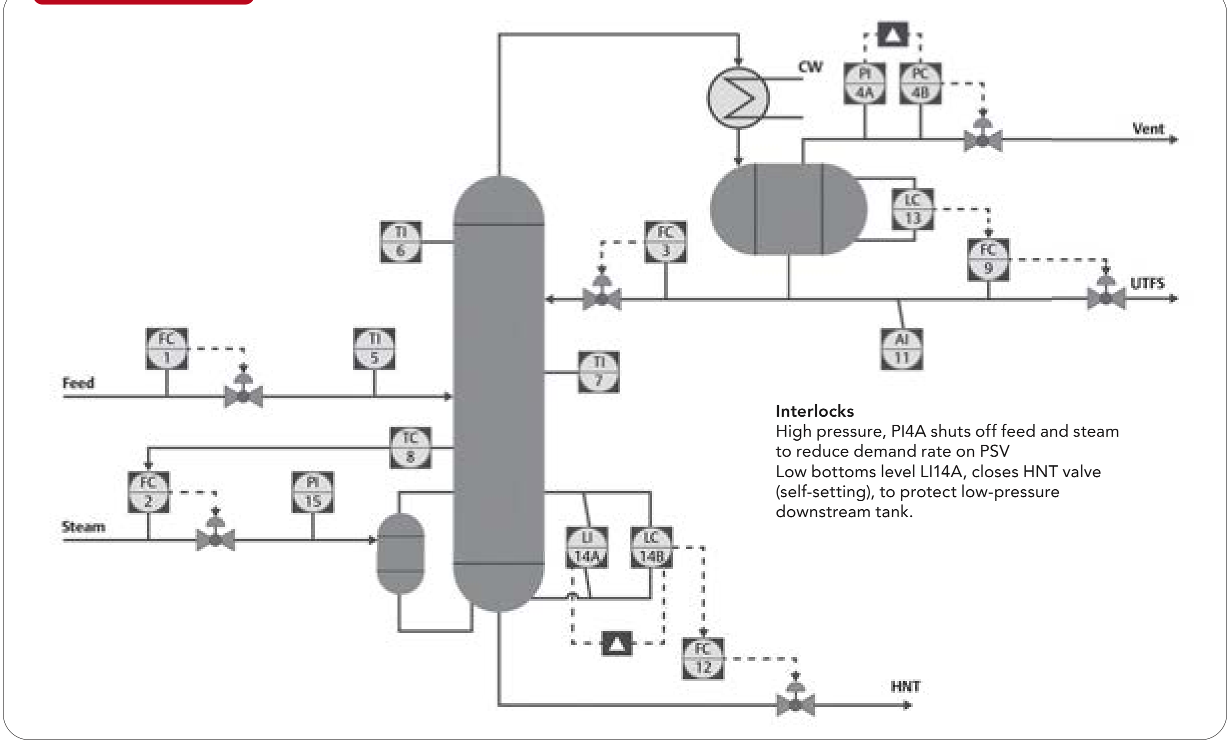


Figure 1. The system includes a number of interlocks.

to operate, this will guarantee the presence of a standing alarm at all times. The better alarm to configure in this situation is a failure or command disagree alarm for the pump, indicating it is stopped when commanded to run or vice versa.

Another common situation involving alarming normal events is where there is on-off control action, such as an automatic start-stop on a sump pump. As the sump level rises, the pump is turned on. When the pump action successfully reduces the level to the desired point, the pump is stopped. These normal control actions often are alarmed — but only serve to disturb the operator. A proper alarm in this situation would be one that is set above the autostart level, at a point that indicates the pump failed to start or is malfunctioning.

Status information must be kept off the alarm summary. Instead, the operator should get statuses via indications on the graphical interface associated with the equipment in question.

3. *Multiple alarms draw more attention to problems.* Nobody wants a safety incident to occur; so, teams configuring alarms look for ways to ensure operators are immediately notified when something is wrong. It seems intuitive, then, to create multiple alarms for the most-severe equipment aberrations. After all, multiple alarms popping up are much harder for operators to ignore, intentionally or accidentally.

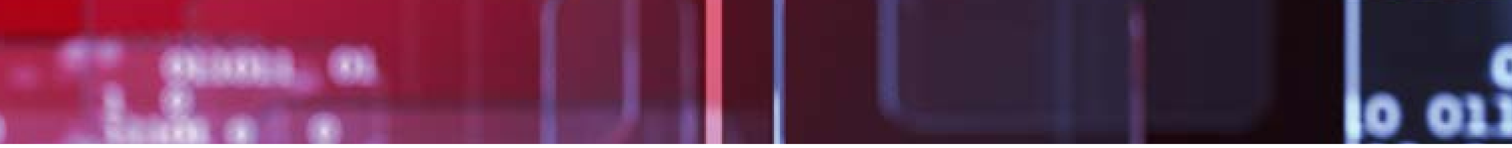
However, having multiple alarms for a single event creates its own set of problems. As alarms flood in, operators quickly can become confused as to which they must address first, delaying responses. Moreover, even when operators identify the source of the problem and begin to take action, they waste valuable time silencing the other alarms.

A better strategy is to create a single alarm for each event. This not only will present the operator with an alarm but also will provide clear severity information to help in understanding the importance, simplifying prioritization.

For example, where a reactor has multiple temperature indications, with each having a high temperature alarm, then multiple alarms will sound during a process upset where only one really is needed. The best option here is to configure a maximum temperature and have an alarm on that value. When the alarm sounds, the operator can consult the reactor graphic to see where the high temperature exists and can respond appropriately.

State-based or dynamic alarming also should be employed to ensure that multiple alarms do not annunciate when an upset condition occurs.

4. *We don't need dynamic alarming.* The plant environment is not static. Plant activities and environments



change from day to day; alarm management must reflect that fluctuation. Even in the best operating facilities, plants go through many different operating states; each state often will require a unique alarm configuration to avoid nuisance alarms.

These state changes complicate alarm management. Alarms, by definition, identify abnormalities in plant and equipment operation. However, what is normal and abnormal often varies with operating state. As a result, to be effective, alarm management also must adapt to the state of the plant.

Dynamic management enables alarm configuration changes based on logic defining the operating state and process conditions. Alarm systems configured with dynamic management facilitate smooth transmissions from one operating state to another using state determination logic.

The ideal alarm management system will integrate seamlessly with the distributed control system (DCS) to make dynamic management easier. When the alarm management system and DCS work in tandem, operators will have clear, instantaneous visibility of alarm status right from their consoles, regardless of operating state. Such a scenario dramatically reduces the risk of operator error during high-stress operating states, such as startup and shutdown.

The best strategy is to incorporate dynamic management from the earliest stages of developing an alarm management strategy. Dynamic management can be effectively handled during an alarm rationalization process without significantly increasing time and budget.

Let's consider the application of dynamic alarming to the distillation system shown in Figure 1. Here, the alarm rationalization team identified three basic operating states and developed logic to determine when the system is operating in each state. The logic is based on reading key operating variables from the control system and then applying those readings in a logic structure (Figure 2).

This logic prompted a number of alarm changes (see Table 1) to optimize the alarm configuration for each state and improve the operator's experience.

5. *Our tag and alarm descriptions are perfectly clear.* Alarms only are useful if operators can quickly understand what they mean. Few plants still have the luxury of a deep bench of veteran operators; even the plants that do have highly experienced operators will need to bring in new personnel at some point.

Even to a seasoned operator, an alarm description such as HDR PNL 17LP3n-1B-C likely will mean very little. Those abbreviations may capture a wide array of information but, if operators can't decipher their meaning, the alarm is not useful. Simply avoiding abbreviations is not the answer — names so long that pertinent information runs off the screen still have little value in a crisis.

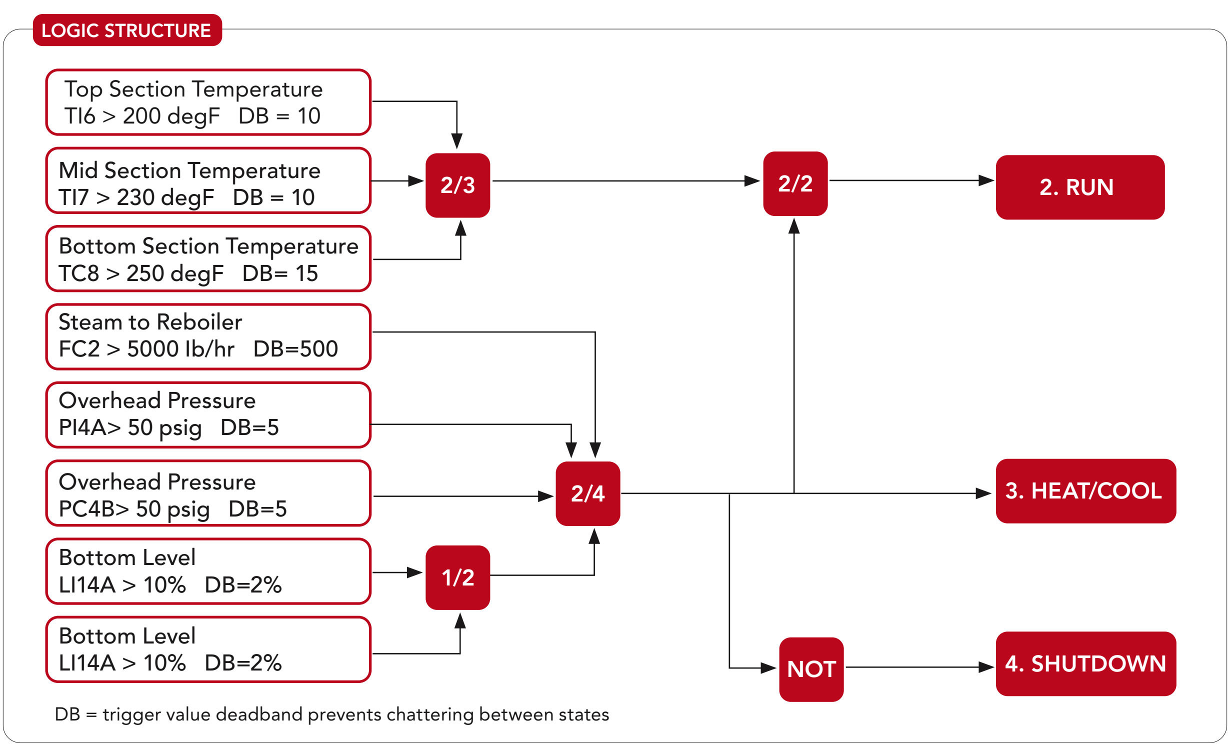
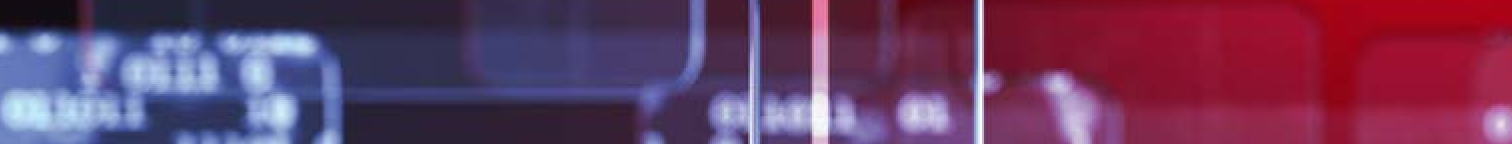


Figure 2. Readings of key operating variables determine the state of the process.



A better strategy is to develop a standardized naming convention in partnership with the operations team. Each name should be short, use abbreviations and terminology the operators understand, and be taught easily to new operators.

Creating a standardized convention helps ensure that operators, even if unfamiliar with the alarm at first glance, quickly will be able to determine its meaning based on experience. This type of fast comprehension can save precious minutes.

6. *Triggering interlocks with alarms saves effort.* Often, DCS configuration teams will try to save effort by tying interlocks to their associated alarms. For example, it may be easier to configure a high-level reading as an alarm and an interlock if it exceeds 95%.

Alarms and interlocks exist for different reasons. So, enforcing both with the same parameter generally is not recommended; ISA 18.2 and its technical reports discourage the practice. When the two are tied together, the alarm management team cannot change alarms without changing interlocks, which creates new risks for the plant.

Moreover, suppressing alarms tied to interlocks can disable the interlock. This creates a potential safety and security loophole.

The better strategy is to spend a bit more time to configure the interlock separately from the alarm. Many modern control systems provide separate parameters for that purpose.

7. *We only need to rationalize bad actors.* Setting up a successful alarm-management strategy takes time; the more equipment a plant has, the more time it likely will take. Often, alarm management practices review only the bad actors, for example the top ten or twenty most-frequent alarms. Just reviewing bad actor devices does not meet ISA 18.2 guidelines; the standard advises rationalization of all alarms.

While a bad actor review might produce a quick win in reducing alarm rates, this methodology does little or nothing to prevent alarm floods — and it does not ensure an optimum overall alarm configuration. Instead, considering alarms as a system rather than individually is essential.

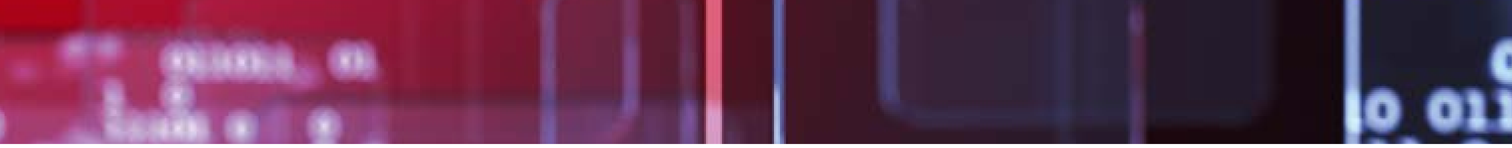
Only a thorough rationalization, including all alarms and dynamic alarming, will produce a result that provides optimum alarm configuration with a satisfactory experience for the operator while conforming to the recommended ISA metrics in terms of average and peak alarm rates, percent of time in flood, and other factors.

8. *The best alarm strategies are the ones that satisfy management.* Whether because the facility recently had a safety incident or because metrics are identifying problems, the call for improving alarms often comes from upper management. Because a need to demonstrate success to management is necessary, it is easy to think of management as the primary audience for alarm reform. Seeing alarm management as a top-down edict fosters a "check the box" mentality and only doing the minimum without considering the true benefits.

ALARM CHANGES

Measurement	Tag Number	Alarm	Run State	Heat/Cool State	Shutdown State
Overhead Product Quality Analyzer	A1-11	PV Hi	Low Priority	Suppressed	Suppressed
Steam to Reboiler Flow Controller	FC-2	DEV Lo (deviation fromset point)	Low Priority	Suppressed	Suppressed
Reflux Flow Controller	FG-3	PV Lo	Low Priority	Suppressed	Suppressed
Receiver Level Controller	LC-13	PV Lo	High Priority	Low Priority	Suppressed
Bottoms Level Controller	LC-148	PV Hi	High Priority 80% Alarm Limit	Low Priority 98% Alarm Limit	Suppressed
Bottoms Level Controller	LC-148	PV Lo	High Priority	Low Priority	Suppressed
Overhead Pressure Controller	PC-4B	PV Lo	High Priority	Suppressed	Suppressed
Bottom Section Temp Controller	TC-8	PV Lo	Low Priority	Suppressed	Suppressed

Table 1. Optimizing alarms based on the state of the column enhances operator experience.



However, while management will evaluate the results of alarm management, the true audience is the operators who rely on the alarms to help them safely and efficiently perform their jobs. Developing an alarm strategy that satisfies ISA 18.2 guidelines means designing based on solid principles and on the feedback of the board operators who must deal with each alarm. Therefore, an alarm configuration that empowers operators to control the process effectively and safely should be one of the ultimate goals of the program.

Involving experienced operators trusted by their peers in alarm strategy design from the very first sessions will help the team create an alarm system that suits the way they work, while increasing the probability of acceptance from the remainder of the operators.

9. *Metrics can guide our entire alarm strategy.* Modern alarm-management tools provide enterprise-level, web-based alarm and event reporting tools. Engineers can use these tools to create customized reports; dashboards, like those that can be created in Emerson's AgileOps software, can afford improved visibility of plant performance from anywhere in the world (Figure 3).

CUSTOMIZABLE DASHBOARD

Figure 3. This can provide enterprise-level teams with better visibility of plant performance.

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Metrics are important. Not only do they help enterprise-level personnel guide overall business and plant strategy but also, when properly configured, they help plant personnel gain more visibility into the safety, efficiency and effectiveness of their own facility. However, metrics never must be used as a basis to compromise an alarm management process.

For example, excluding startup and shutdown alarms in alarm reports sent to management does not comply with ISA 18.2 guidelines. The plant must be able to meet metrics for all states, not just the run state. Also, doing this may make alarm system performance look deceivingly good and, consequently, could result in a lack of funding for a thorough rationalization and improvements that are truly needed.

Successful alarm management is not about metrics but instead requires providing only quality alarms that support the operators' efforts to monitor and control the plant efficiently and safely. A well-conceived and well-run alarm rationalization effort that includes dynamic alarming very often will result in a reduction in the alarm count and conformance to metrics — but metrics should not drive the process.

DON'T BLUNDER

Recognizing the misconceptions that lead to poor alarm management strategies enables teams to better leverage their alarm management system and tools to promote safer and more efficient operation. The most-effective teams combine the right tools and strategy to dramatically improve the way they operate.

Modern alarm-management tools provide a wide range of features such as native DCS integration, dynamic alarm management, and intuitive dashboards. When coupled with a clear knowledge of the potential pitfalls of alarm management, these tools not only help teams configure alarms correctly from the very first moments of operation but also bring alarm strategies in line with ISA 18.2. This improves visibility and guides operators through the riskiest and rarest moments as well as everyday operations.

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Open Automation Passes Key Tests

Success with a prototype and a test bed prompts an upcoming field trial

By David L. DeBari, ExxonMobil Technology and Engineering Co.

EXXONMOBIL ORIGINALLY started discussing what has become Open Process Automation (OPA) in 2010. The end of life for a significant amount of legacy automation systems in the marketplace had resulted in myriad migration projects that yielded an updated set of systems at a very high cost and with little benefit beyond temporarily mitigating obsolescence. After evaluating the situation, considering possible solutions, and creating a vision for the future of automation, ExxonMobil began sharing that vision of what OPA might look like along with advocating for inserting the appropriate information technology (IT) into our operational technology world. In early 2016, ExxonMobil began to put action to the words with a development collaboration with Lockheed Martin and, then, in late 2016, by joining with other like-minded companies to form the Open Process Automation Forum (OPAF), http://bit.ly/38HJ89C, within the Open Group. Since its formation, OPAF has been working on a standard of standards to describe and enable a standards-based, open, secure and interoperable automation architecture. ExxonMobil and Lockheed Martin by early 2018 had positively answered the "art of the possible" questions about whether an OPA-based system could demonstrate the desired features. Once the proof of concept was successfully built, tested and reported to the marketplace, ExxonMobil turned its attention to a prototype system to run a pilot-unit-scale process.

PROTOTYPE SYSTEM

Figure 1. Pilot unit in New Jersey contained four reactor trains and had about 130 I/O points.

The prototype system project was envisioned as a migration of a legacy distributed control system (DCS) to an OPA-based automation system on a real process that operations technicians would run continuously for 4–6 months. As this first step in the development of an OPA system for manufacturing, ExxonMobil selected a pilot process at our research facility in Clinton, N.J. This OPA-based automation system provided a basis for evaluating the ability to supply a system adequate for real-world control, monitoring and conducting operating procedures as well as to validate such a system in the hands of operators, who are renowned within industry for achieving high standards of system performance and quickly offering tough feedback on what has been done wrong. Primary criteria for the future of an OPA-based automation system are whether operations technicians can successfully run a process and regard the replacement systems as a useful and beneficial tool in that effort.

FIRST STEP

The pilot unit for the prototype project is a refinery-catalyst-testing process made up of four parallel reactor trains (Figure 1). This process is operated at about 1,200 psi and around 750°F with H_2 and crude oil as raw materials with process flow rates measured in ml/h or g/h. While the pilot unit is small in scale, the presence of sensors for H_2S and combustibles and an emergency shutdown capability provide proof this tiny plant is a very real process that can be operated safely by trained operations technicians. The process automation system interfaces with an existing safety instrumented system (SIS), gas chromatograph, and laboratory information system. The pilot-unit automation system uses about 130 input/output (I/O) points including AI, AO, DI, DO and J type thermocouples, and has 25 control loops and nearly 600 tag parameters recorded in the historian each second.

The pilot unit produces data in balance batches where the priority is to maintain tight control of the process conditions because disturbances and deviations cause the immediate invalidation of the test and require a restart of the test once process conditions stabilize. For the purposes of the prototype test, the process conditions would be repeated in consecutive batches and the process control performance, OPA-based automation system functionality, and balance data would be compared to batches run just prior to the migration from the legacy DCS system.

THE PROTOTYPE SYSTEM

The prototype project team consisted of people from ExxonMobil, Lockheed Martin, and Wood. ExxonMobil brought the process expertise and automation project criteria, Lockheed Martin provided the automation system hardware, software, infrastructure integration, and the "factory" to build the process automation system and support a duplicate system for troubleshooting, and Wood contributed its expertise in field engineering, installation/migration of automation systems, and the control-logic engineering, human-machine-interface (HMI) graphics building, and process data integration for the OPA system. The research facility supplemented the team with a chief operator to torture the system in the factory acceptance test (FAT) to help us understand what needed correction as well as a couple of site support engineers to ensure the system was cyber-secure, reliable and safe to add to the existing environment.

Engineering of the prototype system began in late 2018 and proceeded into 2019. Two-and-a-half prototype systems were fully constructed in a Lockheed Martin laboratory facility; these comprised a test rack, an acceptance system and a production system. The acceptance and production systems were duplicates of each other. The production system was relocated and installed in the ExxonMobil research facility in Clinton, N.J. The prototype system, after completing the FAT in the third quarter of 2019, was installed on the pilot unit, with I/O checkout completed in December. Then, SIS and process control interlock checks were conducted, process safety reviews were finalized, and the pilot unit was turned over to operations for production use in the week of January 13, 2020.

ExxonMobil operations immediately began performing balance tests on the pilot unit. On two occasions, the process experienced failures, one in instrumentation and the other from a valve; operations reported the OPA system was flawless both times in its ability to gracefully bring down the unit for repair and then restart the unit to continue operations. The process control and automation system performance along with the balance data confirmed the OPA-based automation system was performing well, and operations feedback was very positive. Upon review of all operations data to date in late February, the six-month prototype run schedule was shortened to four months as the operation of the OPA system already was considered successful and routine. In mid-March 2020, pandemic-induced lockdowns began to impact the research facility. Due to resourcing limitations instituted to protect personnel in late March, the prototype project agreed to suspend OPA system usage after completion of the running balance. On March 31, 2020, operations shut down the pilot unit. The process was purged, cleaned and idled by mid-April. In total, 12 balance tests were successfully completed using an OPA-based automation system with no perceivable negative difference in performance or utility compared to the legacy DCS. Operators successfully ran the process using an OPA-based automation system for nearly 12 weeks and were happy about the experience.

As the prototype project moved to the operational state, ExxonMobil commenced planning for the next phase of the OPA research-and-development program and began preparing for the test bed. It is the next step in bringing OPA technology to a state of technical readiness for commercial usage for both brownfield and greenfield projects.

THE TEST BED

This is a facility located in The Woodlands, Texas, operated by Yokogawa, the systems integrator. The purpose of the test bed is to perform further testing of components from a variety of vendors and to validate the application of

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standards-based technology as documented in the Open Process Automation Standards (O-PAS).

We devise the test-bed experiments around the questions we have about the OPA-based system design and architecture, then we identify and source the hardware and software needed for the experiment. When ready, the prioritized experiments are conducted using a DevOps Sprint methodology. Besides the experiments and testing mentioned, we employ the test bed to discover and share information related to the use of OPA architectures and the Forum standards. Information sharing will occur with the OPA Forum and among ExxonMobil's test-bed collaboration partners — eight other end-user companies aligned in their desire to conduct independent field trials of OPA technology. Ultimately, the test bed will create confidence the system can succeed in the field trial for ExxonMobil, as this demands components and integration that meet the quality and performance requirements of an automation system. The test bed also will help the collaboration partners prepare for their independent field trials of OPA-based systems.

ExxonMobil specifically is focusing on continuous and sequential control operations as they relate to the processes in our facilities. We also are looking at the other features that round out an automation system like the operations HMI, data collection, event logging, the historian and the alarm system. The automation needs of our collaboration partners may differ from ours based on their processes and products. One purpose of having the collaboration is to allow others to address these differences to ensure that OPA is not an industry-specific automation solution. ExxonMobil and our collaboration partners are exploring continuous and discrete automation requirements, various technical capabilities of an automation system, and the integration of advanced automation and IT technologies that will provide benefits to operating an automation system. All this work is to confirm the quality and performance requirements necessary to proceed to independent field trials.

The test bed results will produce a workable architecture for building an OPA-based automation system and inform the OPA Forum on the practical uses of the O-PAS. The research also will help us understand the system integration tasks and OPA-based system support needs. Again, the test bed will create confidence that an OPA-based automation system will meet the quality and performance requirements for successful independent field trials.

THE NEXT STEP IS STARTING

We are satisfied that we have a workable design basis and architecture, and now are following our process to conduct a field trial within ExxonMobil. We have received management approval and have commenced the front-end engineering and design (FEED) for the field trial project, which will take place at an ExxonMobil chemical manufacturing site in Baton Rouge, La., with expected start up in the first half of 2023. The test bed will continue to support the field trial development and early operation, collaboration partner experimentation, and testing of new technical capabilities and standards as they become available.

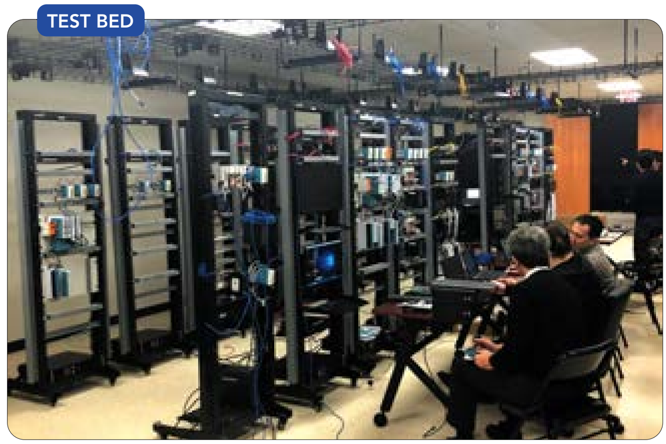

Figure 2. It enables testing components from various vendors and validation of the applicability of standards-based technology.

The ExxonMobil field trial system will replace a legacy DCS system and some obsolete programmable logic controllers with OPA-based components. The selected site has about 2,000–2,500 I/O points with 90–100 control loops and a single operator span of control; it includes utilities, tank farm, process, and product finishing and packaging. The field trial system will integrate with an existing SIS; the process also will link directly with other operations for raw material supply and byproduct return. This OPA-based system will enable the deployment of advanced process control applications that should generate additional value and data and allow for faster and better decision-making.

The decision to progress to a field trial reflects ExxonMobil's confidence in the standards and technology related to OPA-based automation systems. The technical team has tested and evaluated the components selected for the field trial and feels confident the system will perform according to expectations. Additionally, the field trial will encourage other end-users to trial their own OPA-based systems and create the conditions for a thriving marketplace for open, interoperable, conformance-certified components needed to build O-PAS-based automation systems. The open process automation premise and vision is that a standards-based, open, secure and interoperable process-control architecture will promote innovation and value creation.

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Scrub Successfully and Safely

Determining how best to remove multiple materials requires care

USE MULTIPLE APPROACHES

Scrub the NH_3 with water to see if it provides sufficient control. Solubility is not a problem; if kinetics are slow, that might be addressed with engineering.

For formaldehyde and methanol vapors, you might find success with drums of activated carbon.

Andrew Yeung, R&D scientist,
Afton Chemical Corp.,
Pasadena, Texas

CHOOSE A DIFFERENT SOLVENT

Consider the following:

1. NH_3 scrubbing solvent needs to be relatively safe and cost-effective. Although H_2SO_4 is a widely used scrubber solvent, other choices include phosphoric acid and nitric acid. Phosphoric acid is not as severe an inhalation hazard as H_2SO_4 and is not considered a carcinogen. However, it is not hazard-free, and demands proper handling procedures and use of personal protective equipment. It also likely would not match the operating cost-effectiveness of H_2SO_4.
2. Strictly from a safety vantage point, citric acid is an appropriate scrubbing medium. However, its consumption rate will exceed that of H_2SO_4. Similarly, because NH_3 has a high solubility in water, you could consider cold water as a scrubbing medium but, unlike acids which convert NH_3 into salts, ammoniated water could pose odor and regulatory compliance issues.
3. Avoid piping the compressor relief valve vent directly to the scrubber because high velocity from the relief valve could damage scrubber internals. Consider an intermediate vessel to stabilize flow and pressure. Arrange scrubber gas entry to avoid striking internals such as bed support and packing at high velocity.
4. Address all findings of process hazard assessments per regulatory requirements. In general for relief valves, a quick checklist would include, for example, inlet piping and pressure drop (3% limit), back pressure and type of relief valve (pilot operated or non-pilot), and pressure release scenarios to ensure relief valves have adequate capacity to handle likely events. API-520 (October 2020) provides guidelines for sizing and installation of relief valves.
5. Repurposing the scrubber for the oxidizer vapors containing formaldehyde requires consideration of flow rate, formaldehyde content, solvent concentration, packing height equivalent to a theoretical plate, and temperature. Plastic packing has an obvious temperature limitation — so the exhaust from the oxidizer will need to be cooled. You must check velocity and pressure drop to see if the 4-ft diameter scrubber is adequate. Depending on the regulatory requirements, you may need to install an online analyzer for formaldehyde in the vent exiting the scrubber. In addition, you will need to identify a suitable scrubbing medium for formaldehyde; this could include alkaline urea, sodium meta bisulfite, and the like. Finally, you must consider disposal of the effluent from the scrubber. This may turn out to be problematic. If so, check if you can modify the oxidizer operation (temperature, vapor distribution, etc.) to improve destruction efficiency of formaldehyde and achieve environmental compliance.

G.C. Shah, consultant,
Houston

THIS MONTH'S PUZZLER

A safety review has discovered serious flaws in our relief valve vent system and electrical area classification. The reliefs for our ammonia (NH_3) compressors vent on to the roof of a busy area in our plant. In addition, the compressor building lacks an exhaust fan, which makes it a Class 1, Div. 1, Group D zone.

I designed a 4-ft diameter scrubber with the relief vents going to a basin. I proposed 10% sulfuric acid (H_2SO_4). The superintendent doesn't like operators working with acid. He also complains the scrubber will be ignored: the ammonia alarm goes off about six-to-ten times a year (when someone actually takes note of it). The safety director gripes about having to resize the relief valves for the pressure drop: it's a 300-psig system! He's also concerned the ammonia relief flows will blow right through the basin without being captured. The project group is troubled over the cost of the scrubber because of material selection.

Now, the superintendent has talked corporate into the idea of using the scrubber to handle the formaldehyde and methanol that escapes our storage tanks when we do inspections and repairs. We have a thermal oxidizer (TOX) but it only captures about 90% of the vapor from the plant.

Are there any options other than sulfuric that would lower the project cost? How much of a concern is resizing the relief valves? Can you suggest other ideas to meet the scope of this project?

SCRUB ONE CHEMICAL AT A TIME

The trouble with most scrubbers is that the product of the chemical reaction between the solvent and the absorbent can be reversed or produces something that is also dangerous.

Consider what NH_3 produces when it reacts with H_2SO_4: ammonium sulfate. Sulfate can be used as a fertilizer — power companies have proposed projects to recover scrubber waste.

Now, consider the reaction of formaldehyde with acid. It is an acid-catalyzed Cannizzaro reaction producing formic acid and methanol. However, it's much more complicated as multiple carbon species are present. I prefer to call the results "muck."

The methanol will react with H_2SO_4 in a saponification (soap) reaction to create an ester — again, "muck."

So, in effect, using one scrubber to handle all these compounds probably won't work out well. However, ammonium sulfate has some advantages: stick to scrubbing ammonia alone. Because you can burn the carbon compounds in the TOX you must have on site, leave it to the TOX; for that matter, a TOX can handle NH_3.

As for resizing of the relief valves: "Bill me, should be your answer." The pressure drop only will be about 2–3 psig maximum, which is less than 1% of the set pressure. You shouldn't be concerned about the relief vent losses until they rise to about 10% of the set pressure.

The risk of only blowing through the basin is real. I suggest something creative: put 10% glass-filled packing in the basin to add some resistance to the NH_3. Add a bed limiter to the top of the packing. Use the pressure drop you would get from packed scrubbing as the pressure drop adder for the relief sizing: ~ 5–10 IWC. With a large scrubber basin, the relief flows become negligible.

Handling H_2SO_4 is risky. I have a safer alternative: acetic acid; ammonium acetate is marketable as a fertilizer but I doubt it will react efficiently with formaldehyde or methanol.

The gas-phase volumetric mass-transfer coefficient, $K_g a$, for these solvents, water, acetic acid and H_2SO_4 will be about 2, 4, and 12, respectively in lb-mole/hr×ft^2×atm. A 1–2% H_2SO_4 solution works well with a constant pH, although you may need a stronger solution to achieve a high $K_g a$. The water value is the minimum. You could use the acetic acid at a much higher acid concentration without fear of heat of dilution.

In summary, the Swiss-army knife solution proposed by operations is a bad idea: stick to scrubbing one chemical at a time.

Dirk Willard, consultant,
Wooster, Ohio

OCTOBER'S **PUZZLER**

As part of our massive plant expansion, we added a new 200-psig boiler to our 30-year-old boiler. ASME inspectors de-rated our old boiler to 100 psig (see Figure 1).

BOILER EXPANSION

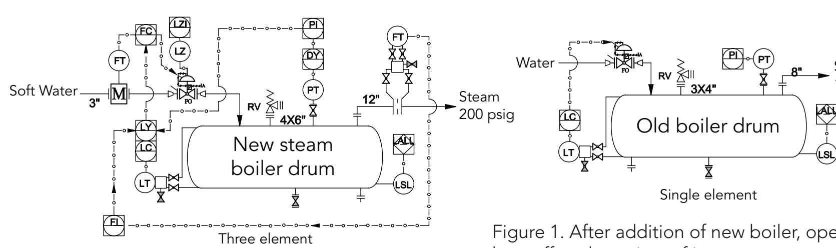


Figure 1. After addition of new boiler, operation has suffered a variety of issues.

We've had nothing but trouble. The relief valve blew on the new boiler shortly after start-up. Even the old boiler is operating strangely with surges in the steam flow; its mud drum has a troubled history of corrosion.

We have a new steam-flow measurement for the old boiler that comes from a vortex-shedder-type meter. (Corporate wanted a Coriolis device but it was too expensive.) The meter gave a false high reading initially but then settled down; there is an unsettling variation in the reading. The flow measurement for the new boiler surged initially but also then stabilized. Rumor has it that one of our old operators did something. We convert the steam measurements from both boilers into mass measurements. The material balance for the new boiler doesn't make sense with the feedwater.

Another issue is the oscillation in the pressure transmitter reading on the new boiler. This has caused some disturbances in the drum level measurement and material balance.

How can we get the boilers operating as reliably as the old boiler? Should we be concerned about a boiler control issue?

Send us your comments, suggestions or solutions for this question by September 9, 2022. We'll include as many of them as possible in the October 2022 issue and all on ChemicalProcessing.com. Send visuals — a sketch is fine. E-mail us at ProcessPuzzler@endeavorb2b.com or mail to Process Puzzler, *Chemical Processing*, 1501 E. Woodfield Rd., Suite 400N, Schaumburg, IL 60173. Fax: (630) 467-1120. Please include your name, title, location and company affiliation in the response.

Correctly Quantify Column Capacity

Using a suitable system factor for distillation equipment is crucial

The F_ss different plants find appropriate can vary enormously.

EVALUATING THE actual capacity of distillation equipment requires care. Most testing uses either air/water or relatively simple and pure mixtures with low viscosity. Moreover, test systems usually have good vapor/liquid separation and relatively low foaming tendencies A real system may exhibit much-more-complex flow behavior. So, the calculated capacity often is adjusted by a system factor (F_s), also called a derating factor, based on demonstrated performance in a specific system. An F_s provides a straightforward way to quantify maximum capacity in a system. The same F_s typically is used for both packed and trayed towers, and for both downcomer flooding and active area (jet) flooding in trayed towers.

The adjusted capacity is:

$$Limit_{actual} = Limit_{base} \times F_s$$

Or, thinking of this another way,

$$F_s = (Actual\ capacity)/(Predicted\ capacity)$$

Conventionally in design, the tower operating limit is set as some percentage of the flooding limit. One popular approach is to size new tower equipment for 85% of flood. The margin between 85% and 100% gives a cushion that accounts for uncertainly in the flooding correlations. If a specific system has an FS of 0.75, then the flood limit should be 0.75 × 85% = 64%. Table 1 lists some typical values for common systems published by various tray vendors.

Besides their role in sizing equipment and towers, F_ss are used to evaluate the capacity of current equipment, and to check if demonstrated capacity limits of existing towers are reasonable. In all cases, questions can come up about how sure we are the F_s is right.

System factors are not calculated but are based on observation of where industrial systems flood compared to where they were "expected" to flood. This difference could stem from many factors such as viscosity, surface tension, foaming tendencies, etc. An F_s can be as low as 0.3 in some extreme systems. For a design, an F_s of 0.3 gives 3.33 times the tower cross-section area. For a capacity evaluation of a given tower, it reduces the expected capacity to 30% of the rate for a "normal" system.

The F_ss different plants find appropriate can vary enormously. For example, the F_s for water stripping for volatile contaminant removal often can range from 0.5 to 0.7 depending upon the facility. Opting for an F_s of 0.7 creates an expectation of 40% more capacity than if using an F_s of 0.5.

In many systems, surface active contaminants can hugely change the capacity at the flooding point. Amine contactors for acid gas removal are good examples. Amine flooding varies greatly with the amounts of entrained hydrocarbons, solids, surfactants and accumulated trace contaminants. Between plants, the same equipment may differ in capacity by up to 30% depending on the system chemistry. Filtering the amine helps, but plants diverge in their standards of what's "clean-enough" amine.

So, if F_ss can vary so much for a single service, how do you decide which one to use? Regretfully, there's no clear-cut answer here.

For design purposes, use the more-conservative end of the range of values. For existing equipment, the best approach is to find a way to run performance testing that pushes the unit to as high a capacity as possible. These performance tests should include detailed pressure surveys; I also highly recommend scanning the tower at test rates. Without operating data for the specific process, you're only making a guess. So, to quote Harry Callaghan in "Dirty Harry," "You've got to ask yourself one question: 'Do I feel lucky?'".

ANDREW SLOLEY, Contributing Editor
ASloley@endeavorb2b.com

COMMON VALUES

Service	System Factor, F_s
Alcohol synthesis absorbers	0.35
Amine contactors	0.70–0.80
Amine regenerators	0.85
Carbonate strippers (hot)	0.90
Caustic regenerators	0.30
Fluorine systems (BF_3, Freon, …)	0.90
Glycol contactors (dehydrators)	0.65–0.75
Glycol regenerators	0.85
Oil absorbers, top section	0.85
Sour water strippers	0.50–0.70
Non-foaming (conventional) systems	1.0
Moderate foaming	0.85
Heavy foaming	0.73
Severe foaming	0.60
Foam-stable	0.30

Table 1. While these values often are used, they are not always appropriate.

Flow Meter Targets Small-Scale Gas Dosing

The compact ST75 Series air/gas flow meter, available in both insertion and inline configurations for small-line batch and continuous processes, is designed for gas dosing and injection in tight, crowded equipment areas. It reportedly measures the gas flow rate and the totalized flow of gas with high accuracy and repeatability. The flow meter's solid-state thermal-dispersion mass-flow sensing element with platinum RTDs is housed in equal-mass thermowells for trouble-free service. It measures virtually any gas or gas mixture. It can be calibrated to measure gases over a flow range from 0.04 to 559 SCFM (0.07 to 950 NCMH), depending on line size, which is useful in low-flow applications requiring small doses.

Fluid Components International (FCI)
800-854-1993
www.fluidcomponents.com

Diaphragm Switch Alerts to High or Low Levels

The BM-25 bin level indicator alerts operators to high or low levels or when chutes or conveyors are clogged. It is said to be a simple and convenient way to stop overflowing product or wasting valuable material in the bottom of a bin. The indicator's mechanism activates a sensitive micro-switch to indicate when material reaches the level of the switch in the bin. Typically, it is wired to a light, horn or alarm panel. The switch has a silicone diaphragm and is enclosed in a nylon housing, designed to increase durability. There are models to mount internally or externally. Its corrosion-free polymer construction is designed to withstand dry bulk solids.

BinMaster
800-278-424
www.binmaster.com

Mixer Suits Viscous Processes

The PDDM planetary dual disperser offers shear intensity and rapid dispersion of dry powders into viscous batches. The system enables solid additions to be made quickly and efficiently, thanks to two stainless-steel high viscosity "HV" stirrer blades and two high-speed shafts with saw-tooth dispersers. When equipped with removable disperser shafts, the unit can serve as a regular double planetary mixer for processing even more viscous applications including very stiff, dough-like formulations that rely more on a purely kneading action. Sizes range from lab scale to full production models.

Charles Ross & Son Company
800-243-7677
www.mixers.com

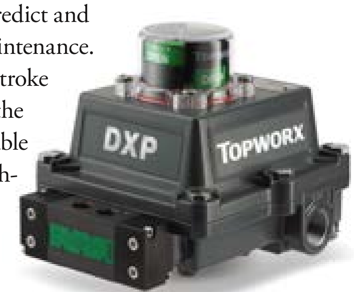
Meter Measures Trace Water Vapor Content

The battery-powered, portable, fast-responding, PPM2 hygrometer uses a fundamental principle and a diffusion barrier to measure trace water vapor in gases from 0.1 to 1,250 ppmv. Recalibration is not required under normal usage, says its maker. It is configured to meet remote, spot sampling or semi-permanent absolute humidity measurement requirements. The unit is designed for relatively clean, dry, inert gas measurement. It uses an electrolytic phosphorus-pentoxide sensor in combination with a protective, proprietary, semi-permeable diffusion membrane. The principle of operation applies Faraday's Law of Electrolysis to determine the water vapor content by measuring the dissociation current needed to electrolyze the water molecules in a gas sample.

Edgetech Instruments Inc.
978-310-7760
www.edgetechinstruments.com

Controller Improves Safety, Uptime

TopWorx DX partial stroke test (PST) with HART 7 integrates seamlessly with existing valves and control systems, giving operators access to critical valve data, trends and diagnostics that can be used to predict and schedule maintenance. The partial-stroke test ensures the system's reliable function without shutting down the process. A safety feature confirms the valve will fully close and stop the process if an emergency is detected; the test is activated by simply pressing the local PST button — no additional equipment is required. To prevent critical failure in upset conditions, the unit will override testing to perform an emergency shutdown.



Emerson Automation Solutions
888-889-9170
www.emerson.com

Thermometer Meets Hygienic Standards

Bimetal thermometer model TG58SA is ASME BPE-compliant, meets the 3-A Sanitary Standard and has EHEDG and ATEX approval. This display instrument is flexible with industry-standard scale ranges and process connections (clamp, DIN 11864, VARINLINE). All information about the connections is lasered on. In addition, the active length of the sensor is indicated on the dial to ensure correct temperature measurement. The measuring instrument's stem has a hemispherical bottom. The unit can be cleaned in a process-safe manner in accordance with 3-A and EHEDG. It is suitable for clean-in-place/sterilization-in-place and wash-down processes. The thermometer offers a high overtemperature resistance, and includes a shatterproof, UV-resistant window.

WIKA
888-945-2872
www.wika.com

System Minimizes Contamination of Solids

This mobile sanitary IBC (intermediate bulk container) unloading and conveying system transfers contamination-sensitive bulk solid materials from IBCs to downstream processes, dust free. The discharger frame is mounted on casters for in-plant mobility, while a hinged subframe supporting a surge hoper, flexible screw conveyor and support mast can pivot down for maneuvering through doorways and low-headroom areas. Materials flowing from the IBC into the charging adapter of a flexible screw conveyor are propelled at an incline, and discharged into the elevated process equipment and storage vessels. The conveyor handles free- and non-free-flowing bulk solids, ranging from pellets to sub-micron powders with no separation of blended products.

Flexicon Corp.
888-353-9426
www.flexicon.com

Portable Meter Cuts Process Interruptions

This portable transit-time ultrasonic flow meter measures flow on demand, without difficult installations or process interruptions, says its maker. The hand-held unit is encased in a rugged IP67 housing and works with three interchangeable transducers, suiting it for measurements in varying metal and plastic pipe materials ranging in size from ½-in. to 48-in. in diameter. A simple menu allows for fast and easy programming of pipe diameter, pipe material, liquid types and measurement units. In addition to providing a standard 4–20-mA/0–5-V analog output, optional Modbus RTU and HART communications provide instantaneous flow rate, volume, total, run hours and diagnostic information.

AW-Lake
800-850-6110
https://aw-lake.com/

Monitoring Instrument Detects Corrosion Early

The ÅirIQ corrosion-monitoring instrument features real-time monitoring of the effects of airborne contaminants on critical equipment.

Based on ISA 71.04-2013 standards and using electrical resistance technology, the system monitors not only temperature, but also relative humidity, differential pressure, and other potential threats to critical equipment. Data are transmited directly to the control system in real-time, reflecting changes in the environment immediately and allowing for quick implementation of corrective actions. The unit operates in any industrial environment with multiple communication protocols to integrate with a range of electronic infrastructures.

Cosasco
800-635-6898
www.cosasco.com/airiq

Controller Manages Multiple Feeders

The Gericke GUC-F universal feeder controller allows additional feeding capacity to be installed to meet increased or changing production demands without purchasing additional, individual controllers for each feeder. Devised to future-proof against sudden demand spikes and provide flexibility to accommodate frequent recipe changes, the universal feeder controller instrumentation automates control over weighing, dosing and feeding from up to four feeders on up to four different processing lines from a single human-machine-interface screen. Accurate weighing and precise powder feeding are ensured in a streamlined production operating with reduced equipment, labor, and maintenance costs.

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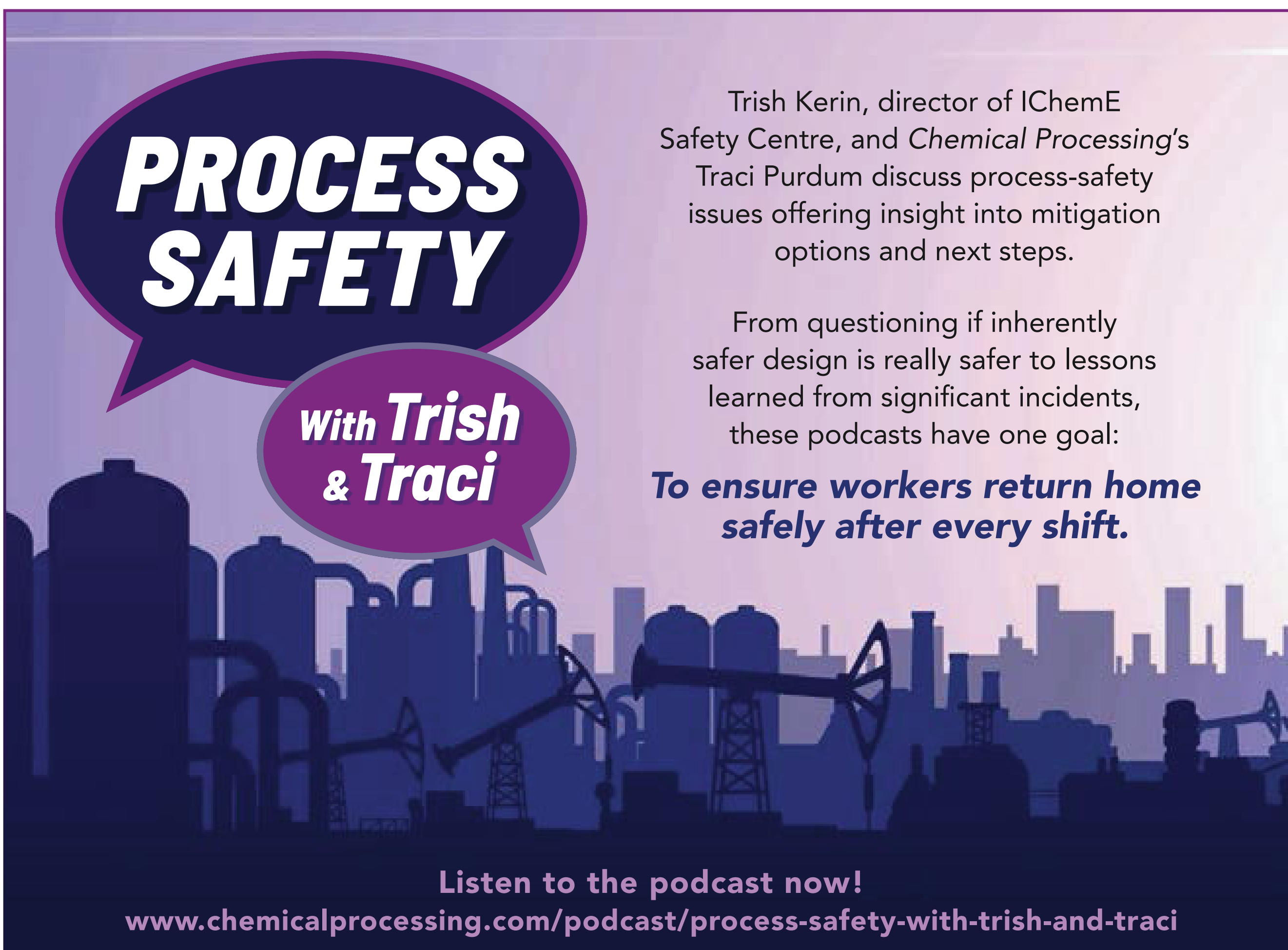
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Biodegradable Materials Need a Closer Look

A 10-year biodiversity probe raises questions for the chemical industry

"We don't know what impacts these materials may have on ocean life."

AN INTERNATIONAL team of experts has identified 15 key issues as likely to have a significant impact on marine and coastal biodiversity over the next 5–10 years. Several tie in with chemical industry interests.

Thirty experts in marine and coastal systems from 11 countries, and from a variety of backgrounds including scientists and policymakers, developed an "horizon scanning" technique that focuses on identifying issues not currently receiving widespread attention, but that will likely become important over the next decade. The aim is to raise awareness and encourage investment into full assessment of these issues now, to drive policy change before the issues have a major impact on biodiversity. Their latest report is published in a recent issue of *Nature Ecology & Evolution*.

"Marine and coastal ecosystems face a wide range of emerging issues that are poorly recognized or understood, each having the potential to impact biodiversity," says James Herbert-Read of the Department of Zoology at the University of Cambridge, Cambridge, U.K., and joint first author of the paper. "By highlighting future issues, we're pointing to where changes must be made today — both in monitoring and policy — to protect our marine and coastal environments," he adds.

Of particular relevance to the chemical industry is the section concerning the effects of biodegradable materials in the marine environment. While consumer pressure is prompting the replacement of some fossil-fuel-based plastics with biodegradable polymers, the report's authors stress rigorous toxicity testing or lifecycle assessments of biodegradables is needed.

"Materials such as polybutylene succinate, polylactic acid, or cellulose and starch-based materials may become marine litter and cause harmful effects akin to conventional plastics. The long-term and large-scale effect of the use of biodegradable polymers in products (e.g., clothing) and the unintended release of byproducts, such as microfibers, into the environment remain unknown. However, some natural microfibers have greater toxicity than plastic microfibers when consumed by aquatic invertebrates," the authors note.

They urge jurisdictions to enact and enforce suitable regulations to require individual assessment of all new materials intended to biodegrade in a full range of marine environmental conditions. In addition, testing should include studies on the toxicity of major transition chemicals created during the breakdown process, ideally considering the different trophic levels of marine food webs.

"Governments are making a push for the use of biodegradable materials — but we don't know what impacts these materials may have on ocean life," Herbert-Read emphasizes.

Another issue raised is resource exploitation. Here, the report points to pharmaceuticals, cosmetics, nutraceuticals and biomedical industries' efforts to find new sources of collagen for use in their products. Religious issues and potential disease transmission hazards from traditional bovine and porcine sources is focusing attention on alternatives such as marine organisms discarded by fisheries. However, the report notes that this could discourage the industry's efforts to reduce the capture of non-target species. More sustainable could be jellyfish harvesting and waste products from the fish processing industry including skin, bones and trims.

Then there is lithium, demand for which is expected to increase five-fold by 2030. As well as battery manufacturers, biomedical applications including pharmaceuticals, industrial agents, and biomaterials are all clamoring for new supplies. One potential source is deep-sea brines and cold seeps, using solid-state electrolyte membranes to enrich the element's concentration. However, these deep-sea ecosystems and potential sources of novel marine genetic resources that could be used by the same industries are little understood. "These concerns point to the need to better quantify and monitor biodiversity in these extreme environments to establish baselines and aid management," the authors write.

Trace element contamination is another issue and one likely to be compounded by the transition to green technologies. Electric car batteries currently depend almost exclusively on lithium-ion chemistries, with potential trace element emissions spanning their lifecycle from raw material extraction to recycling or end-of-life disposal. The report notes, "Increasing pollution from battery production, recycling, and disposal in the next decade could substantially increase the potentially toxic trace element contamination in marine and coastal systems worldwide."

This horizon scanning process has previously been used by Cambridge researchers to identify issues that later came to prominence; a scan in 2009 gave an early warning that microplastics could become a major problem in marine environments.

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