WWW.CHEMICALPROCESSING.COM

CHEMICAL PROCESSING

LEADERSHIP | EXPERTISE | INNOVATION

CONJURE MACHINE MAGIC

Digitalization of machine performance keeps chemical plants running during challenging times

Avoid Big Trouble from Little Changes, Part 1

9 Tips for Silos, Hoppers and Bins, Oh My

Identify and Address a Water Hammer Event

FEBRUARY 2023


HISTORY
IN THE MAKING
Over 175 years...but who's counting?
Mixing our experience and quality craftsmanship
to make your process productive and cost-effective.
Learn how ROSS equipment serves in the chemicals industry.
mixers.com/chemical
ROSS
Charles Ross & Son Company
Pioneers in mixing and blending since 1842
mixers.com | 1-800-243-ROSS

CHEMICAL PROCESSING FEBRUARY 2023 | VOLUME 85, ISSUE 1

COVER STORY

14 Conjure Machine Magic
Remote condition monitoring enables real-time insights that keep plants operating during the most challenging times, while increasing efficiencies and worker productivity.

FEATURES

DESIGN AND OPTIMIZATION

19 Avoid Big Trouble from Little Changes, Part 1
Objective criteria and consistent use drives better process safety review screening, which helps prevent process hazard review misses.

MAINTENANCE AND OPERATIONS

23 How to Identify and Address a Water Hammer Event
Water hammer events can burst pipes and lead to significant damage. Learn how to prevent downtime and costly repairs with some key mitigation strategies.

SOLIDS AND FLUIDS HANDLING

27 Silos, Hoppers and Bins, Oh My
Proper storage and handling of vessels for bulk materials is a critical factor that often gets overlooked when it comes to chemical safety. Here are nine tips to mitigate those risks.

MAKING IT WORK

31 Filtration Solution Outperforms Standard
Eaton's filtration engineers chose Loftrex Nylon filter cartridges with a retention rating of 100 µm to provide the ideal homogenization of the amine condensate.

COLUMNS

5 From the Editor: Ready For the Second Act?

7 Solid Advice: Don't Overlook Orphaned Physical Properties

8 Stay Safe: What Are Your Shell Middens?

12 Energy Saver: Consider Price Equivalent Efficiency Savings

13 Compliance Advisor: FTC to Revise Green Guides, Again

32 Plant InSites: Fight Foam Accumulation

38 End Point: Gene Tool Fixates on Fungi

DEPARTMENTS

6 Chemical Processing Online

9 In Process: Catalyst Cuts Haber-Bosch Costs | Fine Bubbles Increase Hydrogen Production 50-Fold

34 Equipment & Services

35 Classifieds

37 Ad Index

Chemical Processing© is a registered trademark. Chemical Processing is published monthly by Endeavor Business Media, LLC 2023, 1233 Janesville Avenue, Fort Atkinson, WI 53538. Subscription rates per year: U.S. $68.00; Canada and other international $200 (payable in USA funds). Single copies: U.S. $15.00. All rights reserved. Reproduction in whole or in part without permission is prohibited. We make portions of our subscriber list available to carefully screened companies that offer products and services that may be important to your work. If you do not want to receive those offers and/or information via direct mail, please let us know by contacting us at List Services Chemical Processing 1233 Janesville Avenue, Fort Atkinson, WI 53538. Printed in the USA. POSTMASTER: send address changes to Chemical Processing, PO Box 3257, Northbrook, IL 60065-3257.

Ready For the Second Act?

The stage is set for more *Chemical Processing* magic

BACK IN 2008, I left a chief editor gig at another publication and accepted a position with *Chemical Processing* as the brand's digital editor, focused on building the brand's webinars, podcasts, blogs and newsletters.

For 14 years I served as Teller to Editor-in-Chief Mark Rosenzweig's Penn (although no one would ever peg me as the silent type). Now, I've dusted off my editor-in-chief cape — and I'm ready for the show.

After five magical decades in the industry, Mark pulled off one final trick as our master mage — he made himself disappear. When the curtain closed, he packed up his typewriters (he boasts well over 100 machines) and drove off toward retirement in his Studebaker Gran Turismo Hawk.

Before Mark left, he made sure he practiced what we preach in our industry coverage: Don't let knowledge vanish. He enrolled me in the Rosenzweig Ramblings program of prestidigitation and taught me many of his trade secrets — from his New York style of nudging sources to perform at their best to the keys to conjuring up exactly what readers need.

To help me on stage, I set out on a search for an executive editor. Enter Jonathan Katz, a journalist who brings nearly two decades of experience to *Chemical Processing*. He has expertise on a wide range of industrial topics and has hit the ground running, writing features and news coverage for the brand. He and I have worked together over the years and we both cut our teeth in the B2B space on *IndustryWeek*, one of *Chemical Processing*'s sister publications.

As you'll learn in this month's cover story, "Conjure Machine Magic" (page 14) by Seán Ottewell — *Chemical Processing*'s editor at large — knowledge should not be compartmentalized. "Rather, it should focus on complementing process engineers' traditional service activities by offering new aspects that will expand and enhance what they are already doing."

While the article is referring to condition monitoring, this sentiment rings true in our roles as editors. We strive to offer new ways for the audience — you — to expand and enhance their knowledge. Our web-exclusive coverage is growing, and we are introducing new voices to our expert lists.

Another feature in this issue, "Avoid Big Trouble from Little Changes," (page 19) by Jody E. Olsen, P.E., takes a deep dive into the nuances of management of change as it pertains to process-hazard reviews. Working with Jody to make certain her words delivered exactly her meaning proved to me that even the slightest deviation could be catastrophic. Both Seán's feature and Jody's story work in tandem to drive home an important point: information matters.

Success requires more than simply connecting equipment to the cloud. "A partner with service expertise is essential to make effective use of the data collected." And even where questions are carefully crafted to identify conditions needing process-safety assessment, without a skilled process-safety practitioner signing off on the screening, changes can be missed — and it's that sleight of hand that can lead to failure.

Jon, Managing Editor Amanda Joshi and I have a big task in front of us to ensure Mark's legacy lives on through the pages and web-exclusive content we create. We intend to move forward with the blueprint Mark crafted but we also aim to create a few new tricks of our own.

TRACI PURDUM, Editor-in-Chief
tpurdum@endeavorb2b.com

Before Mark left, he practiced what we preach in our industry coverage: Don't let knowledge vanish.

ENDEAVOR BUSINESS MEDIA
30 Burton Hills Blvd, Ste. 185
Nashville, TN 37215
800-547-7377
www.chemicalprocessing.com
chemicalprocessing@endeavorb2b.com

EDITORIAL STAFF

Traci Purdum, Editor-in-Chief
630-454-7077
tpurdum@endeavorb2b.com

Jonathan Katz, Executive Editor
jkatz@endeavorb2b.com

Amanda Joshi, Managing Editor
ajoshi@endeavorb2b.com

Seán Ottewell, Editor at Large
Ireland
sottewell@endeavorb2b.com

CONTRIBUTING EDITORS

Andrew Sloley, Troubleshooting Columnist
Lynn L. Bergeson, Regulatory Columnist
Michiel Spoor, Energy Columnist
Trish Kerin, Stay Safe Columnist
Tom Blackwood, Solid Advice Columnist

DESIGN & PRODUCTION

Derek Chamberlain, Art Director
dchamberlain@endeavorb2b.com

Rita Fitzgerald, Production Manager
rfitzgerald@endeavorb2b.com

PUBLISHER

Brian Marz, Publisher, (708) 404-3334
bmarz@endeavorb2b.com

EXECUTIVE STAFF

Chris Ferrell,CEO
June Griffin, President
Mark Zadell, CFO
Patrick Rains, COO
Reggie Lawrence, CRO
Tracy Kane, Chief Administrative & Legal Officer
Mike Christian, EVP Industrial Group
Keith Larson, VP/Group Publisher

FOR SUBSCRIPTIONS

Local: 847-559-7598
Toll free: 877-382-91870
ChemicalProcessing@omeda.com

CIRCULATION REQUESTS

Carmela Kappel, Assistant to the Publisher
ckappel@endeavorb2b.com
Phone: 630-454-7008

Folio Editorial Excellence Award Winner

UPCOMING WEBINAR

Pneumatic Conveying Roundtable 2023

Date: Thursday, February 23, 2023
Time: 2:00 PM EDT / 1:00 PM CDT / 11:00 AM PDT

This discussion will feature experts from some of the industry's best pneumatic conveying suppliers. Each expert will begin with a short update about new developments, improvements and industry trends. Then moderator Todd Smith, manager at the Kansas State University – Bulk Solids Innovation Center, will lead a discussion about the most important issues affecting anyone who uses pneumatic conveying. Audience questions will be addressed by the experts throughout the program.
https://chemicalprocessing.com/21439131

Speakers:
Brad Schultz, Regional Sales Manager, Magnum Systems
Todd Smith, Business and Strategy Manager,
Kansas State University - Bulk Solids Innovation Center
Kevin Solofra, BSIC Lab Manager,
Kansas State University - Bulk Solids Innovation Center
Traci Purdum, Editor-in-Chief, *Chemical Processing*
Sponsor: Magnum Systems

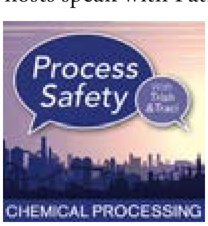
AWARDS

Vie For Vaaler 2023

Nominations are open for *Chemical Processing's* biennial Vaaler Awards, which honor products and services that have dramatically improved the operations and economics of plants in the chemical industry. To be considered for a 2023 Vaaler Award, the product or service must have been commercialized in the United States between May 2021 and June 2023.
https://chemicalprocessing.com/21486880

PODCAST

In this episode of Process Safety with Trish & Traci, our hosts speak with Patrick Jessee, commander/paramedic for the Bureau of Operations of the Chicago Fire Department, about the dangers first responders face and how chemical-processing facilities can mitigate risks and help save lives. Jessee has a degree in chemistry and serves as the Hazardous Materials Training Program Manager for the Northeastern Illinois Public Safety Training Academy.



Hosted by Traci Purdum, Editor-in-Chief of *Chemical Processing*, and Trish Kerin, the director of the IChemE Safety Centre. https://chemicalprocessing.com/11304889

WEB-EXCLUSIVE FEATURES

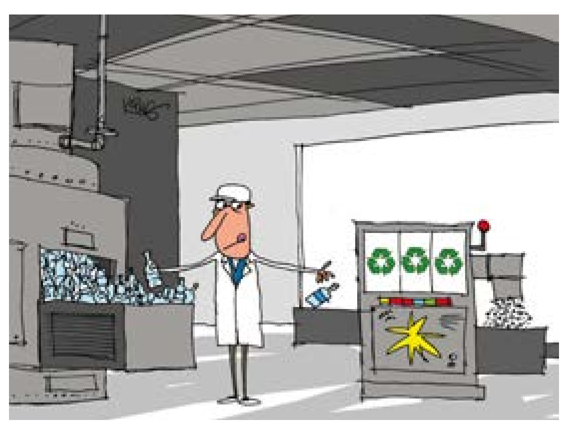
2023 Chemicals Industry Outlook: Brace for Challenges

There are pillars of strength amid the news of slowing growth, soaring inflation and rising energy prices, according to the American Chemistry Council.
https://chemicalprocessing.com/21439097

Single-Use Technology Growth Poised to Continue in 2023

Vendors report high demand as customers look to increase efficiencies.
https://chemicalprocessing.com/21450864

COMICAL PROCESSING



The Comical Processing page features drawings by award-winning cartoonist Jerry King.

Visit the site to submit your own caption. View the gallery of past cartoons, winning captions and all submissions.
www.chemicalprocessing.com/cartoon-caption

Don't Overlook Orphaned Physical Properties

Finding hidden properties will solve emission problems

The number of smokestacks in the area signaled prosperity.

WHEN I started in industry, the number of smokestacks in the area signaled prosperity. Before long, those smokestacks had to be cleaned up. Nowadays, at the end of most processes is some kind of cleanup device to control costs, protect the environment or sustain operations. Think of it as an extension of the process design. It may involve a recycling process or even the development of a new product. The operations cover all the same solids-processing steps we use in process design but often at very low concentrations of solids. This makes for a challenging situation. In air-pollution control, the particles can be sub-micron, with only a few micrograms per cubic meter allowed to be released. For water quality issues, we may draw in water for a cooling process and return it cleaner than what was received.

One of my first jobs was to build a sewage sludge incinerator. Our company was on the cutting edge of this technology, and we needed to make sure people didn't look at our emissions as hazardous, stinky or damaging to the area. The incineration operation did a nice job of getting rid of these issues but still would have a noticeable white plume. Luckily, the plant had an excess of water after processing the sewage. We incorporated that flow into the scrubber design to cool the gas low enough to eliminate the visible plume. While regulations or expectations may change, this system was state-of-the-art in those days. Today, energy usage would be the forefront concern, but biological processes have advanced to take over that operation.

The company also had a process that made a very specialized form of fuel. It roasted the starting material to remove all contaminants without any visible emissions. The product was several million tons per year with very low emissions. However, changes in regulations required an order-of-magnitude decrease in the emission rate. An end-of-the-pipe emission control system was not feasible due to lack of water, high process temperatures and low power availability. So, we looked at several alternatives. One option was to change the process equipment, but that proved to be a dead end. A literature search uncovered a little-known characteristic of our feed material. The inorganic chemicals were in the crystalline lattice on the fault lines and accounted for most of the particulate emissions. The addition of a grinder and a fluid bed removed most of the particulate before going into the roaster. This very simple front-end addition to the process allowed the plant to reach the new emission requirements.

Many people don't realize that solids have a vapor pressure similar to liquids. A new process had been developed for an agricultural product known to kill vegetation. The tail end of the process had a HEPA filter to prevent any of that material from leaving the plant. However, shortly after starting the operation, some dead vegetation showed up around the plant. Although the solid had a vapor pressure of less than one Torr, the particles were concentrating on one side of the filter and migrating to the other side and being released as fine particles. The addition of an adsorber that immobilized the particles solved the problem. This was not an easy problem to diagnose, especially when no liquids were involved.

I like to call these examples the "lost or orphaned physical properties" because they are simple to overlook when designing a process involving solids. It is even easier to miss these properties when we are concentrating on particulate control. Scrubbers remove particles, but their discharge can attract attention even though it may be only condensed water vapor. Fabrics (including HEPAs) are porous, but they are seldom effective by themselves on gases because of the vapor pressure, as mentioned above. Sometimes, the solution is hidden in the front end of the process. We just need to find that hidden physical property that will solve the emission problem.

The difference between design of a chemical plant and pollution control is the very small solids loading and the value of the product. Replacing the old smokestacks is considered a sustainability and compliance matter. ●

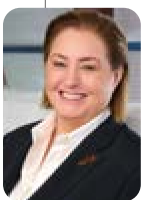
EXPLORE ISSUES POSED BY SOLIDS

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

TOM BLACKWOOD, Contributing Editor
TBlackwood@endeavorb2b.com

What Are Your Shell Middens?

Storytelling provides a great way to communicate vital process-safety information



The human brain has an amazing ability to learn all sorts of information.

STORYTELLING AS a means of communication is a valuable tool to help people learn and retain important lessons. It is not about making things up but rather creating a memorable interaction.

Early in my career, I was involved in the aviation fuel industry. The power of understanding the importance of product-quality checks hits home when you stand below a passenger aircraft and see people boarding — you realize your personal effort makes a difference to their safety.

To ensure traceability, everything had to be documented. Indeed, a wise airport terminal manager once said to me (as I stood below the aircraft watching it refuel), "If it's not written down, it never happened." This statement has stayed with me my entire career. However brief, it's still a form of storytelling, a method to communicate important messages in a way that sticks.

With that in mind, let me share a story with you. I recently traveled to a remote and beautiful part of Australia called The Kimberley. It's a sparsely populated, rugged area with prehistoric significance. To prepare, I read a book on ancient rock art. However, you can't really prepare for seeing art believed to be between 3,000 and 5,000 years old that is directly linked to the current indigenous population. From there, we hiked to a beach that featured a shell midden — thousands of years of shells discarded after being cooked and eaten. All these experiences got me thinking about how the First Nations people in Australia had maintained a continuous civilization in harmony with nature for an estimated 60,000 years, and secondly, what can we learn from them in today's world?

The many different nations of people in Australia had no written language, but they had amazing scientific knowledge and understanding of the environment. They communicated life lessons via stories and rock paintings. The creation stories tell of how features in the earth formed, helping them map out and remember where to find fresh water. The rock art showed what food was edible (illustrations of various animals and plants). The shell middens showed which crustaceans were safe to eat. They had sophisticated methods of making food safe, such as processing various root vegetables to remove toxins before consumption. They then communicated their methods.

In modern society, we seem to focus on the frenetic speed of life. We focus on the present without thinking about the future and passing on lessons. As adults, we often dismiss stories as childish and don't take the time to share lessons effectively. Sure, we publish bulletins or safety posters showing what went wrong, but we don't often take the time to share a story or create the emotion to make the learning stick.

The Kimberley features ancient rock art believed to be between 3,000 and 5,000 years old.

The human brain has an amazing ability to learn all sorts of information, depending on how it's presented. Think about when you hear your favorite song; you know the lyrics and can sing along. This is a form of a story, and something that you remember without even trying. Yet reading a document with a set of facts and details is something we may not always recall.

Think about the last time you heard someone give you important information. How was the information conveyed? Was it a presentation or report full of facts and details? Or were the facts and details conveyed via a story — giving background and meaning to the data and explaining details using examples? My guess would be it has been some time since you heard or read a story using examples to explain a concept.

Storytelling is gaining momentum in business and provides a great way to communicate vital information, such as how we manage process safety. This is because it allows us to use familiar examples to explain unfamiliar things.

So, when it comes to safety in our organizations, I wonder if we could improve outcomes if we took the time to slow down and communicate with stories. Certainly, the impact of seeing people board a plane and knowing their safety depended on me doing my job is a visual story that still resonates.

In your workplace, what are the symbols and stories that help people stay safe in their jobs? What are your shell middens? ●

TRISH KERIN, Director of the IChemE Safety Centre
TKerin@icheme.org

Catalyst Cuts Haber-Bosch Costs

The metal-nitride catalyst is stable in the presence of moisture

RESEARCHERS FROM Japan and China have developed a new catalyst that could be used as an inexpensive option to reduce the carbon footprint of the Haber-Bosch ammonia manufacturing process.

According to a report in a recent *Angewandte Chemie*, it consists of a metal nitride catalyst containing an active metal — nickel — on a lanthanum nitride (LaN) support that is stable in the presence of moisture.

Nitride-based catalysts containing active metal nanoparticles such as nickel (Ni) and cobalt (Co) have long been investigated as ways to allow the Haber-Bosch process to proceed under milder conditions. However, the presence of moisture during the reaction causes rapid catalyst degradation.

What the team based at Tokyo Tech, Japan, has done is dope aluminum atoms into the LaN structure and then synthesized a chemically stable La_3AlN support containing La-Al bonds. It is these bonds that prevent lanthanum atoms from reacting with moisture.

The new La-Al-N support together with active metals such as nickel and cobalt (Ni, Co) was able to produce NH_3 at rates similar to that with conventional metal nitride catalysts and could maintain a stable production when fed with nitrogen gas containing moisture. The Ni- or Co-loaded La-Al-N catalysts showed no distinct degradation following exposure to 3.5% moisture.

Another advantage is the catalyst doesn't contain ruthenium and as such presents an inexpensive option for reducing the carbon footprint of ammonia production.

One issue that needs to be overcome with the new catalyst, however, is that preparing La-Al-N requires a relatively complicated material synthesis process.

"We first melt La, Al and LaN and then need to anneal the products at 850°C for one week. In addition, the annealing process needs to be progressed in an inert atmosphere or vacuum," says Yangfan Lu, study co-author and professor with the College of Materials Science and Engineering, National Engineering Research Center for Magnesium Alloys, Chongqing University, Chongqing, China.

One option, trialing alternative rare-earth elements, is not on the table at the moment. "We believe developing a facile synthesis technique is more important than exploring different rare-earth elements," explains Lu.

"So, while this step is still in the R&D stage it is unlikely to be immediately applied to industry. Instead, our previously studied systems, such as Ru/C12A7:e− [a catalytic promoter], which show high catalytic activity for ammonia synthesis, and which can be prepared by an easier method, are considered more suitable for industrial applications at this stage," he concludes.

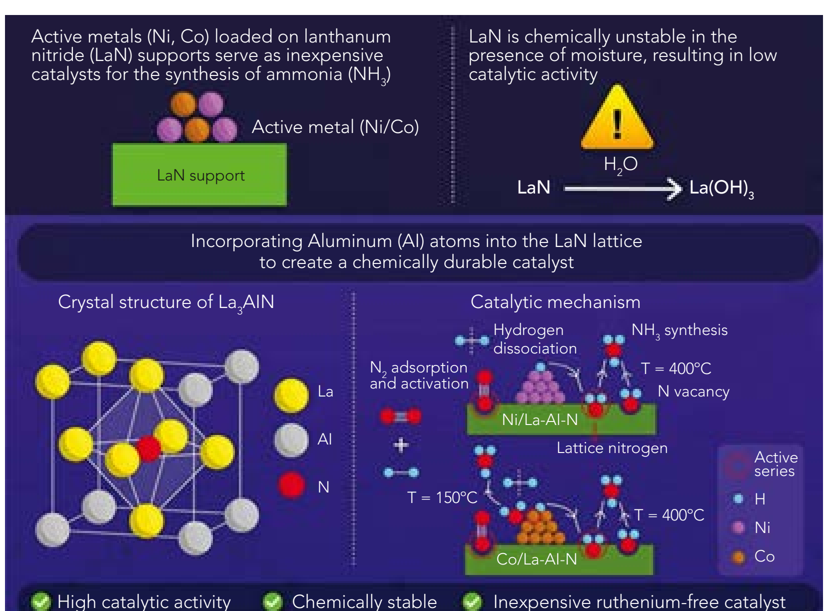


Figure 1. The introduction of La-Al bonds to LaN prevents lanthanum from reacting with water, stabilizing the metal nitride support and maintaining its high catalytic activity. *Source: Angewandte Chemie.*

Fine Bubbles Increase Hydrogen Production

Reaction holds significant potential for the future green-hydrogen economy

RESEARCHERS IN Erlangen, Germany, have discovered a way to increase by 50-fold the mass transfer in a heterogeneously catalyzed reaction. The development could play a central role in future hydrogen storage and transport technologies.

The researchers say their findings came about due to the nucleation of gas bubbles in the catalyst pore structure. They also found productivity increases significantly for this type of catalyst in gas-generation reactions when gas bubbles form easily in the catalyst pores.

"This additional factor, which significantly determines the reaction rate, was previously unknown," says Peter Wasserscheid, professor and director of the Helmholtz Institute Erlangen-Nürnberg for Renewable Energy and head of chemical reaction engineering at Friedrich-Alexander-Universität Erlangen-Nürnberg. "Until now, it was assumed that the reaction rate was determined only by the chemical surface reaction or by the transport of molecules to the active centers of the catalyst."

When the researchers made their findings, they were investigating catalytic hydrogen release

A catalyst pellet for hydrogen release. *Source: HI ERN/Thomas Solymosi.*

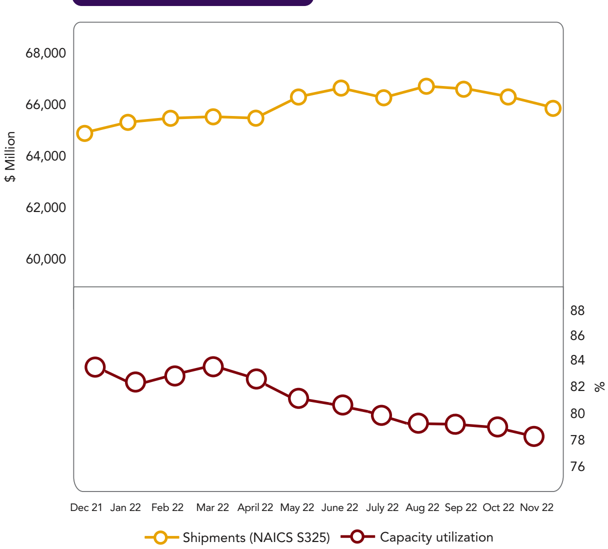
from the liquid organic hydrogen carrier (LOHC) compound perhydro-dibenzyltoluene — a reaction they believe is of the highest relevance for the future green-hydrogen economy.

The researchers determined a nucleation-inhibited catalytic system produces only dissolved hydrogen with fast saturation of the fluid phase around the active site, while bubble formation enhances mass transfer by more than a factor of 50 in an oscillating reaction regime. Nucleation can be efficiently triggered not only by mechanical stimulus but also by temperature changes and catalyst surface modification.

Bubbles in the catalyst pores are acting like tiny pumps, says Wasserscheid, helping to remove the released hydrogen. Once a bubble has formed in a catalyst pore, as it grows it collects hydrogen formed there. When the bubble then detaches into the surrounding liquid, the loaded hydrogen carrier flows back into the pore and the process starts all over again.

The work appears in a recent issue of *Science Advances*, where in the "competing interests" section, Wasserscheid is named as a founder and a minority shareholder of the company Hydrogenious LOHC Technologies, also in Erlangen, and offering commercial hydrogen storage systems based on LOHC technology. He and the other authors also are listed as inventors of two patent applications related to the preparation of catalyst material for the dehydrogenation and/or hydrogenation of a hydrogen carrier material, and to the release of a gas from a carrier material. ●

ECONOMIC SNAPSHOT



Both shipments and capacity utilization decreased.
Source: American Chemistry Council.

Consider Price Equivalent Efficiency Savings

Use this simple methodology to optimize your energy management system

Because of high energy prices and regulatory changes, we are under pressure to reduce emissions.

NEW BEGINNINGS and a new writer for the *Chemical Processing* Energy Saver column mark the new year. As an avid reader of *CP*, I have thoroughly enjoyed the past columns by my predecessor, Alan Rossiter. I am deeply honored to serve as your next columnist.

I'd like to start off my first print column by noting big changes are happening in our industry. Because of high energy prices and regulatory changes, we are under pressure to reduce emissions. New technologies are emerging to save energy and bring the industry to a net zero standard. As a consultant in the field of energy efficiency, energy transition, emission reduction and decarbonization programs, I'm delighted to share my experiences with you.

With that in mind, I would like to introduce a simple but useful tool to help you reduce the cost of energy imports while optimizing the efficiency of shaft-power production. You can argue reducing energy cost is not always equal to emission reductions, and that may be true. However, many refining and petrochemical operators are driven by energy costs to become more efficient and reduce emissions.

First, let's consider some concepts. Chemical plants use shaft power to drive equipment like pumps, compressors, fans, blowers and other rotating equipment. This shaft power can be provided by electrical motors, steam turbines, gas turbines and sometimes direct coupling with turbo expanders to transfer kinetic energy from a high-pressure process source to drive a pump or compressor. At many sites, the steam turbines and gas turbines may also be used as drivers to generate power, which in turn will be used for electrical motors. Each of these drivers operates on different efficiencies.

The concept of price equivalent efficiency (PEE) can be used to determine which drivers to use to generate shaft power and whether you need to focus on increasing power imports or on-site generation. The PEE is defined as the ratio of cost of marginal fuel divided by the cost of marginal power.

FIND MORE ENERGY SAVINGS OPPORTUNITIES

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

$$PEE(\%) = \text{Cost of Marginal Fuel (in \$/MWh)} / \text{Cost of Marginal Power (in \$/MWh)} \times 100\%$$

Marginal fuel is defined as the variable amount of fuel imports that will change if you produce more steam to drive steam turbines or produce more power with your gas turbine in your cogeneration or combined heat and power plant. The cost of marginal power is the cost of power imports in this methodology.

Typically, an external (cogeneration) power plant, such as a utility plant, produces the imported power that uses fuel, too. With these factors in consideration and the inefficiencies of these power plants, the PEE typically ranges from 25% to 60%. This means that on an equivalent energy basis the fuel cost is 25% to 60% compared to the cost of imported power. The PEE can differ based on power tariffs, day and night tariffs and summer and winter tariffs. These will determine your power generation strategy on a continuous basis.

For example, consider your site uses a steam-turbine generator with a condensing cycle. When taking the boiler's efficiency into consideration, the machinery's overall cycle efficiency typically ranges from 25% to 30%. With a PEE under 25%, this generator will run more efficiently and minimize your power imports. With a PEE over 30%, you would prefer to import power and shut down (or minimize production of) this generator. This can potentially change between day/night import power tariffs.

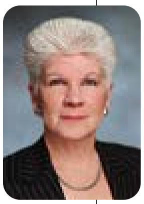
Recently, I visited a refinery in South America to improve the cost of their energy imports. A quick calculation showed a PEE surpassing 120%. This scenario appeared unusual. The refinery benefited from cheap renewable power imports but paid high natural gas prices. As no power generation will ever be more efficient than approximately 90%, the refinery had to shut down all shaft-power production by steam and gas turbines, where sparing and reliability made it possible, while maximizing power imports. This allowed the refinery to reduce its operating costs and overall emissions.

I look forward to sharing more stories like this one in future columns. ●

MICHIEL SPOOR, Energy Columnist
mspoor@endeavorb2b.com

FTC to Revise Green Guides, Again

The demand for environmentally friendly products also means false claims could increase



The Green Guides are arguably more important now than they were when first issued.

THE FEDERAL Trade Commission (FTC) is tinkering with the Guides for the Use of Environmental Marketing Claims (Green Guides). Given the growing appeal of "green claims" for a variety of products, it is fitting the FTC is refining and modernizing the Green Guides to help marketers avoid making environmental marketing claims that are unfair or deceptive under Section 5 of the FTC Act. Importantly, the FTC seeks to update the guides "based on increasing consumer interest in buying environmentally friendly products."

The Green Guides were last revised in 2012. A lot has changed since then; the demand for "green" products has increased significantly. So too has the opportunity for deception. The guides provide much-needed guidance on environmental marketing claims, including how consumers are likely to interpret claims and how marketers can substantiate claims to avoid deceiving consumers in violation of the FTC Act.

The FTC has asked specific questions to elicit comments from the public on general issues related to the Green Guides. These include the continuing need for the Green Guides, their economic impact, their effect on the accuracy of various environmental claims, and their interaction with other environmental marketing regulations. The FTC also seeks consumer survey evidence and consumer perception data regarding environmental claims, including those not in the Green Guides currently.

As of press time in early January, the FTC stated it expects "many public comments" (comments are due in late January 2023) on specific issues that have sparked significant controversy over the past decade. These include:

- Carbon offsets and climate change. The current Green Guides provide guidance on carbon offset and renewable energy claims. The FTC asks whether the revised guides should provide additional information on related claims and issues.
- The term "Recyclable." Among other things, the FTC seeks comments on whether it should change the current threshold that guides marketers on when they can make unqualified recyclable claims, as well as whether the Green Guides should address in more detail claims for products collected (picked up curbside) by recycling programs but not ultimately recycled.
- The term "Recycled Content." The FTC asks whether unqualified claims about recycled content — particularly those related to "pre-consumer" and "post-industrial" content — are widely understood by consumers, as well as whether alternative methods of substantiating recycled content claims may be appropriate.
- The FTC also seeks comment on the need for additional guidance regarding claims such as "compostable," "degradable," "ozone-friendly," "organic," and "sustainable," including those regarding energy use and energy efficiency.

The FTC's website lists recent cases relating to topics covered by the Green Guides.

Given the ever-growing commercial imperative to be green, sustainable and a member of the circularity crowd, the Green Guides are arguably more important now than they were when first issued. They provide important guidance to companies by setting forth factors and/or required criteria for truthful, substantiated claims as opposed to otherwise potentially amorphous claims such as "recyclable."

In the decade since the Green Guides were last updated, there have been scientific, regulatory, and consumer perception developments. The FTC seeking comments and reflecting these new developments in updated guides to assist companies in making an increasing number and variety of "environmentally friendly" claims is a positive step.

The FTC may also wish to intensify its enforcement of the guides. Non-compliance can be expected to increase beyond what already is considered widespread as demand for green products increases.

When the Green Guides were last updated, the FTC relied heavily upon submitted comments in determining marketing perceptions and whether and how it could provide guidance for both general and specific environmental claims. The FTC determined at that time insufficient information or evidence existed to provide guidance for several claims, including for "sustainable," "organic," and "natural." Claims related to "energy use" and "energy efficiency" were not specific terms for which the FTC sought comments in 2012. The FTC's ability to update the guides effectively hinges on well-reasoned and well-supported comments from stakeholders.

LYNN L. BERGESON, Regulatory Editor
lbergeson@endeavorb2b.com

By Seán Ottewell

CONJURE MACHINE MAGIC

Digitalization of machine performance keeps chemical plants running during challenging times

REMOTE CONDITION-MONITORING technologies and services, which increased in use during the Covid-19 pandemic, continue to change the way process engineers work.

The growth of digital connectivity via the cloud has provided the infrastructure that makes it possible to offer condition-monitoring services without the need to be on site, according to Mari Haapala, digital solutions unit lead for ABB Motion.

"Digitalization and enhanced connectivity through the cloud have been crucial in tackling the access problem," she says. "Remote-access services have increased safety since teams don't need to be on site. Yet companies were still able to receive the services they needed to keep their operations up and running."

Cloud-based condition monitoring also enables more data sharing, Haapala says. That's because industrial operations can gather and process equipment performance data in real time, which adds significant value by delivering more timely business insights. The result, she says, is better decision-making that maximizes productivity, improves resilience and reduces costs.

> **"Users want easier, faster ways of working with instrumentation as a younger, more technology-savvy workforce becomes responsible for running the plant. They're used to technology working like 'magic,' and that's a much higher standard than the process control world has had in decades past."**

FULL SHUTDOWN AVERTED

An example of this occurred during lockdown at Xianglu Petrochemicals Zhangzhou's plant in Fujian, China. It produces benzenes, liquefied petroleum gases and other products.

According to ABB, the plant reported an outage after one of three ACS1000 variable speed drives on a raw materials mixer tripped due to a power fault. Any downtime of more than 24 hours would allow the raw materials to solidify, requiring manual clearing and then a full cleaning of the mixer. The loss of material in the mixer would cost $150,000 alone, says ABB. The whole process also would have to be stopped, leading to additional losses.

But the plant had installed a condition-monitoring-for-drives service from ABB in 2018 that had been remotely collecting all the drive performance data, including availability, condition, operating parameters and fault events.

The condition-monitoring data allowed ABB engineers to trace the fault to a failed output capacitor. On-site tests by the plant operator further confirmed this. It then took four hours for ABB engineers to source and supply the spare parts needed.

POWERTRAIN MONITORING GETS A BOOST

To further expand its condition-monitoring offerings, in September 2022, ABB announced a partnership with Dutch electrical signal analysis (ESA) company Samotics. The plan is to develop a system that uses both Samotics' SAM4 plug-and-play ESA technology and ABB Ability condition monitoring service for powertrains, a sensor-based technology that analyzes the health and performance of rotating equipment. The solution will be designed to help process engineers optimize maintenance, boost reliability and reduce downtime – particularly of assets in harsh environments.

The two companies are currently setting up four joint pilots in four unnamed process segments — harsh conditions being the common factor. "Samotics has already successfully implemented their solution in these environments — so we are looking forward to fast joint results," says Mari Haapala, digital solutions unit lead for ABB Motion

Further down the line, the plan is to co-develop digital services solutions with Samotics to fully integrate its technology with the ABB Ability powertrain portfolio and offer customers a seamless asset monitoring experience in any given environment.

In terms of the initial agreement, Haapala says the companies were on track with their plans to roll out the Samotics technology in limited markets by the end of 2022, with plans to increase availability geographically over time.

TECH-SAVVY MAGIC

Increasingly, industrial operations are realizing the value of digitalizing manual activities using wireless, self-powered instrumentation as a low-cost way to collect data compared with traditional manual methods, says Andrew Cureton, business development manager for the chemicals market at Emerson Automation Solutions. Chemical plants can send the data to a historian or similar application for analysis or storage.

"Once that data is being collected, getting it off-site over a VPN or a cloud service empowers engineers and technicians to get more done remotely from home or from a central work location in support of multiple facilities," he explains.

The chemical industry, in particular, has shown a strong interest in wireless instrumentation and continuous online data collection.

"We see countless users replacing manual indication gauges with wireless process instrumentation," Cureton says. "The goal is to reduce time in the field that is low value-added. It lowers personnel risk exposure and frees up time to work on actual maintenance activities. Most chemical plants focus on one type of inspection or one process cell/unit to try wireless out, while a few have gone all-in for a transformational upgrade. Covid 19 had a lot to do with accelerating these projects as personnel were discouraged from being on site."

The move to continuous online data collection means plants don't have to shut down operations to observe maintenance issues, such as corrosion. For example, one chemical plant used a corrosion-monitoring sensor on a gasification column for continuous data collection over a couple of years to determine when a section of it needed to be safely retired and replaced, Cureton says.

User experience also has become increasingly important as the workforce changes, Cureton says.

"Users want easier, faster ways of working with instrumentation as a younger, more technology-savvy workforce becomes responsible for running the plant," he shares. "They're used to technology working like 'magic,' and that's a much higher standard than the process control world has had in decades past."

TOP CONDITION MONITORING TIPS

When it comes to advice for process engineers who might be struggling to find the best technologies and strategies to pursue with a condition monitoring project, Mari Haapala, digital solutions unit lead for ABB Motion offers the following guidance:

First, digital condition monitoring should not be compartmentalized. "Rather, it should focus on complementing process engineers' traditional service activities by offering new aspects that will expand and enhance what they are already doing," she says.

Second, projects don't always have to be a "big bang." A stepwise approach can enable customers to progress at whatever pace they find most comfortable. "Condition monitoring will deliver tangible benefits even when just applied to the most critical applications," she notes. "Although, the benefits multiply rapidly when connectivity is rolled out to an entire industrial powertrain."

More generally, she emphasizes that an important, and often overlooked point about digitalization is that success requires rather more than simply connecting equipment to the cloud: "A partner with service expertise is essential to make effective use of the data collected."

Andrew Cureton, business development manager for the chemicals market at Emerson Automation Solutions urges an openness to working with multiple technologies. "One-size-fits-all is a mentality I see many users struggling with, and this approach can make it hard to get started and create positive change," he says. Cureton acknowledges that while it can be uncomfortable for people who have lived entirely in the world of critical process control, stepping outside that and into the world of monitoring opens up many more opportunities for trial and error. Experimentation should be made a priority, he stresses.

Nathan Hedrick, national product manager overseeing level, flow, temperature and pressure at Endress+Hauser, underscores the importance of starting with an installed base audit, either carried out in-house or by a service provider.

"Many users already have smart instruments installed in their operations today, but there is a lot of untapped potential," he says. "It's quite possible that the user already has what they need in terms of the installed base, and they simply need to make a few upgrades rather than purchasing new equipment."

This, he notes, can be a much more cost-effective way to start gaining experience without the need to purchase entirely new equipment. Hendrick's other recommendation is to begin by focusing on a problem that needs to be resolved, such as build-up, corrosion, foaming or entrained gas or gas breakout.

"Ultimately, users can begin collecting data in these areas where known issues are present to later correlate the additional instrument diagnostic data with the issues themselves," he advises. "Manufacturers can also provide guidance and suggestions on the most relevant monitoring parameters to correlate with the issues, specific to the process and application."

Another trend is a growing demand for environmental monitoring capabilities as sensors become more versatile and less costly to implement versus traditional process control instrumentation, notes Cureton. The sensors can measure environmental variables, such as air temperature, wind speed, gas emissions, noise emissions and radio spectrum utilization.

EXPOSING ISSUES

Predictive maintenance is another key area where wireless, cloud-based technologies are helping chemical processing organizations optimize their operations. This includes digital diagnostics and analytical tools, such as Endress+Hauser's Heartbeat Technology, which continually audits instrumentation for measurements, such as flow, level, pressure, temperature, liquid analysis and gas analysis.

The technology delivers instrument diagnostics to a control system, cloud-based application or an on-site historian for monitoring/trending and alerting purposes, explains Nathan Hedrick, national product manager overseeing level, flow, temperature and pressure at Endress+Hauser USA.

"The biggest evolution has been through the extension to other technologies and measurement tasks, Hedrick says.

In some cases, it makes sense to deploy several types of measuring technologies to monitor and diagnose a maintenance problem, such as build-up of deposits in pipes.

"For instance, if a user knows that they have issues with build-up in their process, it can be extremely valuable to have multiple technologies installed informing them when build-up is occurring," Hedrick explains. "One device alone indicating a possible build-up is present could be sufficient, but if two, three, or four devices start to warn of the same thing, it becomes even more credible." ●

Avoid Big Trouble
from Little Changes PART 1

Applying sound process-safety review screening to *every* change is the first step

By Jody E. Olsen, P.E.

JUST AS Management of Change (MoC) is an essential element of any process safety management (PSM) program, the process-hazard review that occurs under MoC is an essential element of an effective MoC process. But what is the best way to determine the process-hazard review needs for small changes? And how do you ensure that reviews are adequate and not missed?

CLARIFY THE TERMINOLOGY

Terminology for process-hazard reviews varies from region to region and between regulating authorities. As shown in Figure 1, safety reviews are one of many reviews performed under MoC [1]. Safety reviews include both personal safety and process-safety reviews.

Process-safety reviews can be subdivided into process hazard analyses (PHAs), facility siting studies, flare studies, major accident risk (MAR) studies, functional safety reviews (such as using ISA 84 or ISO 61511 standards), consequence modeling and others. PHAs may be further subdivided by the methods used for conducting the studies, which may include hazard and operability (HAZOP) studies, layers of protection analysis (LOPA), checklists and others [2]. Hazard identification and risk analysis (HIRA) [3], also known as hazard identification and risk assessment [4], is another term used to describe the same suite of process hazard analysis methods. (Note, the terms PHA, HIRA, process hazard assessment and process hazard review may be used interchangeably and refer to the same practices.)

PROCESS SAFETY REVIEW SCREENING

How do we determine the applicable process-safety reviews for a given change or MoC? Screening the change for review requirements is the first step.

Effective screening is needed not only to define process-hazard review requirements but also to assess all reviews for applicability under a given MoC [1]. However, the need for certain reviews may be more apparent than others. Introducing a change that has the potential for process-safety impacts may not be intuitively obvious; therefore, a structured and objective screening process can help ensure consistency. A checklist specifically designed to highlight modifications that result in process changes or changes to equipment can support the determination of further process safety review needs.

SCREENING FORM CATEGORIES

When creating a process safety review screening form, consider the following types of changes. Changes in these categories will prompt the need for process safety review(s).

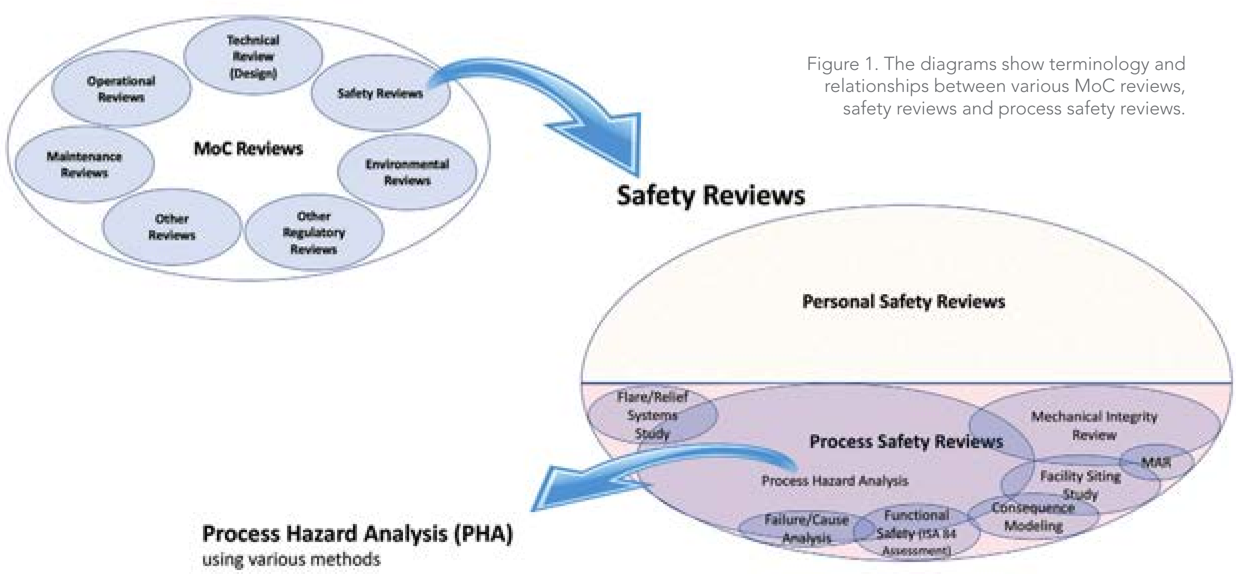


Figure 1. The diagrams show terminology and relationships between various MoC reviews, safety reviews and process safety reviews.

- Process changes
- Mechanical changes
- Changes to safeguards
- Changes to scenario causes
- Changes to consequences (including changes to consequence assessment based on other work, studies or guidance)
- Changes to occupancy or access
- Changes to operational procedural steps
- Other

The flow chart in Figure 2 shows an overview of a decision process for determining whether process-hazard reviews are required.

Process-safety incidents typically involve loss of containment of process media. Containment is directly dependent on both the properties of the process media being contained and on the equipment containing the process. Because of this relationship, the mechanical properties of the equipment are referenced directly in many areas of the process-hazard review. Mechanical design also undergoes discipline-specific technical review, as well as maintenance consideration outside of the process hazard review.

Improper design stemming from other disciplines, such as civil and structural, could potentially lead to process-safety hazards and to the release of process media. However, the methodologies used for conducting process-hazard reviews will generally not support the identification of hazards associated with these design failures. Any past or known operational or design issues that may lead to process hazards, such as structural failure due to vessel or tower overfill (if not designed for a fluid-filled column), need to be included in appropriate hazard scenarios. Operating limits and safe limits need to align with design assumptions. Technical reviews and checklists associated with various disciplines should be updated to address design weaknesses,

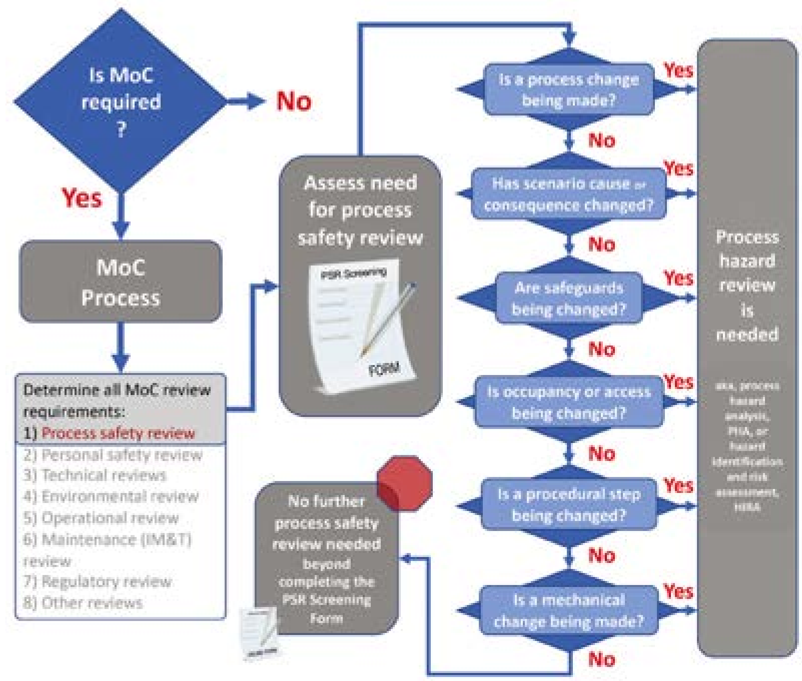


Figure 2. A decision support flow chart for process safety review screening should include categories and detailed questions.

incorporate new learnings, and, where possible, integrate inherently safer design. However, mechanical changes to piping, static equipment and rotating equipment are highlighted as triggering a process-hazard review because of the direct impact on hazard scenarios throughout the study.

SCREENING FORM QUESTIONS

Figure 2 shows an overview of categories needing consideration. To ensure thorough and consistent screening, include specific questions in each section of the screening form. Some practitioners may believe more detailed questions are unnecessary or overly time-consuming to answer. However, past auditing of process-safety-review screening failures under MoC shows even competent engineers miss relevant changes if only general questions are asked. These misses result in incomplete or fully bypassed process-hazard reviews. More detailed and specific questions better ensure consideration of pertinent factors that improve consistency and prevent human errors.

See an excerpt from a process safety review screening form at https://bit.ly/CP_Fig3 for identifying changes to the process. The questions in the form are examples and do not represent a complete list of changes that would indicate a process change has occurred. Other sections of the form also need to include specific screening questions. These questions should be routinely reviewed and refreshed through continuous-improvement efforts.

In some cases, prescribed questions are too limiting or may be incomplete. To address this, "other" may be used as a catch-all for open-ended brainstorming.

WHO COMPLETES AND APPROVES?

MoCs are ubiquitous in modern processing and manufacturing operations. Companies address MoCs constantly of all scopes and sizes. Because operating companies handle so many MoCs, their protocol may allow personnel in a variety of roles to initiate or manage the change through its lifecycle. However, to ensure proper design, assessment and implementation of the change, specialists from all impacted disciplines need to be engaged in evaluating the change [1]. This need is especially true for process-hazard assessment. Even where questions are carefully crafted to identify conditions needing process-safety assessment, without a skilled process-safety practitioner signing off on the screening, changes can be missed that should receive process-hazard review. Auditing has shown these types of errors are routinely introduced when qualified process-safety personnel are not involved. These misses indicate that providing process safety-related training to personnel filling other roles is not sufficient.

For this reason, ensure the process-safety screening is approved only by qualified, skilled personnel representing the process-safety department or group. Other personnel may initiate or fill out the form, but final review and approval should be conducted by skilled process safety professionals.

Case in point: While conducting an MoC audit on a company's process-safety-review screening step, several errors were discovered on completed screening forms. Certain process changes were missed including a modification involving a pipe-size change. Pipe-size changes may result in various integrity-related concerns, including erosion from higher velocities, corrosion stemming from particulate settling caused by lower velocities, or pump damage due to cavitation resulting from improperly installed upstream reducers. The screening form had been completed by a well-qualified plant engineer who had received training on MoC and general process safety principles.

Several changes were made to the screening process following this audit to prevent similar errors in the future. Changes were made to the form criteria, including stipulating velocity changes as a type of process parameter change and naming size change as a type of equipment change that defines a process change. To further support the process, administrative changes were made requiring process-safety representative review and approval of all completed screening forms.

WHEN SHOULD SCREENING HAPPEN?

As the title implies, the MoC process-safety review is inherently one of the most critical reviews under process-safety management. Therefore, process safety review *screening* — at a minimum — is needed for *all* MoCs.

If the change is screened and no items on the checklist trigger the need for process-safety reviews of any type, including process hazard review, then the completed process safety review screening form along with a statement supporting the decision to not conduct further process safety reviews can become the record of the assessment (Figure 2). In general, changes that fall into this bucket should be less common than changes needing further process-safety review.

In addition to MoCs, any practices that may handle changes through alternative protocol outside of the MoC system should use the same screening process and tools. Construction change orders are one example. Construction groups may handle many changes during a project. However, any change triggering criteria from the process-safety-review screening form represents a change to the approved design as reviewed during the project PHA. Changes introduced through construction change orders may bypass process-hazard review if consistent tools and approval processes are not used. Supplementing construction change management practices by using the same process-safety-review screening form with process-safety representative sign-off can prevent those misses.

WHAT NOT TO DO — INAPPROPRIATE SCREENING QUESTIONS

Avoid asking questions during the screening process that presuppose the outcome of the hazard review. Examples of questions that should *not* be included on screening forms include:

- Does the change introduce new process safety hazards?
- Does the change elevate process safety risk?
- Does the change have the potential to be hazardous or highly hazardous?
- Does the change involve hazardous operations or processes?*

*When MoC is required, safety reviews, are applicable. Where companies have elected to apply MoC more broadly than required by regulation, exclusions need to be clearly defined in procedures.

Opinion, judgment or perceived risk assessment should not be part of the screening process. The purpose of the process-hazard review is to identify process-safety hazards that would not otherwise be apparent. Process-hazard reviews use a structured method to help team members see hazards that a cursory assessment would not uncover. Screening questions should categorize the change into types of changes that require process-hazard review. Injecting opinion into the screening process short-circuits the hazard review.

AUDITING

Auditing of the full MoC and hazard-review process under MoC, including this screening step, is a key part of maintaining an effective program. Internal or self-auditing support continuous-improvement efforts. Routinely audit the usage of the screening form to ensure the checklist is being used as intended.

Validate that the change has been correctly characterized on the screening form based on the criteria given and ensure the proper personnel review and sign off. If misses or errors are found, seek to understand the origin of the failures through standard root-cause analysis. Follow-up with edits or revisions to the tools and process, as needed.

CONCLUSION

Why devote so much effort to a seemingly straightforward task? The reasons are simple. First, if the need for process-safety review is not identified, the process-safety reviews including the process-hazard assessment by any method will not occur. Concerns regarding the quality and selection of the review method are immaterial if the process-hazard review has been inadvertently or intentionally bypassed. Secondly, failures occurring at the screening step are not uncommon. Careful auditing may demonstrate that problems related to conducting effective process-safety reviews on MoCs may originate at the screening stage.

Better practice involves applying the process-safety review screening form and process to *every* change no matter how small. Changes to the process being contained, the equipment containing the process, the equipment involved in protecting the process, and operating procedures all need complete process-hazard review. To aid in a thorough initial assessment and to help avoid misses, include specific, detailed questions under all categories of the process-safety review screening form and involve skilled process-safety practitioners as approvers of the screening. ●

Part two of this series will address the selection of the type of process hazard review method for small changes.

JODY E. OLSEN, P.E., is the principal engineer and manager at JE Olsen Consulting LLC.
Email at jodyo@jeolsenconsulting.com

REFERENCES

1. Olsen JE, "Management of Change Reviews for Small Modifications," pp. 35-38, *Chemical Engineering Progress*, American Institute of Chemical Engineers, December 2022, www.aiche.org/resources/publications/cep/2022/december/management-change-reviews-small-modifications.
2. U.S. Department of Labor Occupational Safety and Health Administration, Process safety management of highly hazardous chemicals, 29 CFR §1910.119 (e) and (l), Jun 1, 1992.
3. CCPS, Guidelines for Risk Based Process Safety, Center for Chemical Process Safety, American Institute of Chemical Engineers, New York, NY, 2011.
4. U.K. Health and Safety Executive, "The Control of Major Accident Hazards Regulations 2015," L111 (Third edition), 2015, www.hse.gov.uk/pubns/priced/l111.pdf.

How to Identify & Address **a Water Hammer Event**

Prevent costly damage and downtime with these preventive and mitigation strategies

By Nick Vastine and Stephanie Villars, Applied Flow Technology

IN INDUSTRIAL applications, "water hammer" is a phenomenon that can have significant consequences beyond a loud hammering sound, which may be familiar to people in residential environments. For the chemical processing industry, water hammer can result in a disastrous pipe burst that can lead to costly downtime and potential losses.

Water hammer, also known as fluid hammer, or surge, refers to the pressure response due to a rapid change in fluid velocity in piping systems. When fluid is brought to a sudden halt, the momentum of the fluid is converted to potential energy in the form of pressure. The initial pressure spike due to an instantaneous halt in flow can be predicted by the Joukowsky equation. The Joukowsky equation has been used as a first approximation for more than a century to estimate water hammer pressure surges. Any rapid transient change can produce water hammer including events such as valve closures, pump startups and shutdowns.

Pressure surges following a water hammer event cause both high- and low-pressure waves, each of which may be uniquely problematic. High-pressure waves can exceed pressure ratings, induce large forces and cause excessive vibrations. Low-pressure waves can cause sub-atmospheric pressures, which can collapse equipment and form a vapor cavity if the pressure is reduced to the fluid's vapor pressure. Subsequent vapor cavity collapse, when the pressure in the pipe rises, can cause secondary pressure surges. The propagation and reflection of the high-pressure wave will also result in a low-pressure wave and vice-versa. While the Joukowsky equation is a common hand calculation when considering surge, system pressures may exceed the initial Joukowsky

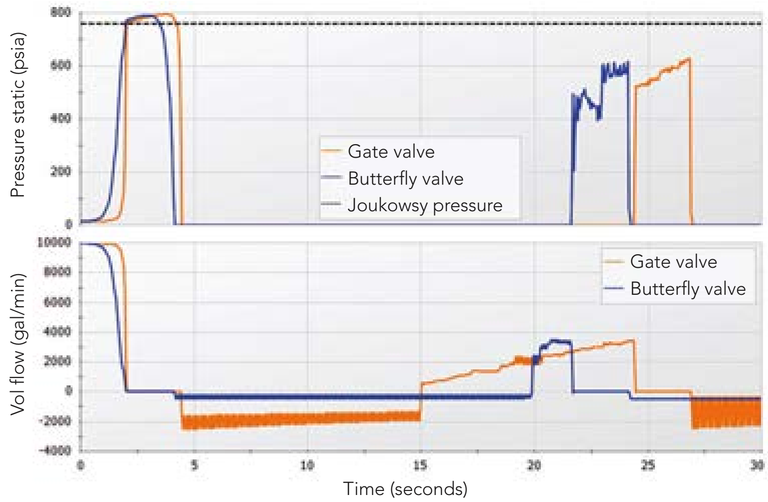


Figure 1. The orange and blue curves compare the responses of an 18-in. gate valve and an 18-in. butterfly valve in the same 2-second closure system.

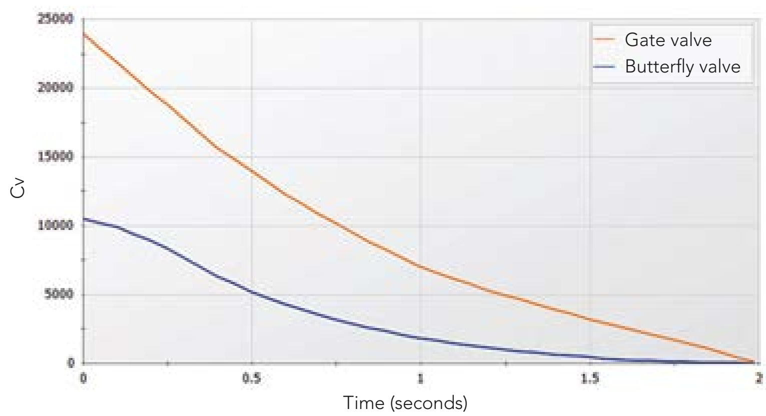


Figure 2. This graph illustrates the vastly different Cv-vs.-time closure profiles of a gate valve and butterfly valve.

pressure spike due to reflection and combining of pressure waves, vapor cavity collapse causing secondary pressure spikes, and line pack as pipe friction is recovered.

Although a single water-hammer event may not be enough to burst a pipe or destroy a pump, repetitive stress over time due to water hammer can increase maintenance costs as weak spots in the system are worn down. The pressure response from water-hammer events can be complex to predict, so computer simulation is recommended to account for the real effects of wave propagation and interaction in a particular system. Understanding the cause and effect of water hammer enables an engineer to mitigate its consequences.

HOW TO MITIGATE WATER HAMMER

Addressing water hammer during the design process provides an engineer more flexibility in mitigation strategies. For example, engineers could select non-slam valves before construction or adjust the system configuration to mitigate water hammer without purchasing additional equipment. Other cases may still call for equipment such as surge vessels, air valves, relief valves or similar devices depending on system requirements.

The options available to prevent or mitigate a water-hammer event will depend on when the water-hammer issue is caught and the cause of the water-hammer event. There are two questions an engineer should focus on during the mitigation process:

- Can the transient event that creates water hammer be altered to prevent surge?
- Can the pressure surge wave be dissipated?

DO YOU HAVE A TRANSIENT EVENT?

A transient event refers to a component change that causes water hammer, such as a valve closing or pump tripping. Altering the event that initiates the water hammer transient can be effective if the event is slowed enough to no longer be considered instantaneous. A non-instantaneous event should prevent the full Joukowsky pressure spike, though the analysis is not always so clear-cut.

For the purposes of hydraulic analysis, a transient event is considered instantaneous if the event is shorter than the system's communication time, or the time it takes for a pressure wave to travel to the farthest point in the system and back. The communication time can be calculated as two times the overall length of the system divided by the wave speed. If there are branching paths, then it is common to use the length of pipe from the component that is opening or closing to the end of the longest branching path. Keeping the communication time in mind is important as even relatively slow transients may still act as instantaneous closures given the right circumstances. Here's a look at scenarios in which valves and pumps can cause a water hammer event:

Valves. The most considered source of water hammer is valve closures. For this discussion, we're talking about any

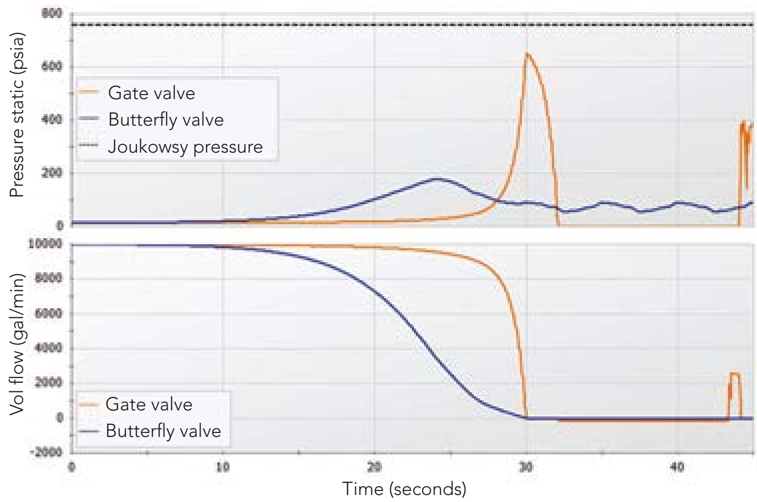


Figure 3. The gate valve still causes a larger pressure spike due to the steep decrease in flow rate at the end of the 30-second valve closure.

type of valve, including manually operated valves, check valves, control valves, relief valves, air valves, etc.

Operators should consider the inherent and installed characteristics of a valve to understand the full impact of a closure. "Inherent characteristics" are mainly driven by valve geometry and measured by the manufacturer. This could include the valve's characteristic curve (Cv vs. open percentage) and full open-pressure loss. "Installed characteristics" are how the valve behaves when installed in the actual system and can be thought of as the pressure drop ratio of the valve to the system. Installed characteristics can be influenced by all components in the system, including the system's length, pipe friction, pump curves and other fittings and losses. The more pressure loss through the valve, the more likely it is to control the flow rate through the system to gradually slow the fluid.

Both the inherent and installed characteristics of the valve will determine the pressure response at the valve.

Consider the below graph comparing pressure and flow for a relatively short system in Figure 1. The orange and blue curves compare the response for an 18-in. gate valve to an 18-in. butterfly valve in the same system. The Cv vs. time graph also can be seen below in Figure 2, reflecting each valve's characteristic curve.

For this example, assume the fastest closure time for both valves is 2 seconds, which is shorter than the communication time of 3 seconds. This indicates that the 2-second valve closures would be considered instantaneous and should see the full Joukowsky pressure rise. At 2 seconds the gate valve pressure rise is exactly the Joukowsky pressure rise of 744 psi, but the butterfly valve experiences a slightly larger pressure rise. The extra pressure at the butterfly valve comes from line pack, as frictional pressure is recovered at the valve as flow begins to halt sooner than with the gate valve. After 2 seconds, the pressure at both valves continues to increase due to line pack. Ultimately, the gate valve experiences the higher maximum pressure as all the line pack pressure accumulates at once, unlike with the butterfly valve where some pressure is dispersed before the maximum pressure is reached.

Now, consider the case where both valves close over 30 seconds, which is much longer than this system's 3-second communication time. For this case, both valve closures are not instantaneous, and neither valve sees the full predicted Joukowsky pressure rise as seen in Figure 3.

In this case, the gate valve still causes a larger pressure spike due to the much steeper flow rate decrease at the end of the valve closure, showing a dependence on the valve's characteristics as to when each valve starts reducing flow.

As shown through the above example, a few key strategies exist to reduce surge pressures. In all cases, consider ways to reduce the velocity change and pressure surge. This may involve changing the system to reduce the operating velocity in the lines, such as choosing a larger pipe size or introducing equipment.

For valve closures, if possible, reduce the closure rate at the end of the valve closing time to gradually decelerate the fluid. This can involve lengthening the valve closure time, using an 80/20 valve closure (closing the valve 80% in the first 20% of the closure time), or choosing a different type of valve with a gradual Cv change at lower open percent values. Look for valves with characteristic curves that close quickly early in the closure, then slow down later. For cases where surge originates at valves like check valves and relief valves, look for valves marketed as "No-Slam" as these options will typically be engineered with the above options in mind.

Pumps. The other common source of pressure surges in systems is pumps. As pumps start up or shut down, the energy imparted by the pump to the system can rapidly change fluid velocity, resulting in water hammer events. For routine operations, using a variable frequency drive (VFD) at the pump to control the pump speed ramp is the simplest and most efficient solution to prevent surge. However, emergency cases where the pump trips, nullifying the VFD, must also be considered.

Predicting how fast a pump starts or trips largely depends on the rotating inertia of the pump. Calculations for the pump transient can be very dependent on the total rotating inertia, so performing a sensitivity study using one-half times the predicted inertia and two times the predicted inertia is recommended by engineering sources, such as "Fluid Transients in Pipeline Systems" by Thorley.

Mitigating unacceptably high pressures due to a pump transient often is more complex than addressing other events due to the more complex nature of the pump. One measure to consider is installing a flywheel on the pump shaft to increase the rotating inertia of the pump, forcing a slower pump trip.

Besides using a flywheel or VFD, changing the system configuration to reduce the fluid acceleration is another means to decrease the pressure surge in the system. This may involve adding a recirculation loop, or other means to redirect flow at the pump. Reducing the fluid acceleration may also be accomplished using components such as surge vessels, which are discussed further in the next section.

For high-pressure surges with unacceptable pressures, consider options such as closed surge vessels or relief valves.

CAN YOU DISSIPATE THE PRESSURE SURGE?

In some situations, such as for existing systems, the component changes discussed above may not be available. Alternatively, the piping layout may cause operational changes to be ineffective for surge mitigation. In these cases, other safety measures may be required to alleviate the surge wave.

For high-pressure surges with unacceptable pressures, consider options such as closed surge vessels or relief valves depending on the application. To address low-pressure concerns, consider surge vessels or air valves to avoid sub-atmospheric pressures. Here's a look at the different options and how they might help during a pressure surge:

Surge Vessels. This term can refer to a closed tank or an open tank that supplies or absorbs flow during a transient. Both types of vessels can combat a high- and low-pressure surge by absorbing fluid to reduce the pressure during high-pressure events and supplying flow into the pipes during low-pressure events to keep the pipes pressurized. One advantage of surge vessels is they can keep the operating fluid contained and prevent air from entering the system. The disadvantages are that surge vessels can require a large amount of space and may require frequent maintenance to maintain pressure in the vessel.

During sizing, place surge vessels as near to the source of the transient as possible. However, keep in mind that a poorly located surge vessel can potentially make surge waves worse due to acoustic resonance or check-valve slam, so location is crucial. The size of the vessel will depend on the magnitude of the wave that is being absorbed by the vessel, with a larger tank being required for larger flow rates/pressures.

It is recommended to work with the surge vessel vendor when selecting a vessel for the system as the sizing process is complex and mistakes can be costly.

Relief Valves. Designed to open at a specified pressure, relief valves quickly reduce the pressure in the system and protect sensitive components from high pressures. These valves are relatively low maintenance but can cause the loss of working fluid depending on the configuration. They can be installed to open to atmosphere or into a contained tank depending on the fluid.

Standards such as API 520/526 provide information on best practices for sizing relief valves. It is important to consider all operating cases when choosing a relief valve. Poorly sized relief valves can cause operating issues if they close too quickly or if they repetitively open and close, known as valve chattering.

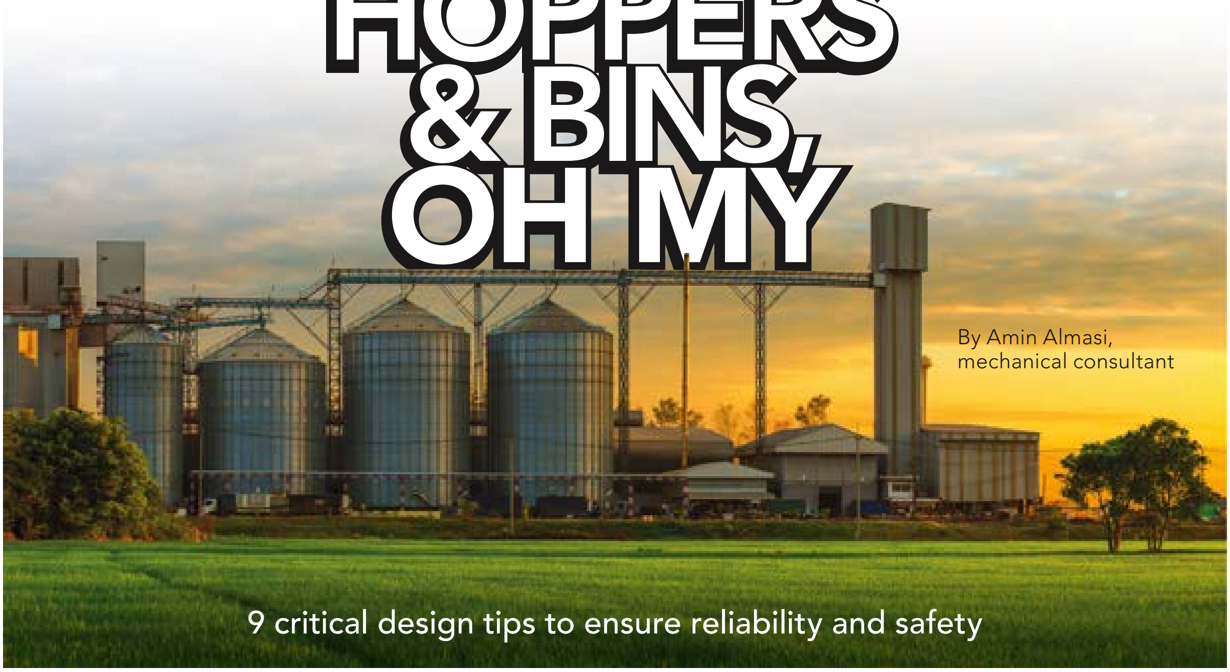
Air Vacuum Valves. To prevent vacuum conditions, air vacuum valves let air into the pipe when the pipe's pressure reaches atmospheric pressure. As the pressure rises in the pipe, the air is then driven out of the pipe causing the valve to close. Air valves also can open to release pockets of air in the pipes. Air valves can't be used with fluids that are flammable or reactive with air, so they are often only used with water systems.

Air valves are often sized to match the pipe size in inches, so a 1-in, air valve would be suitable for a 1-ft diameter pipe. Typically, air valves should be located at high points in the line or near sources of low pressure. Perform simulations to confirm the sizing and location of the air valve; if the valve is too small vacuum may not be prevented, but too large and air pockets may be trapped in the pipeline, causing further water hammer events.

By assessing potential water hammer events during the design process, chemical processing plants can prevent surge waves and serious damage to their system. For existing designs, plants can install mitigation equipment, such as surge vessels, relief valves, and air vacuum valves, when simpler changes are not possible. ●

NICK VASTINE is a senior business applications engineer for Applied Flow Technology (AFT) in Colorado Springs, and **STEPHANIE VILLARS** is a former applications engineer with AFT. Email Nick at nickvastine@aft.com.

SILOS, HOPPERS & BINS, OH MY



By Amin Almasi, mechanical consultant

9 critical design tips to ensure reliability and safety

CHEMICAL PROCESSING companies face increasing scrutiny from regulators and the public over substance exposure and safety. Proper storage and handling of vessels for bulk materials is a critical factor that often gets overlooked when it comes to chemical safety. That's unfortunate when considering the number of failures, collapses and operational problems the industry has encountered over the years with clogging, ratholing and flow stoppage.

Statistically, there have been more failures and problems in handling and storage equipment of solids and bulk materials compared to fluid handling equipment and other branches of equipment in the processing industries. Causes of failures may include flow stoppages, feed-rate/flow-control issues, particle segregation, attrition, product quality concerns, degradation, material build-up, wear, corrosion, and inadequate structural/mechanical integrity for equipment and vessels.

Among the key considerations chemical companies must evaluate are the different sizes, shapes, configurations and construction materials available for silos, bins and hoppers. Here's a closer look at nine factors chemical processing companies should understand to ensure they're selecting the best storage and handling option for their applications.

1. OPTIMIZE THE FLOW PATTERN

The ideal flow pattern of solids and bulk materials is mass flow, meaning the bulk material in the vessel remains in motion whenever anything is removed from the storage container. The mass flow is the most desired flow because it is inherently safer with minimum risks and issues. Mass flow is particularly important if the application is vulnerable to operational difficulties, such as ratholing, or if there is a concern about particle degradation, such as caking, spoilage or oxidation.

For any flow regime, the particle movements in different locations vary and often the pattern of movements would be complex. Typically, particles near the center of the silo/bin see virtually no shearing resistance, whereas particles sliding along converging hopper walls flow (move) slowly. This velocity distribution (the differences of velocities of particles) can be minimized by an appropriately steep hopper angle.

For desirable mass flow, manufacturers should configure walls of the hopper sufficiently steep. Two key parameters in this regard are wall friction angle and the effective angle of internal friction. Some factors that impact these two parameters include temperature, moisture, time of solid storage at rest, particle size distribution and content of the bulk solid.

The wall friction angle plays a major role in the flow pattern. This is the arc tangent of the coefficient of sliding friction between the bulk solid and hopper wall. This value often changes with local pressure of the bulk material. To achieve mass flow throughout a hopper, it's important to determine the wall friction angle at different locations, including the outlet.

As a rule of thumb, for wall friction angle of 10°, 15°, 20° and 25°, the conical hopper angle (from horizontal) should be larger than 58°, 61°, 65° and 71°, respectively. As a guide, the conical hopper angle (from horizontal) larger than 65° can provide mass flow regime for many practical situations. For some difficult bulk materials, this angle should be larger than 70°. In a hopper, the wall friction angle varies. Its highest value usually occurs at the lowest pressure. During the flow of bulk material, the lowest pressure is at the outlet. Therefore, the outlet region requires the steepest hopper angle for mass flow to develop.

Figure 1. An example of a small hopper for bulk material handling under revamp and renovation at a workshop.

2. PREVENT ARCHING AND RATHOLING

Arching, also known as bridging or doming, is a major problem in the storage of bulk materials and solids. Causes of arching include mechanical interlocking or cohesive strength. Mechanical interlocking occurs when particles are large relative to the outlet opening, whereas cohesive arching occurs because of bonding between particles.

To avoid interlocking arching, the outlet should be wider than the largest particle. A way to estimate this is by measuring the length of a chord that spans the largest particle in any direction. In other words, the outlet dimension should exceed some critical multiple of the characteristic particle dimension. As a rough indication, for a circular or square outlet, the outlet size should be at least seven to nine times the characteristic particle dimension.

Ratholing is another major problem associated with the storage and flow of bulk materials/solids. In ratholing, a vertical flow channel develops above the hopper outlet and, once emptied, remains stable. At this point, peripheral bulk materials remain in place, so the hopper cannot be emptied. The outlet is the smallest flow channel through which the bulk material should move. Therefore, arching or ratholing nearly always occurs at the outlet. To prevent these problems, a "mass flow" pattern should be ensured, for instance, by using a sufficiently large outlet and steep walls.

3. UNDERSTAND FINE POWDERS VS. COARSE SOLIDS

Fine powders behave dramatically differently than coarse bulk solids do. The discharge rates of fine powders through the outlet may be excessively high (referred to as flooding) or excessively low. Which of these extremes occurs depends to a large extent on the flow pattern in the silo or bin. Flooding often occurs in a funnel flow due to a stable rathole collapsing or the addition of fresh bulk material to a stable rathole.

Mass flow regimes, on the other hand, typically offer a controlled rate of discharge when handling fine powders. One reason is the interstitial gas or air flow through the voids. This gas or air flow is due to the small gas or air pressure gradients that develop naturally as bulk material flows through a converging hopper. Such gradients are not present with coarse materials or solids because of their much larger void space. Often, the gas or air pressure gradient at the outlet of a mass flow regime acts upward, drawing in air through the outlet. Acting counter to gravity, this retards the flow. This effect can limit rates of discharge that are several orders of magnitude smaller than the one of the free-flowing coarse bulk material having the same bulk density. In other words, for coarse bulk materials there might be a risk of uncontrolled fast discharge of materials (flooding).

4. CAREFULLY CONFIGURE THE OUTLET

The outlet region of a hopper, silo or bin is an extremely important region for the smooth and trouble-free operation. It has tremendous effects in the developed flow pattern in the vessel and the type and extent of potential flow problems. As a rule of thumb, critical discharge rates vary more or less linearly with the outlet area. Typically, operators desire a sufficiently large outlet for optimal flow. However, there are practical limits on the size and configuration of the outlet due to several factors, including the size of the feeder, subsequent equipment (next equipment on the process that the bulk material is supplied to), etc.

It’s important to emphasize good configuration, weld quality and finishing in the outlet region, even while recognizing there could be practical limits and challenges for the outlet opening. The instantaneous rate of discharge is an important parameter, but considerations should also be given to the expected minimum and maximum rates.

Also, a generally symmetric/concentric shape and layout of the outlet is preferable over asymmetric, offset or eccentric outlets due to many reasons including better flow of bulk materials and fewer risks of problems. A single outlet on the centerline of the bin/silo/vessel (a concentric outlet) is ideal. While multiple outlets have been used successfully in some applications, they come with many risks such as problems of material flow and require thorough checks and maintenance, particularly if eccentric outlets are employed.

When flow problems occur, unskilled operators will often use a mallet in the outlet region to encourage flow. Unfortunately, mallet blows can distort a hopper, thereby creating even more of an impediment to flow. Obviously, the mallet blow is not a cure; formulate a proper modification or solution only after a thorough RCA (root cause analysis). Also, the outlet section should be strongly designed and fabricated with proper thicknesses and reinforcements.

5. MATCH THE FEEDER TO THE OUTLET

In most bulk material handling applications, a feeder is used to control discharge from the outlet of the vessel. The control involves not only stopping and starting flow but also metering the rate of discharge. A feeder typically provides the ability to meter or control the throughput rate, often in flood-loaded mode.

The type of feeder to be used also influences the shape of the outlet. If the operation is using a rotary valve, the hopper outlet should usually be either circular or square. On the other hand, if the facility is using a belt or screw feeder, the outlet is often elongated. With an elongated outlet, the interface details become extremely important to ensure the outlet area is fully active.

Several hopper configurations are possible in this scenario. Perhaps the most common is a transition hopper. Another hopper configuration compatible with an elongated outlet is a chisel hopper. A wedge-shaped hopper also can be used with elongated outlets, although as with pyramidal hoppers, there are some concerns with valley angles and inflowing valleys. Ideally, for bulk materials, which are prone to flow problems, it’s best to avoid elongated or unusually shaped outlets and, instead, opt for large, circular outlets.

In addition to arching, ratholing and flow-rate considerations, it’s important to carefully consider the size of the feeder in the overall design of the vessel. Most commercial feeders come in standard dimensions. For this reason, it may be necessary to increase the outlet size to match the next-larger feeder size above the one required by the design/operational considerations.

A small feeder operating at too high a speed may not be efficient or may be subject to unacceptable abrasive wear or cause excessive particle attrition. Enlarging the feeder to reduce its speed is often the correct selection.

6. CAREFULLY CONSIDER AERATION

Operators can significantly increase the discharge rate of fine powders by using low levels of aeration. There are several different aeration techniques. One technique is to use an air permeation system, which consists of a sloping shelf or insert that allows a small amount of air to be added to a silo or bin. This air permeates into the bulk solid and lessens the need for air to be drawn in through the outlet. The careful and uniform distribution of air is necessary to maximize its effectiveness, limit the air flow rate and pressure to avoid fluidization.

Aeration can be a solution for overcoming poor silo or bin designs versus more expensive modifications as any modifications usually need re-design, cutting, welding, etc. However, some operators consider aeration to be risky. Use it only as a last resort when other options, such as steep walls for the hopper are not practical.

7. SEGREGATION AND SIFTING

Segregation is a common problem in storage and handling of bulk materials and solids, resulting in unacceptable quality variations and safety concerns. Segregation typically occurs by one of three common mechanisms: sifting, dusting and fluidization.

Sifting involves the movement of smaller particles through a matrix of larger ones. Dusting (particle entrainment) occurs when small or light particles are carried by air currents within a vessel, resulting in a segregation profile that is difficult to predict and to avoid.

Fluidization (air entrainment) occurs when larger or denser particles settle through a fluidized matrix of finer (or lighter) particles. The result is a top-to-bottom segregation pattern that is difficult to overcome.

8. FABRICATION AND SITE INSTALLATION CONSIDERATIONS

Generally, if the bin or silo is not too large, it can be shop fabricated in one piece, and welded equipment is preferable. It can then be lifted into place with a crane. A challenge for large bins and silos, which should be fabricated in two or a few subassemblies and delivered in pieces to the site, is the selection of field welds or bolt connections.

For larger vessels that should be field welded, alternative bolted construction is often preferable, although stress concentrations of bolted joints tend to weaken the entire structure. Furthermore, the possibility of leakage exists even if gaskets are used. It's usually better to assemble and disassemble very large bins and silos using bolt connections. On the other hand, subassemblies should be as large as possible to minimize the number of bolt connections.

Construction material is another important consideration. Many large silos and bulk material storage units are made from reinforcement concrete. The advantage here is that reinforced concrete can overcome abrasion or corrosion concerns common with metals. A double layer of reinforced steel will likely be required, especially if the silo or bin has multiple outlets or any type of asymmetry in loads applied to the vessel walls.

9. PICK A LINER

Usually, some form of liner or coating is required in bins, hoppers and silos, particularly for abrasive applications. One of the main reasons for using a liner or coating is to achieve a low-wall friction angle. As a result, less-steep hopper angles are required for the mass flow. Liners or coatings also can provide abrasive wear or impact resistance as well as chemical or corrosion resistance.

Whatever liner or coating is chosen, it's important to consider the ability to repair or replace it as such a liner/coating might be damaged or worn out after some years of operation. Differential thermal expansion and contraction between the vessel and liner should be considered carefully. Different thermal movements always mean stresses and risk of damage or cracking. ●

AMIN ALMASI is a mechanical consultant based in Sydney, Australia. Email him at amin.almasi@ymail.com

Filtration Solution Outperforms Standard

Melt-blown nylon filter cartridges double service life and increase process reliability

By Wim Callaert, Eaton

FOR MANY years, Leverkusen, Germany-based Levaco Chemicals GmbH — which produces dispersants, emulsifiers, wetting agents, defoamers and superabsorbent polymers — has relied on phenolic resin filter cartridges to homogenize amine condensate that is used in coatings. However, increasing costs, long delivery times and the environmental impact of the filter material spurred the chemical company to look for alternatives. In 2021, the decision was made to replace phenolic filter cartridges with nylon ones.

SUPPLY ISSUES

Being shatter-resistant, torsional-resistant and heat-resistant, phenolic resin has been a popular product in industrial applications for decades. This material is a thermosetting plastic and is still in use today as a filter material as it demonstrates the high level of temperature and pressure resistance that is necessary for filtering aggressive media. However, phenolic resin availability is scarce, which means rising prices and long delivery times.

To prepare its production processes for the future and reduce its ecological footprint, Levaco (a former member of the Bayer Group) started looking for alternatives. The challenge: process parameters were not allowed to be changed. In order to find a suitable replacement, Eaton Technologies GmbH, Netterscheim, Germany, tested various filters and the filtration specialist was able to offer Levaco an option that can outperform phenolic resin filter cartridges, both in terms of cost and environmental impact.

HOMOGENIZATION CHALLENGE

One of the intermediate products in Levaco's coating solutions division is an amine condensate agglomerated with dichloroethane. Filter cartridges made from phenolic resin have long been an essential process component in the manufacture of this product. This gel-like fluid also serves as a base material for pigments and fillers. It particularly helps to improve the protective properties of paints and coatings, which are essential for many industrial applications.

To achieve the desired consistency, the amine condensate is mixed with water. This produces inhomogeneous agglomerates, which have a negative influence on product quality. The filter cartridges are therefore primarily used in the process to distribute the particle sizes evenly so that a homogeneous product can be produced.

SUITABLE ALTERNATIVE

The exceptional properties of phenolic resin filter cartridges did not make it easy to find an alternative. High temperature and pressure resistance and strong chemical resistance are reasons filter cartridges made from this all-rounder material have been the standard for a long time.

Figure 1. The Loftrex Nylon filter cartridge product range includes a variety of lengths and pore sizes. In its production processes, Levaco uses filter cartridges with a retention rating of 100 μm.
Source: Eaton Technologies

Eaton suggested polyamide as a possible alternative since it can withstand greater pressure and higher temperatures than polyester or polypropylene. The available filter ratings are approximately equal to those for phenolic resin and may even be better in some cases. The company's Loftrex Nylon filter cartridges (Figure 1) were therefore good for Levaco's application.

Indeed, the melt-blown filter cartridges made from polyamide can withstand high operating temperatures of up to 248°F and a differential pressure of up to 36 psi at ambient temperatures. The result is a powerful and durable filter cartridge made of a fine-pored material. Its particularly smooth surface also significantly reduces fiber migration — an added benefit for the process at Levaco as any filter fibers released form impurities that can reduce the product quality.

continued on page 33

Fight Foam Accumulation

How to prevent foaming when transferring a solution from a storage container

Excessive foaming of liquids impacts storage capacity.

IN ECONOMICS, "froth" is bad news. It means stock prices are well beyond their actual value and a bubble is about to burst. We deal with a somewhat similar problem in chemical storage. Excessive foaming of liquids impacts storage capacity, taking up precious space and leaving companies with potentially costly remedies.

The accumulation of foam in chemical storage, referred to going forward as "foam inventory," is the result of foam creation competing with foam decay.

foam inventory = foam creation - foam destruction (decay)

The following sections examine one manufacturer's struggle with foaming and how the company addressed the issue. Three factors contributed to foam creation in the manufacturer's system:

- Mechanical work in the centrifugal pump could modify the liquid emulsion feed, likely causing foaming when it contacted air.
- The inlet grating could create foam by mechanical agitation of the liquid as it entered the treater.
- The interaction of the treating liquid and the solid panels to be treated could cause foaming conditions.

ONE MANUFACTURER'S CHALLENGE

As part of a final manufacturing step, a manufacturer needed to treat a porous, solid product sold in sheets. The treating vessel was about 10 ft × 100 ft in diameter and originally intended as an autoclave. The horizontal vessel had a head on one end that could swing open and shut with a hinge. While the vessel was rated for high pressure and reasonable temperatures, it barely operated above room temperature, and it faced slightly more pressure than the static head of liquid that would fill it.

The manufacturer loaded solid sheets on small flatbed rail cars and pushed them into the vessel. The next step was to close and clamp shut the swing-head to the vessel. The centrifugal pump supplied the treating fluid from the tank. After the required treating period, the manufacturer emptied the vessel. The piping configuration allowed the same pump used for filling the treating vessel to return the treating fluid back to its storage tank. Venting of air from the treating vessel was through a long, vertical line to atmosphere. Gratings at the treating vessel prevented large chunks of potentially loose solids from plugging either the liquid line or the vent line. The drum was sealed with liquid by allowing the treating liquid to partially fill the vent line during filling. Figure 1 shows a simplified schematic of the configuration.

Plant capacity was limited by foaming of the treating fluid as the treater was filled. The manufacturer had to drop the filling rate significantly to allow the treater to fill properly. In contrast, foaming was not a significant problem in emptying the liquid from the treater back to the storage tank.

ANTI-FOAM OPTIONS

On the foam destruction side, the only factor in play was normal foam decay. The amount of foam destroyed was related to the residence time of the foam. If the feed rate was too high, the residence time was too short, and foam accumulated.

To avoid excess foaming, the feed rate had to be reduced. When emptying the treater, foam wasn't normally a problem. The storage tank had a much larger free volume than the treating tank. Additionally, there was no inlet grating in the storage tank and no contact with the material to be treated. These factors led to less foam creation, a higher ability to handle foam, and no foam-induced rate reductions when emptying the treater back to the storage tank.

To increase the filling rate, the following, or any combination of them, must be performed: Increase the foam inventory, reduce the foam creation rate, or raise the foam destruction rate. In this particular case, the tolerable foam inventory could not readily be changed. Increasing the treating vessel volume would be cost-prohibitive and difficult to implement.

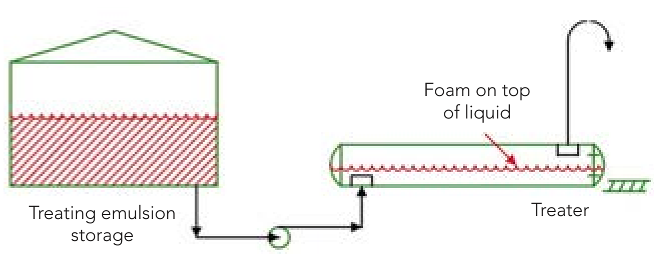


Figure 1. A manufacturer encountered foaming on a treating fluid when transferring it from a vessel to a storage tank.

THE SOLUTION

Using anti-foam agents wasn't an option for the manufacturer because it could not change the required chemistry of the system due to its impact on feed and product qualities. Anti-foam agents, while effective, are costly and would end up in the product. Also, having anti-foam in the product sheets would require extensive testing to see if it could be tolerated.

Based on this, the manufacturer decided to focus on reducing the foam-creation rate first by modifying the inlet grating and piping into the treater to reduce foam creation at the inlet grate. Additionally, the manufacturer no longer needed to use the centrifugal pump to fill the treater thanks to the treaters' original design conditions. Instead, the manufacturer added a vacuum system to pull air out of the treater. After reducing the treater to a low pressure, the treating emulsion storage tank's valve opened to release the treating solution, driven by pressure differential between the tank and the treater. To save costs while testing the idea, the manufacturer used a rental vacuum system to generate the vacuum.

Operation by using vacuum to transfer the treating emulsion had two major benefits:

- First, it reduced the amount of air in the treater so less oxygen was available to induce foaming.
- Second, it eliminated shearing action in the centrifugal pump that was a precursor step in foam creation.

Overall, the foaming rate dropped dramatically. The project was a success and once it was proven to work a permanent vacuum system was purchased and installed.

ANDREW SLOLEY, Contributing Editor
ASloley@endeavorb2b.com

continued from page 31

Figure 2. Loftrex Nylon filter cartridges in the housing. Levaco uses a total of 75 filter cartridges, spread across a 50-cartridge housing and a 25-cartridge housing. *Source: Eaton Technologies*

COST SAVINGS

Eaton's filtration engineers chose Loftrex Nylon filter cartridges with a retention rating of 100 µm to provide the ideal homogenization of the amine condensate. With optimized differential pressure and flow rate, Levaco can use the same filter cartridges for up to five batches of the product. A total of 75 filter cartridges are in use at the company, spread across a 50-cartridge housing and a 25-cartridge housing (Figure 2). Together, they enable a high throughput of 44 gpm. By using a number of filter cartridges in parallel, the performance of the cartridges very quickly begins to have noticeable economic benefits.

The service life of the new polyamide filters is about double that of the old phenolic resin filters. For Levaco, this means that product quality remains the same, while considerably fewer consumables are required. In addition, polyamide is an easily available filter material. Eliminating supply constraints is paramount.

WIM CALLAERT is a senior product manager for Eaton's filtration division. You can email him at WimCallaert@eaton.com.

Sifter Enables One-Person Operation

The Centri-Sifter M1 is a centrifugal sifter designed to help address the high costs associated with maintenance

and recruiting, training and retaining skilled labor. The unit sifts, scalps, de-agglomerates and dewaters granular materials ranging from dry bulk solids to solids-laden slurries and typically only requires one person to operate and maintain it. The sifter can replace the Centri-Sifter MO and features a capacity of up to 15,000 lbs of dry material and up to 50 lbs of wet gallons per hour. This unit is one of six models, the largest of which can handle more than 100,000 lbs of dry material and 300 lbs of wet gallons per hour.

Kason
973-467-8149
kason.com/centrisifter-m1

Pressure Relief Valve Reduces Emission Leaks

The Crosby J-Series pressure relief valve (PRV) Balanced Diaphragm eliminates the need for bellows in PRVs, while providing balanced operation against backpressure. Where backpressure is present, spring-loaded PRVs often utilize bellows to ensure balanced operation. However, excessive backpressure and rapid cycling can cause bellows to fail. Ruptured bellows will cause fugitive emissions and may prevent valve operation at the designed set pressure, with the risk of catastrophic overpressure events. The balanced diaphragm can replace bellows in PRV applications to address these and other issues. Its design extends the backpressure limits from 60% to 80% and increases the Kb backpressure correction factor by up to 15%, expanding the application range of spring-loaded PRVs.

Emerson
888-889-9170
Emerson.com

Dual Shaft Mixer Produces High Shear

The ROSS FDA-3500 has a maximum working capacity of 3,500 gal., a two-zone stainless steel dimpled jacket for heating/cooling, a 4-in. pneumatic discharge valve and an explosion-proof load cell system rated for up to 20,000 lbs. This multi-agitator system is equipped with independently controlled drives and is efficient at producing turnover and imparting shear to a viscous batch. A 300-hp TEFC inverter duty motor powers the high-speed disperser with tip speeds up to 5,000 ft/min., inducing high shear forces. The 60-hp three-wing helical anchor agitator feeds product toward the disperser blade and ensures the mixture is in constant motion. Teflon scrapers on the anchor wipe materials from the vessel wall, enhancing heat transfer from the jacket.

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

Mini Bag Dump Station Improves Worker Safety

The Volkmann Mini Rip and Tip bag dump station offers automated sack tipping for loading small volumes of bulk materials and ingredients into a process. It accepts up to 40 liters of powder, pellets, granules and other dry solids in a hopper, then automatically discharges the material for transfer. It's designed to reduce manual handling of heavy bags, drums and barrels and improve worker safety and efficiency. Typically specified as a companion for the company's pneumatic vacuum conveying systems, the station loads any dry material in modest volumes, such as minor and micro ingredients and small batches in laboratory settings. Stainless-steel construction in product contact areas comes standard, and casters are optional for increased portability.

Volkmann Inc.
609-265-0101
www.Volkmannusa.com

VOC Detectors Read Low Gas Levels

The latest Tiger XT handheld volatile organic compound (VOC) detector line comes in stronger exterior molding for use in demanding environments. Comprising three models, each unit has a humidity-resistant, anti-contamination design and an exterior semi-conductive thermoplastic elastomer outer molding, making it intrinsically safe. The range uses photoionization detection (PID) sensor technology, enabling a T90 response time of less than two seconds. It can detect gases at levels as low as 1 ppb and can detect up to 20,000 ppm. The Tiger XT Select model incorporates a 10.0 eV lamp within the MiniPID 2 sensor capable of detecting total aromatic compounds including benzene down to concentrations as low as 1 ppb.

ION Science Inc.
877-864-7710
https://ionscience.com/usa

ENDEAVOR BUSINESS MEDIA

PUBLISHING HEADQUARTERS

30 Burton Hills Blvd, Ste. 185
Nashville, TN 37215
800-547-7377
www.chemicalprocessing.com

Brian Marz
Publisher
E-mail: bmarz@endeavorb2b.com
Phone: 630-467-1300, x411

Carmela Kappel
Assistant to the Publisher
E-mail: ckappel@endeavorb2b.com
Phone: 630-467-1300, x314
Fax: 630-467-0197

SALES

FAITH ZUCKER
District Manager
Digital Sales Manager
Email: faith.zucker@endeavorb2b.com
Phone: 216-316-8203

CLASSIFIEDS/AD-LITS

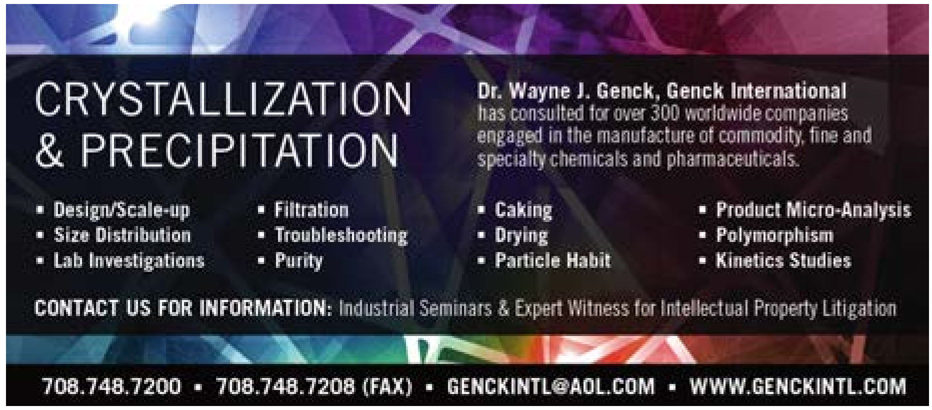
PEGGY HARRINGTON-MARZ
Inside Sales Manager
E-mail:
pmarz@endeavorb2b.com
Phone: 708-334-9348

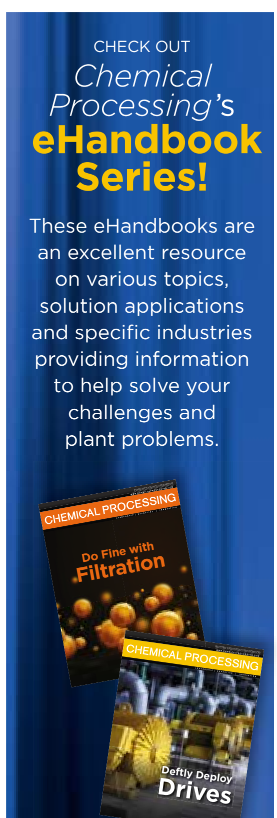
REPRINTS

Lisa Payne
Reprint Marketing Manager,
Mossberg & Co.
800-428-3340
lpayne@mossbergco.com

ADVERTISER INDEX

Benko	30
Busch Vacuum Solutions	29
Check-All Valve	22
Krohne	4
Lion Technology	18
Material Transfer	10
Motion Industries	40
Rembe	11
Reuters Events	39
Ross Mixers	2
Sika	22





Gene Tool Fixates on Fungi

Breakthrough in fungi genetic manipulation could open door to new chemicals

The ability to predictably manipulate multiple genes simultaneously is still largely limited.

WELL-KNOWN DRUGS such as penicillin, lovastatin and cyclosporine are just three examples that derive from fungi. However, fungi, and especially their filamentous incarnations, are hard to manipulate at a genetic level because their genes usually are governed by complex regulation mechanisms.

Researchers at Rice University, Houston, have a long track record of working to unlock the chemical and biochemical potential of fungi. Now, a breakthrough by chemical and biochemical engineers at Rice makes it easier to isolate new chemical compounds from fungi, potentially opening the door to many more novel drugs and other useful chemicals.

Writing in a recent issue of the *Journal of the American Chemical Society*, Xue Sherry Gao and her colleagues at Rice's Brown School of Engineering point to increasing evidence that several epigenetic — i.e. gene control — modifications often act cooperatively to control how fungal genes operate. However, they add, the ability to predictably manipulate multiple genes simultaneously is still largely limited.

"To me, the fungal genome is a treasure," Gao says, referring to the significant medical potential of fungi-derived compounds. "However, under most circumstances, fungi 'keep to themselves' in the laboratory and don't produce the bioactive small molecules we are looking for. In other words, the majority of genes or biosynthetic gene clusters of interest to us are 'cryptic,' meaning they do not express their full biosynthetic potential," she elaborates.

So for the first time, Gao deployed multiplex base-editing (MBE) as a tool for mining fungal genomes for medically useful compounds. Compared to single-gene editing, MBE reduces the research timeline by over 80% in equivalent experimental settings, from an estimated three months to roughly two weeks, she explains.

MBE significantly improved the capability and throughput of fungal genome manipulation. For example, using MBE to inactivate three negative epigenetic regulators combinatorically in the fungus *Aspergillus nidulans* enabled activation of eight cryptic gene clusters compared to the wild-type strains.

"The genetic, epigenetic and environmental factors that instruct organisms to produce these bioactive natural products (NPs) are extremely complicated in fungi," Gao explains. However, using the MBE platform, her team can easily delete several of the regulatory genes that restrict the production of bioactive small molecules. "We can observe the synergistic effects of eliminating those factors that make the biosynthetic machinery silent," she notes.

The disinhibited, engineered fungal strains used in this research produced many more bioactive molecules, each with their own distinct chemical profiles, than possible with traditional genetic engineering. In fact, five of the 30 NPs generated in one assay were never-before-reported compounds. They describe one example as harboring unique cichorine (a phytotoxin) and polyamine hybrid chemical scaffolds.

"These compounds could be useful antibiotics or anticancer drugs," Gao says. "We are in the process of figuring out what the biological functions of these compounds are, and we are collaborating with groups in the Baylor College of Medicine on pharmacological small-molecule drug discovery."

The latest breakthrough followed another in 2021, which also focused on gene clusters in a fungus genome, particularly a bioactive NP known as 21R-citrinadin A, discovered in 2004 in a marine-derived fungal strain of *Penicillium citrinum*. It is toxic to leukemia in mice and human lung cancer cells. Here, the researchers isolated a biocatalyst known as CtdE after identifying it as the natural mechanism that controls the chirality — and therefore effectiveness — of compounds the fungus produces.

Understanding how it works in fungi and analyzing its structure could give scientists, particularly those who design drugs, a new chemical synthesis tool.

"All the genes responsible for expressing this small molecule are clustered together in these fungi, so first we found the gene cluster and looked at each gene individually to see which one could be the most important to catalyze the specific chemical transformations," shares Gao.

"Once we find it, we can take that gene outside of the fungus, put it back into a user-friendly host, *E. coli*, and then use protein purification technology to isolate and test its function in a test tube. By doing everything outside of the fungus, we can be sure there's only one enzyme that performs this one function," she adds.

The modified *E. coli* express CtdE protein in bulk. When subsequently used in chemical transformations, CtdE catalyzed the desired stereoselectivity across the board. ●

SEÁN OTTEWELL, Editor at Large
sottewell@endeavorb2b.com


Mi TIME™ MEANS
MORE ME TIME
With the broadest mix of industrial products and technical expertise at your fingertips, the only downtime you'll need to worry about is yours.
Mi®
motion.com