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October 2015
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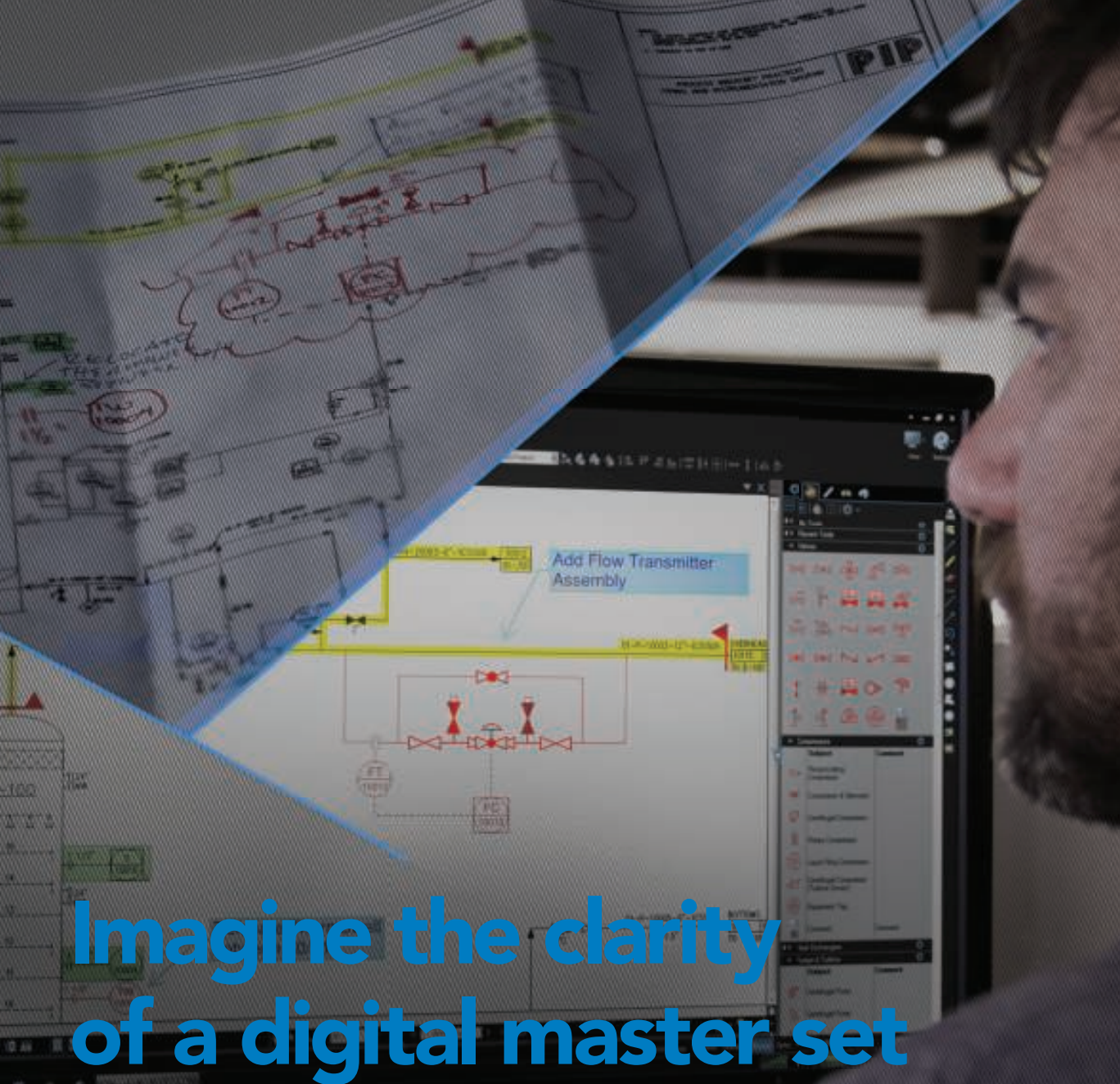

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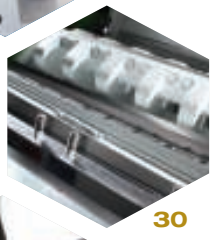

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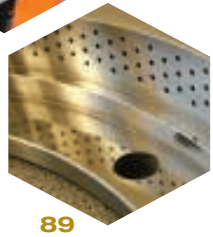

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BPA

Focusing on emissions

This August, two milestone actions were taken to set standards for emissions control in the U.S. On August 3, U.S. President Obama and U.S. Environmental Protection Agency (EPA) Administrator Gina McCarthy released the final Clean Power Plan — the first-ever national standards to limit carbon emissions from fossil-fuel-fired electric generating units. Power plants are the largest source of carbon emissions in the U.S., and the new plan aims to reduce carbon dioxide emissions by 32% from 2005 levels by 2030. The Clean Power Plan is said to take into account some four million comments submitted to the EPA during a public comment period. The emissions targets are state-specific and a host of "Fact Sheets" that give details are available on the EPA's website (www2.epa.gov).

On August 18, the EPA announced its proposal to cut methane emissions, another greenhouse gas (GHG), from the oil-and-gas sector. The proposal is a part of President Obama's Climate Action Plan to cut methane emissions from the oil-and-gas sector by 40–45% from 2012 levels by 2025. Stating that methane is a "potent GHG with a global warming potential more than 25 times greater than that of carbon dioxide," the EPA says that nearly 30% of methane emissions come from oil production, and the production, transmission and distribution of natural gas. The proposal requires the following in order to cut methane and volatile organic compound (VOC) emissions: finding and repairing leaks; capture of natural gas from hydraulic fracturing; and limiting emissions from several types of equipment (more information on the proposal can be found at www3.epa.gov/airquality/oilandgas/actions.html).

Technology

The tightening regulations on emissions provide more impetus to further already ongoing technical developments in a number of areas. There are, for example, promising developments in the area of carbon capture and sequestration (see Post-Combustion Carbon Capture Technologies, *Chem. Eng.*, March 2015, pp. 70–73). And a host of sensor, sealing and vapor-recovery technologies are available to aid in reducing methane emissions (see Targeting Methane Emissions, *Chem. Eng.*, March 2015, pp. 20–24). In response to the EPA announcement of its proposal to reduce methane emissions, the Fluid Sealing Association (FSA; Wayne, Pa., www.fluidsealing.com) recognized the importance of addressing the issue, and Mike Shorts, president of the FSA said "The sealing industry is ready to get to work to fix this issue. Our technology can be part of the solution and we know this is doable."

In this issue

For a broader, global perspective on emissions, this month's Feature Report on Emissions Regulations and Control (pp. 56–60) offers an elucidating look at how fugitive emissions are regulated around the world, and suggests how we can better control them.

This month's two-part cover story on Engineering Ethics (pp. 46–55) includes an interactive section that poses a number of scenarios and asks how you would respond. A link to the survey is available on our website (www.chemengonline.com).

And there is much more in this issue, including articles on ionic liquids, modeling and simulation, and flare operations. We hope you enjoy reading it. ■

Dorothy Lozowski, Editor in Chief

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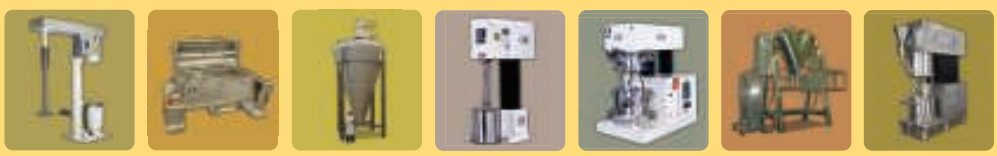

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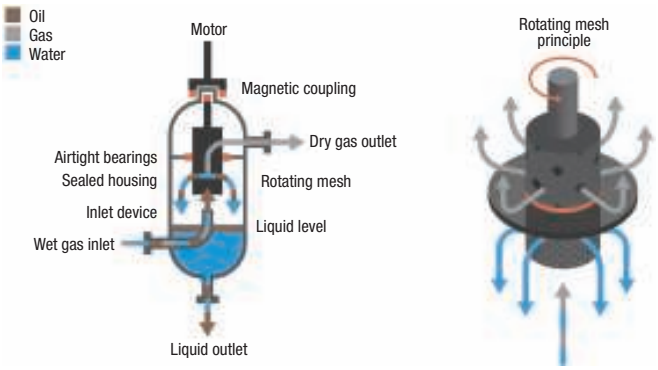
A new spin on liquid-gas separation



Last month, Innsep AS (Trondheim; Norway; www.innsep.com) and EagleBurgmann Norway (Skedsmokorset; www.eagleburgmann.no) began a collaboration to develop Innsep's Lynx Separator technology for protection of EagleBurgmann's Dry Gas Seal systems for compressors. Lynx is a new technology for removing entrained liquids much more efficiently and with a smaller footprint than conventional separators, such as those with stationary mesh contactors or cyclones.

The heart of the Lynx technology is a sponge-like cylinder made of porous stainless steel, which is mounted inside a separator column, and held in place by airtight bearings (diagram). The cylinder is rotated by a magnetically coupled motor. As the wet gas enters the filter, liquids coalesce onto the large surface area and then are thrown by centrifugal force to the walls of the separator to be collected at the bottom. The added pressure drop across the Lynx due to the rotation of the mesh is insignificant, says Innsep's R&D director Maria Fernandino.

The patented technology was first invented by Fernandino and Innsep's chief technology officer Carlos Dorao, who are both researchers at the Norwegian University of Science and Technology (NTNU; Trondheim; www.ntnu.no), from which the company was spun-off in 2011. Full-scale testing of a prototype device was carried out at Colorado Engineering Experimental Station Inc. (Nunn; www.ceesi.com) in 2012, whereby natural gas and liquid hydrocarbons at 60 bars were used. "The test was the first time that hydrocarbons at high pressure were separated by the rotating mesh, probing the concept behind Lynx," says Fernandino.

Since then, Innsep and NTNU have working with Statoil (Trondheim, Norway; www.statoil.com) and other partners as part of the DEMO 2000 project to qualify the technology for applications in the oil-and-gas industry. The goal is to develop a separator that is only half as large as conventional separators. "We have been testing in the range of 0.02–0.2 vol.% [liquid in gas], and are achieving very good results in one single stage," Fernandino says.

Low-cost separation of CO_2 from fluegas

A novel solvent can reduce the costs of capturing and recovering carbon dioxide from gas mixtures compared to the use of amine-based solvents, such as monoethanolamine (MEA). The solvent, along with an associated cyclic absorption-desorption process, was developed by Carbon Clean Solutions Pvt. Ltd. (CCS; Mumbai, India; www.carboncleansolutions.com) to replace MEA for separating CO_2 from fluegas, synthesis gas and other gas mixtures in industrial applications.

By combining amine-based compounds with salts, CCS' CDRMax solvent can react quickly to absorb CO_2, similarly to MEA, but can also reduce the energy requirements for desorption and reduce corrosion, says Aniruddha Sharma, CEO of CCS. The system works by bubbling fluegas (with ash removed) through large cylinders containing the CDRMax to absorb the CO_2. In a second vessel, the CO_2 is released from the solvent at 100°C. "If you can capture CO_2 cheaply, the CO_2 can be converted into more valuable products," says Sharma.

CCS says that capital costs for the CO_2-removal process can be reduced by 50% because the CDRMax solvent reduces corrosion significantly compared to MEA, and the process loss of solvent can be lowered from 40–95% to around 5–10%.

The CDRMax solvent has been substituted into existing plants in the U.S., E.U. and India with no need for equipment changes, Sharma says, and has been introduced at existing process plants in Asia and Europe. CCS' first "greenfield" project will begin operation in the first quarter of 2016, where the technology has been licensed for use in carbon capture at a new plant.

Edited by:
Gerald Ondrey

CO_2 TO FORMIC ACID

Professor Yutaka Amao and colleagues at Osaka City University (Osaka City, Japan; www.osaka-cu.ac.jp/en) have enhanced the photocatalytic efficiency for the conversion of CO_2 to formic acid by up to 20 times. The efficiency boost was achieved by replacing the natural coenzyme nicotinamide — used to activate formate dehydrogenase (FDH) — by an artificial coenzyme, dithionite-reduced methylviologen. The achievement has implications for the production of organic chemicals, such as methanol, using CO_2 as a feedstock.

SWEET SURFACTANT

Late August, Clariant Oil Services (Houston; www.clariant.com) introduced HofstaFrac SF 13213, a new "flowback aid" for hydraulic fracturing applications. The new sugar-based surfactant is said to dramatically lower the fluid's surface and interface tension to significantly increase the flowback of the hydraulic fracturing fluid. HostaFrac SF 13213 effectively lowers the formation damage caused by emulsification of the fracture fluids in the reservoir. While as little as 13% of the fluid used during the hydraulic fracturing process can be recovered without flowback aid additives, the new HostaFrac SF 13213 increases fluid-recovery levels to as high as 87%, says Clariant.

ADHESIVES

Last month, Perstorp AB (Malmö, Sweden; www.perstorp.com) and Corbion NV (Amsterdam, the Netherlands; www.corbion.com) introduced Capa lactide caprolactone copolymer

(Continues on p. 8)

Note: For more information, circle the 56-digit number on p. 102, or use the website designation.

for application in hot-melt adhesives. The product, resulting from a partnership agreement both companies signed in 2011, has a renewable content exceeding 80% and is fully compostable, thus providing adhesives manufacturers with a new technology to improve food-safety aspects of packaging, as well as meeting the growing demand for more sustainable products.

The new material will create a strong technology platform for the development of polymers that provide a genuine alternative to traditional materials like ethylene vinyl acetate (EVA) and metallocene-catalyzed polyethylene (mPE) for the adhesives industry, says Corbion's senior vice president Biochemicals, Marco Bootz.

The new Capa product is expected to be commercially available in the final quarter of this year and will be brought to market by Corbion. The new material is expected to be the first in a series of innovations for the adhesives industry.

ELECTROCURING

Scientists from Nanyang Technological University, Singapore (NTU; www.ntu.edu.sg) have invented a glue that hardens when a voltage is applied to it. The discovery offers a new alternative to traditional curing methods that are activated by light, temperature or two-component thermosets — such methods do not work in wet environments. With electrocuring, such limitations are overcome, say the researchers. As a result, the technology may find applications for underwater pipe repairs or for surgical procedures.

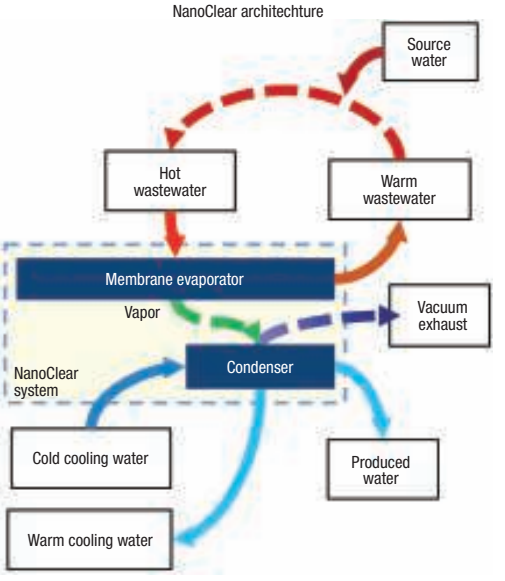
The so-called Voltaglue is developed using hydrogels consisting of carbenes grafted onto tree-shaped plastic known as dendrimers. Upon contact with electricity, the reactive carbenes, which are capable of hooking onto any surface nearby, are released. This technol-

(Continues on p. 13)

Nanostructured membrane for water purification

A new composite-membrane distillation process capable of removing salt, toxic elements and microorganisms from water is being offered commercially for the first time this month. The process, known as NanoClear, was developed by Dais Analytic Corp. (Odessa, Fla.; www.daisanalytic.com) for industrial wastewater treatment and desalination. The process is said to offer significant advantages in fouling resistance and eventually cost savings over reverse osmosis at similar flowrates.

The NanoClear process (diagram) leverages the unusual properties of Dais' patented Aqualyte membrane, which has been used commercially in HVAC (heating, ventilation and air conditioning) applications for over a decade. "Our nanostructured Aqualyte membrane is able to remove a wide range of contaminants to parts-per-billion levels, and is highly resistant to fouling," says Dais chief technology officer Brian Johnson.



The 25–30-micron-thick membrane is made from a block copolymer with regions of polystyrene and rubber. A polar functional group is added to the styrene to make those regions hydrophilic, while the rubber regions remain hydrophobic. As the polymer solidifies, it develops inherent structure at the nanometer scale: hydrophilic channels form that allow water molecules to selectively pass through the membrane, while contaminants are retained. The channels are not open pores, Johnson says, but rather solid regions of hydrophilic plastic that interact with water molecules via hydrogen bonding to enhance their permeation between the polymer molecules.

Nanoclear operates via a pervaporation process, in which heated wastewater is circulated on one side of the membrane, and water molecules are drawn through the membrane by a vacuum on the other side. The membrane allows significant surface area density while eliminating defects in the film of source liquid that lead to scaling in conventional evaporators.

Dais now operates two pilot-scale facilities using the NanoClear process and is working with partners to retrofit the system into existing facilities.

This cobalt complex catalyst is less expensive, more active than its rhodium analog

The research group of professor Shigeki Matsunaga at Hokkaido University (Sapporo, Japan; www.oia.hokudai.ac.jp), in collaboration with associate professor Takeshi Sakata at Hoshi University, has developed an inexpensive cobalt-based catalyst that can synthesize useful chemicals with fewer reaction steps and reduced waste generation compared to the analogous rhodium-based catalyst.

The new catalyst is a metal complex of Co(III) with the ligand 1,2,3,4,5-pentamethylcyclopentadienyl (Cp*), designated as [Cp*Co^{III}]. The researchers demonstrated the unique reactivity of a [Cp*Co^{III}] catalyst over analogous [Cp*Rh^{III}] catalyst for the C–H allylation reaction with allyl alcohols in dichloroethane (DCE). After 8 h at 60°C, a cationic [Cp*Co^{III}] catalyst promoted the direct, dehydrative C–H allylation with non-activated allyl alcohols to give C2-allylated indoles, pyrrole and 1-phenyl-pyrazole with good yields. Analogous [Cp*Rh^{III}] catalysts were not effective. Allylated products were obtained with high γ-selectivity in 62–99 % yield, and good turnover numbers of up to 62, were observed.

The cost of rhodium is not only about three orders of magnitude higher than that of cobalt, but using [Cp*Rh^{III}] as a catalysts for this type of reaction requires additional steps to activate the allyl alcohol, which generates additional waste from the pretreatment chemicals, says Matsunaga.

This filter renders secondhand smoke harmless

A research team, led by Jongsoo Jurng and Gwi-Nam at the Korea Institute of Science and Technology (Seoul; www.kist.re.kr), has developed a nano-catalyst filter that can drastically reduce harmful substances in cigarette smoke. The team created the filter by evenly coating a manganese titanium-oxide-based (Mn/TiO_2) nano-catalyst powder onto a ceramic-based filter media.

The filter decomposes harmful substances in cigarette smoke, such as acetaldehyde, nicotine and tar, using oxygen radicals that are generated by decomposing ozone in the air on the surface of the filter. When O_3 interacts with a metal oxide (Mn/TiO_2), it is decomposed on the surface of the manganese, generating oxygen radicals. Acetaldehyde, nicotine and tar are thus oxidized and turn into water vapor and CO_2. The O_3 is not discharged or detected after the decomposition reaction, as it is completely decomposed by the catalyst.

The team says the catalyst removes 100% of harmful substances. It claims its air cleaning equipment can purify more than 80% of the cigarette smoke within 30 min and 100% of it within 1 h in a 30-m^2 smoking room with ten people smoking simultaneously. The air cleaning equipment can also be used in air conditioners and air purifiers.

The team expects that it would take only about a year to commercialize the system, because the nano-catalyst and the filter coating technologies have already been developed. It believes the system is a significant breakthrough, because it represents a great improvement on existing technologies. Hitherto, activated-charcoal-based filters have been mostly used in a smoking room to remove gaseous materials in cigarette smoke. However, those filters are not effective in removing materials such as acetaldehyde. Their performance decreases fast in a smoking room and they need to be replaced every few weeks.

Organomagnesium catalyst isomerizes hydrocarbons

Organomagnesium compounds have become a highly important class of reagents in organic chemistry since the discovery of the Grignard Reaction more than 100 years ago. These compounds are powerful and inexpensive reagents that can be readily prepared from metallic magnesium and organic halides. In most applications, organomagnesium compounds are used as stoichiometric reagents, and there are only few reports of homogeneous magnesium catalysis.

Professor Kazushi Mashima and colleagues at the Dept. of Chemistry, Osaka University (Osaka, Japan; http://resou.osaka-u.ac.jp/en) recently found that alkylmagnesium complexes bearing monoanionic N,N-bidentate ligands are able to catalyze the isomerization of terminal alkynes to allenes, and further to internal alkynes. The key event in the reaction mechanism for both isomerization steps was found to be the activation of C–H bond. The reactions from terminal alkynes to allenes, and further to internal alkynes, proceed

through a temporally separated auto-tandem catalysis so that the macroscopic temporal separation allows for the isolation of the allene or the internal alkyne, whichever is desired.

The organomagnesium complexes were synthesized from N,N-dialkylamineimine ligands and dibenzylmagnesium by benzylation of the imine moiety. When 3-phenyl-1-propyne is used as the substrate, the magnesium complex catalytically transformed 3-phenyl-1-propyne to phenylallene almost completely within 18 h at 60°C. Moreover, by maintaining the reaction mixture at 60°C, the allene was quantitatively converted to 1-phenyl-1-propyne. In contrast, simple alkylmagnesium compounds, such as $[Mg(CH_2Ph)_2(THF)_2]$ and $[Mg(CH_2Ph)_2(TMEDA)]$, were not active for the two-step isomerization reactions. As another example, 3-aryl-1-propyne substrates are converted to the corresponding allenes (up to 89%) and internal alkynes (up to 82%) in toluene at 80°C, respectively.

Uranium processing plant benefits from modularity

A modular processing system for the Husab uranium mine in Namibia, Southwest Africa, has been designed and developed by Adelaide Control Engineering (ACE; Australia; www.adlcontrol.com.au). The company's managing director, Glenn Jobling, says innovative technology and advanced modular design have enabled the company to reduce the build time and requirement for skilled labor at remote sites by almost 50%.

The modular system is based on standard shipping containers and is built, assembled and tested in the company's Australian manufacturing facility before transport to the site. The $11-million contract includes a plant for dewatering, calcining and packing of yellowcake, complete with a waste-gas scrubbing system. The processing system is fed with yellowcake slurry from the mine's primary processing plant. Slurry is dewatered in a centrifuge and then fed to a rotary kiln for drying. From the kiln, the dried yellowcake powder is transferred to the packing module where it is packed into drums.

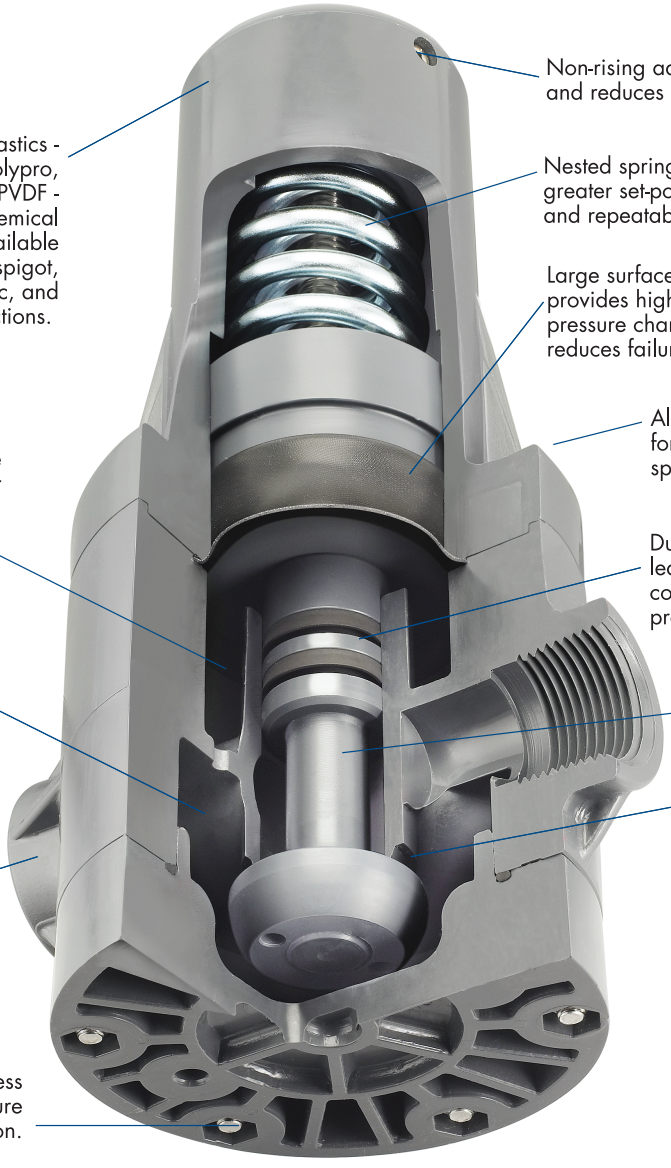
A key design criterion for the fully automatic drum-filling plant was that the risk of operator exposure had to be minimized. To achieve this, the drum filling and sampling system is contained within a sealed module, which has integral dust extraction.

Jobling says the fully automatic system also provides a high level of product security. "No one has access to the product, which provides product security and ensures that all product is accounted for," he says.

One of the most advanced parts of the project is the fluidized-bed precipitator, says Jobling. Fluidized-bed precipitation works with any precipitation method (ammonia, hydrogen peroxide and so on).

Continuous fluidized-bed precipitation provides several advantages over standard tank methods, explains Jobling. These include up to 25% lower cost of production with reduced maintenance, increased recovery of uranium, and reduced fines, thereby creating less dust and therefore lower risk to operators, he says.

Not All Pressure Regulators ARE CREATED EQUAL



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Artificial photosynthesis system demonstrates stability, safety and efficiency

Scientists at the California Institute of Technology's Joint Center for Artificial Photosynthesis (Caltech JCAP; Pasadena, Calif.; www.caltech.edu) have reported the first system for generating hydrogen gas from water using solar energy that simultaneously achieves high efficiency and oxidative stability along with good safety properties, according to JCAP scientific director Nate Lewis. Solar-driven H_2 generation could enable carbon-neutral transportation fuels, as well as a means to store solar energy.

The layered system consists of a photoanode, an ion-exchange membrane and a photocathode. The integrated system converts sunlight into H_2 at an efficiency of over 10% — by far the highest level achieved in a stable (40 h of continuous operation) and intrinsically safe system, Lewis says.

A number of key advances were critical to the prototype's operation. The first involves a method for protecting the system's gallium-arsenide-based photoanode from oxidation by water — a problem that complicates the use of semiconductors to harness light in fuel production. The Caltech team used atomic layer deposition to coat the photoanode with a 60-nm-thick layer of amorphous TiO_2. The TiO_2 prevents oxidation of the photoanode while allowing sunlight to reach the semiconductor and electrons to flow.

The second involved developing inexpensive catalysts to drive the essential reactions. Rather than relying on expensive metals, such as platinum, the Caltech group found that it could add a 2-nm-thick coating of nickel to the TiO_2 layer to efficiently split water molecules into oxygen, protons and electrons. They also integrated an inexpensive Ni-Mo catalyst into the photocathode, where the protons and electrons are recombined.

A third advance is the Caltech team's specialized polymer membrane that maintains separation of the product gases (H_2 and O_2) while allowing ion flow. The research team is now working on modifications to allow larger-scale manufacture of the system at reasonable cost, Lewis says.

ogy — described in a recent issue of *Nature Communications* — is currently patented through NTUitive, the university's commercialization arm.

CARBON FIBERS FROM AIR

Chemists from George Washington University (GWU; Washington, D.C.; www.gwu.edu) have developed a technology to economically convert atmospheric CO_2 directly into highly valued carbon nanofibers for industrial and consumer products. The process was presented at the 250th National Meeting & Exposition of the American Chemical Society (ACS; Washington, D.C.; www.acs.org), which was held in Boston, Mass. last August.

The nanofibers are made by electrolytic syntheses, whereby CO_2 is broken down in a high-temperature electrolytic bath of molten carbonates at 750°C. Atmospheric air is added to an electrolytic cell. Once there, the CO_2 dissolves when subjected

(Continues on p. 14)

to the heat and direct current through electrodes of nickel and steel. The carbon nanofibers build up on the steel electrode, where they can be removed, according to Stuart Licht, who leads the research team GWU.

To power the synthesis, heat and electricity are produced through a hybrid concentrating solar-energy system, which focuses the sun's rays on a photovoltaic solar cell to generate electricity, and on a second system to generate heat and thermal energy.

Licht estimates electrical energy costs of this "solar-thermal electrochemical process" to be around $1,000 per ton of carbon nanofiber product, which means the cost of running the system is hundreds of times less than the value of product output. He says the group is scaling up the process and "soon should be in range of making tens of grams of nanofibers an hour."

Putting more 'bio' into biodiesel fuels

Biodiesel fuels are made by the transesterification of plant-derived triglycerides (fats and oils), a process that generates impure glycerin as a byproduct while consuming fossil-fuel-derived methanol. Although there have been efforts in recent years to utilize the large volumes of glycerin byproduct (see Outlets for Glycerin, *Chem. Eng.* September 2007, pp. 31–37), most of these efforts focused on cleaning up the glycerin for applications in pharmaceuticals and cosmetics, or converting it into other commodity chemicals, such as propylene glycol, epichlorohydrin and acrolein.

Now, chemists from the Cardiff Catalyst Institute, School of Chemistry at Cardiff University (U.K.; www.cardiff.ac.uk) have discovered a way to turn crude glycerin into methanol, which can then be fed back to the transesterification process. Recycling the glycerin as methanol can increase the biodiesel fuel production by an estimated 10%, says professor Graham Hutchings, director of the institute, and lead author of the article describing the research that was published last month in *Nature Communications*. In contrast to other processes that hydrogenate glycerin into methanol using H_2 at high pressure, the Cardiff method uses water as the source of hydrogen atoms, he explains.

The researchers demonstrated that glycerin (10–30 vol.% aqueous solution) reacts with water over a magnesium-oxide catalyst to give methanol with high yields (25% conversion, 40% selectivity). The gas-phase reaction is carried out in a conventional packed-bed reactor at temperatures of 523–680K and atmospheric pressure — much milder conditions than the so-called Supermethanol concept, which integrates gylcerin conversion into synthesis gas production (reforming conditions 24–27 MPa, 950–1,000K) with methanol synthesis (24–27 MPa, 470–520K).

Although the work is still in the early stages, Hutchings says the discovery offers good opportunity to optimize biodiesel production while making it possible to produce fatty acid methyl ester (FAME) with 100% renewable content. The researchers plan to optimize the catalyst to significantly increase its activity and selectivity. ■

LINEUP

BOROUGE
BP
CELTIC RENEWABLES
EUROCHEM
EVONIK
GLAXOSMITHKLINE
KEMIRA
LOTTE
LUBRIZOL
LYONDELLBASELL
MANN+HUMMEL
MESSER
MILLIKEN
NESTE JACOBS
SIEMENS
TECHNIP
TOSOH
UBE
VEOLIA
W.R. GRACE

Plant Watch

Technip to provide EPC services for Unipetrol HDPE plant

September 10, 2015 — Technip (Paris, France; www.technip.com) was awarded a contract by Unipetrol (Prague, Czech Republic; www.unipetrol.cz), covering the engineering, procurement and construction (EPC) of a new polyethylene plant in Litvinov, Czech Republic. The new unit will have a capacity of 270,000 metric tons per year (m.t./yr) of high-density polyethylene (HDPE). The project is scheduled for completion in mid-2018.

Celtic Renewables to construct advanced biofuels plant

September 9, 2015 — Celtic Renewables (Edinburgh, Scotland; www.celtic-renewables.com) earned an £11-million (around $17 million) grant to build what is said to be the world's first plant for the production of biofuel from the residues of the whiskey industry. The biofuel facility will be operational by late 2018, and will produce at least 1 million L/yr of biofuel.

Grace to license Unipol polypropylene technology in South Korea

September 4, 2015 — W.R. Grace & Co. (Columbia, Md.; www.grace.com) will provide its Unipol polypropylene process technology to Hyosung Corp. (Seoul, South Korea) for its new facility in Ulsan, which is expected to open in 2017.The Ulsan plant will produce an estimated 200,000 m.t./yr of polypropylene.

Tosoh to expand production capacity for zirconia powder at two sites

September 3, 2015 — Tosoh Corp. (Tokyo; www.tosoh.com) is increasing the zirconia powder production capacity at its Nanyo and Yokkaichi sites by approximately 30%. The investment for this expansion is around ¥3.9 billion ($32 million). Commercial production is projected to begin in March 2016 at the Nanyo site and April 2017 at the Yokkaichi site.

BP licenses PTA process technology in Oman

September 3, 2015 — BP plc (London, U.K.; www.bp.com) and Oman International Petrochemical Industries Co. (OMPET) have entered into a licensing agreement for BP's purified terephthalic acid (PTA) technology. OMPET intends to build a unit in Sohar, Oman that will produce 1.1 million m.t./yr of PTA using BP's process.

EuroChem begins construction for ammonia plant in Russia

September 2, 2015 — EuroChem's (Moscow, Russia; www.eurochem.ru) subsidiary Phosphorit commenced the construction of an ammonia plant in Kingisepp, Russia. The new plant will have a design capacity of 1 million m.t./yr of ammonia. All EPC work is expected to be completed within 36 months. The company plans to invest €900 million in the project.

Messer invests in new specialty-gas plant in China

August 25, 2015 — Messer Group GmbH (Bad Soden, Germany; www.messergroup.com) has invested €33 million in a new specialty-gas facility in Suzhou, Jiangsu Province, China. The facility has a production capacity of 600 m.t./yr of nitrous oxide, along with other high-purity gases for electronics applications, including silane, ammonia and hydrogen.

Ube-Lotte JV announces launch of butadiene plant in Malaysia

August 25, 2015 — Ube Industries, Ltd. (Ube; Tokyo, Japan; www.ube-ind.co.jp) launched operations at the butadiene-rubber plant of its joint venture (JV) with Lotte, Lotte Ube Synthetic Rubber. Located in the Tanjung Langsat industrial park in Johor, Malaysia, Lotte Ube Synthetic Rubber has a butadiene-rubber production capacity of 50,000 m.t./yr.

Lubrizol to license Daelim polyisobutylene process technology

August 24, 2015 — The Lubrizol Corp. (Wickliffe, Ohio; www.lubrizol.com) and Daelim Industrial (Seoul, South Korea) have signed a license agreement granting Lubrizol the right to use Daelim's technology for the manufacture of polyisobutylenes (PIBs). The commencement of PIB operations at Lubrizol's Deer Park, Tex. site is projected to occur in a minimum of three years.

Borouge awards FEED contract to Neste Jacobs for polyethylene project

August 20, 2015 — Borouge, an Abu Dhabi-based plastics provider, has selected Neste Jacobs Oy (Porvoo, Finland; www.nestejacobs.com) as a front-end engineering and design (FEED) service contractor for its polyethylene plant modification project, located in the Ruwais industrial area, United Arab Emirates. Work for the project will be delivered within 2015.

Mergers & Acquisitions

Lubrizol acquires drug-delivery specialist Particle Sciences

September 9, 2015 — Lubrizol has acquired Particle Sciences (Bethlehem, Pa.; www.particlesciences.com), an organization with a comprehensive suite of services for the formulation, analysis and production of complex drug-delivery solutions. This acquisition further expands Lubrizol LifeSciences' pharmaceutical development capabilities. Particle Sciences will retain its company name.

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Milliken acquires performance-fabrics producer Springfield LLC
September 9, 2015 — Milliken & Co. (Spartanburg, S.C.; www.milliken.com) has acquired Springfield LLC (Jericho, N.Y.), a manufacturer of technical, performance and flame-resistant fabrics for safety apparel. Springfield has manufacturing facilities located in Gaffney and Lyman, S.C.

Siemens and GlaxoSmithKline form partnership for automation
September 8, 2015 — Siemens AG (Munich, Germany; www.siemens.com) will become a strategic partner of GlaxoSmithKline (GSK; Brentford, U.K.; www.gsk.com) for manufacturing automation. The partnership will focus on process and equipment control and building-management systems at GSK's manufacturing and pilot plants.

Evonik purchases Dutch hydrogen peroxide producer
September 8, 2015 — Evonik Industries AG (Essen, Germany; www.evonik.com) signed an agreement for the acquisition of PeroxyChem Netherlands B.V. The transaction, which will increase Evonik's hydrogen peroxide capacity in Europe, is expected to close in the fourth quarter of 2015. The parties have agreed not to disclose the purchase price.

Veolia acquires polypropylene recycler in the Netherlands
September 4, 2015 — Veolia (Paris, France; www.veolia.com) has closed the acquisition of AKG Kunststof Groep (Vroomshoop, the Netherlands), a company focused on recycling and compounding polypropylene. AKG has sold 37,000 m.t. of recycled material, and posted revenues of €34 million in 2014.

Kemira acquires assets of U.S.-based Soto Industries
September 2, 2015 — Kemira Oyj (Helsinki, Finland; www.kemira.com) has acquired certain assets of Soto Industries, LLC (Charlotte, N.C.). Soto specializes in the application of scale-control products, defoamers and settling agents for the pulp-and-paper industry. The parties have agreed not to disclose the transaction price.

Mann+Hummel to acquire filtration operations of Affinia Group
August 19, 2015 — The Mann+Hummel Group (Ludwigsburg, Germany; www.mann-hummel.com) has entered into an agreement to acquire the filtration operations of Affinia Group, which specializes in aftermarket oil, fuel, air, hydraulic and coolant filters. With this acquisition, around $1 billion will be added to Mann+Hummel's finances.

LyondellBasell sells Argentina-based subsidiary Petroken
August 19, 2015 — LyondellBasell (Rotterdam, the Netherlands; www.lyondellbasell.com) announced that YPF S.A. and Grupo Inversor Petroquimica S.L. have accepted an offer to purchase LyondellBasell's Argentina-based subsidiary Petroken Petroquimica Ensenada S.A. in a transaction valued at $145 million. The sale is expected to close in late 2015. Petroken operates a polypropylene plant with a capacity of 180,000 m.t./yr in Ensenada, Argentina. ■

Mary Page Bailey

Ionic Liquids Create More Sustainable Processes

The distinctive properties of ionic liquids enable versatility and efficiency across many industrial applications

IN BRIEF

Ionic liquids — salts in a liquid state at ambient conditions — make up a fascinating family of materials whose unique physical properties have made them highly sought after for many challenging applications. Nearly all ionic liquids (ILs) exhibit extremely low vapor pressure, but the diversity of ILs give way to countless combinations of anions and cations that can provide desirable properties for a vast array of uses.

IL-based technologies are still rather new commercially. BASF SE (Ludwigshafen, Germany; www.basf.com) became the first company to apply ILs at an industrial scale when a unit operating its BASIL (biphasic acid-scavenging utilizing ionic liquids) process technology went onstream in 2004 at BASF's Ludwigshafen site. Since then, industrial applications for ILs have greatly expanded. ILs are now used as industrial solvents, lubricants, additives and more. This article details some recent industrial applications of ILs where they promote efficiency and sustainability.

Roy Kaltschmidt, Lawrence Berkeley National Laboratory

FIGURE 1. JBEI has scaled up biomass pretreatment technologies that utilize ionic liquids from the bench scale to the 100-L scale using a reactor located at the Advanced Biofuels Process Demonstration Unit (ABPDU)

Alternative fuels applications

The pretreatment of lignocellulosic biomass, a challenging step in the preparation of biofuels, is an area where ILs have proven advantageous. Biomass of all types must be pretreated in order to isolate the most useful part — the polysaccharides that are converted into the sugars used in industrial fermentation processes. Conventional pretreatment processes can be expensive and energy-intensive, and in some cases, may actually have damaging effects on downstream microbes, enzymes and sugars. This is where ionic liquids become an attractive alternative.

The Joint BioEnergy Institute (JBEI; Emeryville, Calif.; www.jbei.org), in collaboration with the Advanced Biofuels Process Demonstration Unit (ABPDU; Emeryville, Calif.; www.abpdu.lbl.gov), has been working extensively to develop biomass-conversion processes that effectively utilize ionic liquids (*Chem. Eng.*, Sept. 2013, p. 15), with an emphasis on process optimization and unit-operation consolidation. JBEI has previously reported the creation of a single-vessel process that combines pretreatment and saccharification into one step, decreasing water input and waste generation. Now, in collaboration with the ABPDU, JBEI has turned its focus to scaleup, demonstrating IL-based pretreatment at the 100-L scale (Figure 1). Furthermore, according to the group, in a separate activity, a company has demonstrated IL pretreatment at a scale capable of processing one ton per day of biomass.

With these progressively larger demonstrations, Blake Simmons, JBEI's chief science and technology officer, is optimistic about the prospects of positioning this technology as an economical alternative to other commercial pretreatment methods. "We are very confident that in the near-term, say two to three years, we will be able to generate an IL conversion technology that can compete on a cost basis and outperform current technologies," says Simmons. The industry has taken notice of this work, as Simmons cites several companies that are funding collaborative projects across many applications, including fuels, chemicals and materials.

One key to optimizing the process is narrowing down the best ionic liquid for the job. According to JBEI, among the thousands of known ionic liquids, less than 50 have been shown to be effective for biomass pretreatment. "The selection of the anion and cation dictates how they interact with the principal components in biomass: lignin, cellulose, and hemicellulose," explains Simmons. ILs can be tailored for specific process requirements to selectively interact with biomass components, resulting in the perturbation of

Linde

FIGURE 2. Linde is employing its ionic compressors at hydrogen fueling stations in several locations, including this Geiselwind, Germany site, opened in May 2015

the plant cell-wall structure. JBEI has found that imidazolium-based ILs are particularly suitable for disrupting the plant wall and interacting with the various biomass components, making them an effective choice for treating a large variety of biomass feedstocks. "You can equate this to how other solvents can selectively solubilize a wide range of polymers," says Simmons, "after all, lignin, cellulose and hemicellulose are simply polymers that are produced by nature."

In investigating numerous varieties of ILs for pretreatment purposes, JBEI also began to look into some novel ways to synthesize ionic liquids, specifically from bio-based materials, especially since the costs to procure and recycle ILs are among the major challenges the group faces for industrial scaleup. The group has developed two renewable ionic liquids ("bionic liquids"); one derived from hemicellulose, and one derived from lignin. Lignin, typically viewed as a waste stream, is an especially attractive raw material for the production of bionic liquids.

To synthesize ILs from lignin, first, the lignin must be depolymerized into monomers. The monomers are then functionalized via standard chemical routes to generate aldehydes and alcohols, representing the cation portion of the resultant IL. The anion portion comes from phosphoric acid used in the process. These renewable ILs, says Simmons, are "comparable to the top-performing conventional ILs." Since lignin and residual amounts of hemicellulose are both byproducts of biomass pretreatment, a potentially closed-loop pretreatment process is possible. The bionic liquids not used for pretreatment can be sold to other markets, providing another source of revenue. The development of a renewable, efficient biomass-pretreatment process will

help to bridge the gap between bio-based chemicals and fuels and their petroleum-derived counterparts.

Like biomass, hydrogen gas is poised to become an alternative fuel source, specifically in the automotive sector. The Linde Group (Munich, Germany; www.linde.com) is at the forefront of this movement, opening hydrogen-fueling stations in California, Austria and Germany (Figure 2) in the past year. One very distinctive component of these modular stations is the company's ionic compressor, where ILs behave like mechanical pistons. Non-volatile and nearly incompressible, the ionic liquids used in these compressors provide corrosion inhibition and lubrication, and do not contaminate the hydrogen gas. Linde specially designed the IL for the compressors, seeking out a material that would not mix with hydrogen gas. This renders seals and gaskets unnecessary while providing efficient compression.

Acting as reciprocating pistons, the motion of the IL columns within the five-stage compressor serves to compress the hydrogen gas nearly isothermally, with almost no mechanical wear. According to the company, energy savings of around 40% are achieved with the use of ionic compressors versus those containing traditional pistons. Hydrogen can be compressed from a minimum of 5 bars inlet pressure to a maximum of 1,000 bars outlet pressure, says Linde. A coalescer on the outlet of the compressor allows for the ILs to be recovered and recycled. With construction underway on many new hydrogen-fueling stations, Linde will

FIGURE 3. Dye-sensitized solar cells are highly efficient energy sources that can be implemented into glass units on architectural structures. Merck's work in introducing ionic liquids into DSSC systems has helped to increase the possible service lifetime of these devices

continue to commercially deploy ionic compressors as hydrogen becomes a more widely used fuel source.

Longterm solar-power supply

ILs are also becoming prevalent in the solar-energy sector. Merck KGaA (Darmstadt, Germany; www.merck-group.com; www.emdgroup.com) has been developing electrolyte mixtures for dye-sensitized solar cells (DSSC), where ILs dissolve the electrolyte redox system (consisting of iodine, iodides and additives). DSSC systems employ electrolyte mixtures to facilitate efficient charge transport between the cell's electrodes. Merck commends ILs' "special properties" for instilling stability and longterm service life into DSSCs. "One reason for the long lifetime is the negligible vapor pressure of ionic liquids. Hence, there is no mechanical stress on the sealing or electrolyte evaporation when the cells heat up in the sun," says Hannah Bürckstümmer, strategic marketing manager, Photovoltaics within Merck's Performance Materials business sector. Low viscosity was also extremely important in creating the company's proprietary IL, as conventional electrolyte systems are usually quite low in viscosity. However, a solvent-based DSSC system, while highly efficient, is very volatile and has a shorter lifetime than electrolytes based on ILs. "Evaporation of the electrolyte is a key failure mode. For products with lifetime requirements of several years, experts see electrolytes based on ionic liquids as the best alternative," explains Bürckstümmer.

According to Merck, there are several market sectors where DSSCs are ideal. DSSCs can be used in low-light or indoor environments to supply power for small, non-wired devices like sensors, since they work efficiently and provide very high power densities. They are an attractive option for architectural structures, as well, since they can be made semi-transparent and the color can be adjusted (Figure 3). Here, they can serve simultaneously as a power source and a design element, says Bürckstümmer.

Natural-gas purification

ILs are also being positioned as a valuable material for natural-gas purification processes, including carbon-capture. In a project funded by Petronas (Kuala Lumpur, Malaysia; www.petronas.com.my), researchers from the Queen's University Ionic Liquids Laboratories (QUILL; Belfast, Northern Ireland; www.quill.qub.ac.uk) have investigated the use of various ILs for the capture of carbon dioxide (CO_2) from natural gas (Figure 4). Typically, CO_2 removal involves the use of corrosive and volatile amines, but the alluring physical properties of ILs offer many advantages. For instance, ILs boast very high stability, and they exhibit negligible vapor pressure under typical process conditions. Also, unlike amines, there is little risk of corrosion occurring due to the presence of ILs.

QUILL's research investigated various IL formulations, some containing water, for their CO_2-capture capabilities at the CO_2 partial pressures typically found in submarine natural-gas sources. As in other applications utilizing ILs, selection of the proper cation and anion was of utmost importance. Focusing on ILs with carboxylate anions, QUILL sought to maximize CO_2 absorption on the basis

of solvent volume and weight. IL basicity was another key design factor. The team also found that formulating the IL solvent with a nearly equimolar volume of water enhanced the CO_2 solubility, as water participates in the chemical mechanism of the process and slightly decreases the viscosity of the IL-water formulation.

After examining numerous IL formulations, QUILL's studies indicated that tributylmethylphosphonium propanoate was the most viable IL candidate for CO_2-capture processes. The team worked with the U.K. branch of engineering consultancy company WorleyParsons Ltd. (North Sydney, Australia; www.worleyparsons.com) for an in-depth analysis of the IL-based CO_2-capture process, and their findings indicated that, when compared with one of the most effective conventional CO_2 absorption processes (containing activated methyl diethanolamine), the IL-based process (utilizing tributylmethylphosphonium propanoate), actually had lower operating costs.

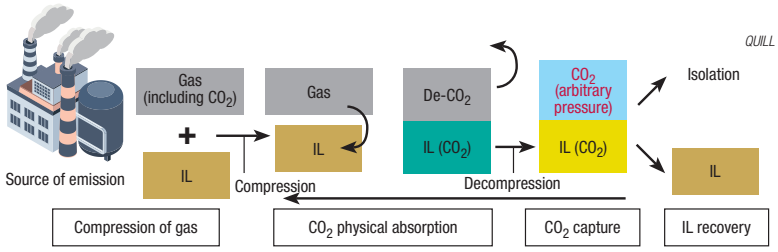


FIGURE 4. A proposed IL-based carbon-capture system has many benefits over conventional absorption processes

Added bonuses were reduced heat input, the absence of corrosion and equivalent selectivity and stability. According to QUILL's Natalia Plechkova, the process has been demonstrated at both laboratory and semi-pilot scale, and two patents have been filed as a result of the research. The next steps for scaleup, says Plechkova, will be to reduce the viscosity of the system and to change existing equipment to adapt to the new ionic liquid technologies. These findings are especially significant to the natural-gas industry, due to the restrictive regulations surrounding amines in some parts of the world.

Scientists from QUILL were also involved in the development of HycaPure Hg, a now commercialized technology that applies ILs to remove mercury from natural gas streams. The HycaPure process was developed in partnership with Petronas, which has been operating the technology at commercial scale in its own facilities in Malaysia since 2011. In 2014, Clariant (Muttenz, Switzerland; www.clariant.com) signed a marketing license agreement for the technology to expand its reach internationally.

Naturally occurring in many hydrocarbon streams, mercury is a toxic

contaminant that can cause corrosion and embrittlement in process equipment, and can generally degrade the quality of the product. Its presence also poses considerable exposure risks to workers. HycaPure Hg technology is said to capture all mercury species (organic, inorganic and elemental) that are present in natural gas streams, with a capacity three times higher than competing commercial mercury-removal methods, such as those containing activated-carbon materials, sulfides or silver. The HycaPure Hg process benefits from its kinetics — reportedly 10–20 times faster than other mercury-removal technologies — enabling it to handle fluctuating mercury content, particularly the large spikes in mercury concentration that could be damaging to downstream processes if not properly mitigated. Furthermore, the non-volatile nature of ILs proves valuable here, as there is no risk for inherent contamination of the gas during the mercury-removal process.

In laboratory tests examining the solubility of mercury in ILs — in this case, a chlorocuprate-based IL — QUILL observed that ILs in their fluid form could be applied to a mercury scrubber. However, the viscosity of the IL system would render it impractical for industrial scaleup. Therefore, a supported-ionic-liquid-phase (SILP) structure, wherein thin IL films are incorporated on a porous solid media, was proposed for use in a fixed-bed scrubber. The SILP format provides adequate contact between the IL and the gas stream, and also imparts mechanical strength.

Petronas took this technology from the laboratory to a gas-processing plant in Malaysia, and demonstrated that, even at commercial scales, the process resulted in natural gas streams that were significantly lower in mercury content than required sales specifications. According to QUILL, HycaPure Hg systems can be directly retrofitted into commercial plants, and the increased mercury-removal capacity can result in lower operating costs. QUILL emphasizes the remarkable nature of HycaPure's rapid commercial implementation, transitioning to commercial operations in less than four years.

Saving energy in catalysis

A notable feature of ILs is their ability to alter the behavior of other materials in their presence. Evonik Industries AG (Essen, Germany; www.evonik.com) has been taking advantage of this trait in the development of advanced SILP catalysts. In June of this year, Evonik announced an industry-first achievement, demonstrating that SILP catalysts can run reliably in a pilot plant for over 2,000 h, proving commercial viability.

Essentially, this SILP catalyst technology can make homogeneous catalysts — which are highly active and very selective, but can require energy-intensive downstream separation and recovery — behave more like their easier-to-handle heterogeneous counterparts. In a SILP system, the homogeneous catalyst can

be dissolved into a solution. This allows the catalyst to be applied to solid materials, eliminating downstream separation requirements.

For the development and application of SILP catalysts, Evonik has been focusing on the hydroformylation reaction, a common industrial reaction that converts olefins and syngas into aldehydes. Hydroformylation reactions traditionally employ a homogeneous cobalt or rhodium catalyst that becomes dissolved in the reaction mixture, necessitating costly separation and recycling steps. According to Evonik, since there is no known heterogeneous alternative for hydroformylation catalysts, this process is a prime candidate for SILP catalysis technology.

As in other IL-based applications, the ability to manipulate the cation and anion of the IL provides the flexibility to optimize the IL for the specific application. Evonik, along with researchers from the University of Erlangen-Nuremburg (Erlangen, Germany; www.fau.eu), began seeking out different IL anion-cation combinations to best adapt the SILP catalyst for hydroformylation. Also crucial was determining the most appropriate ligand for the catalyst. Many compounds were screened as the team targeted the optimal IL solubility, which, says Evonik, had to be high for the catalyst and low for the end product (so that no separation would be required to recover the catalyst materials).

From this work, the best candidate SILP catalyst consisted of a rhodium complex and a ligand based on polycyclic anthracene triol. The IL had an imidazolium cation and a binary amine anion. This was the SILP system that was used in the milestone 2,000-h demonstration. In addition to the intrinsic benefits of making the homogeneous catalyst easier to manage, Evonik also reports that in pilot-plant demonstrations, SILP operations resulted in a greater than 2% reduction in CO_2 emissions when compared with conventional hydroformylation processes, and that the metallic portion of the catalyst could be recycled.

Looking forward

Even as the use of ILs in industrial applications becomes much more widespread, there are still some challenges, mainly stemming from the cost in procuring some ILs in large-enough volumes for commercial-scale operations, and also in the sheer number of ILs that can be synthesized. As reiterated in this article, the ability to "tailor" ILs with the optimal cations and anions for a particular application instills great flexibility in process development. It also introduces some daunting challenges in process development, as it is infeasible for researchers to test literally thousands of anion-cation combinations. This is where predictive modeling tools will increasingly become important to narrow down the field of potential ILs for a particular process. As these tools become more robust and mainstream, it will certainly aid in expediting the development of future IL-based technologies. ■

Mary Page Bailey

Modeling and Simulation Move Forward

More tools and fresh applications bring modeling and simulation to all facets of chemical processing

Chemstations

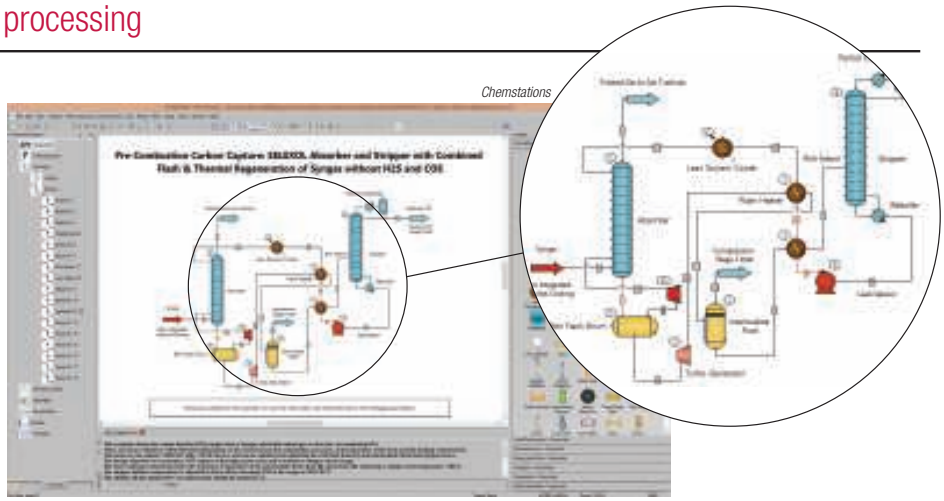


FIGURE 1. Designed specifically for the chemical engineering environment, Chemcad streamlines processes used in projects to improve workflow. Chemcad Version 7 includes a complete overhaul of the graphical user interface

Modeling and simulation software is becoming not only more powerful, but also more user friendly and affordable, making it a valuable tool for chemical processors who are using all types of simulation packages to optimize equipment, processes and practices. Today's offerings include process modeling and simulation software, which is being used in fresh ways, as well as computational fluid dynamics (CFD) tools, simulation solutions for increasing reliability and training simulators.

Process simulation

Process simulation software can be used in a variety of ways. One method is "front-end engineering" in which it serves as an aid when designing a new process or redesigning an existing one. "In these applications, the software is used to provide an engineering analysis that will help users find ways to improve the process or increase throughput efficiency," explains Steve Brown, executive vice president and chief operating officer with Chemstations (Houston, www.chemstations.com), which offers Chemcad, an integrated suite of chemical process engineering software with process simulation (Figure 1).

A more advanced use for process simulation software is in operations where simulators are often employed to compare actual performance against design performance. This operational tool may be used in very simple or very complex ways, according to Brown. "An engineer may open the simulator and compare design parameters to current operational parameters and do some analysis to see what has changed or look for areas of improvement," he explains. "The next step would be more complex, where the simulator is actually connected to the plant data and is reading plant parameters and calculating simulated variables based upon actual data coming from the plant, so they can then do what might be called 'online plant performance monitoring.'"

And, Mark Matzopoulos, marketing director with Process Systems Enterprise, Ltd. (London, England; www.psenterprise.com), adds that formal optimization of process design and plant operation is becoming a key technology trend. "While many people talk about process optimization, because of the limitation of the current toolset in practice, this often refers to incremental improvement determined by trial-and-error simulation. Formal mathematical-optimization techniques applied within an equation-oriented framework have the speed and power to deal with large numbers of decision variables, allowing applications such

IN BRIEF

PROCESS SIMULATION

CFD

RELIABILITY SOFTWARE

OPERATOR COMPETENCY

as whole-plant optimization, including simultaneous optimization of the reaction and separation sections.

"Moreover," he adds, "Decisions can include integer decisions to support, for example, distillation column configuration decisions, such as optimal number of stages or feed and side-draw locations. That means it is now possible to optimize the whole plant, choosing the optimum diameter and number of tubes in the reactor while simultaneously determining the optimal feed-tray location and operating pressure of distillation columns in the separation section."

In order to help users reap the benefits of this type of optimization, PSE recently released its gPROMS ProcessBuilder for model-based support of key process design and operating decisions. Combining the ease of use and solution robustness of traditional sequential-modular flowsheeting tools with the modeling and solution power of the equation-oriented gPROMS platform, it is intended to bring the benefits of advanced process modeling to the wider engineering community.

No matter the type or method of applying simulation software, it is likely to unearth changes that can and should be made to improve the process, increase efficiency and cut costs. However, according to Brown, users were finding that the reports generated by typical simulation software were not adequate when presenting the results. To help overcome that obstacle, the latest version of Chemcad now features professional-looking reports with polished graphics so that engineers do not have to spend time cleaning up studies for reporting.

"Application of the selected ideas resulted in a reduction in plant energy consumption of 3 to 4%, which provided an estimated profit of $10 million."

Terumi Okano, AspenTech

Another way that software providers are improving simulation packages is to allow collaboration between different departments and concerns within the facility, says Terumi Okano, product marketing manager for aspenONE Engineering with AspenTech (Bedford, Mass.; www.aspentech.com). "Once a company has developed a model, there are many different departments within the plant that can use that model to seek improvements, so the model is no longer used just for simulating the process, but also can be used to optimize energy, safety, operations support, equipment design and so on," she explains. "For this reason, we have provided several integrated tools that will help break down the barriers between departments and lead to significant savings throughout the plant."

For example, Okano cites an ethylene plant that employed aspenONE

Engineering's AspenPlus simulation software, along with Aspen Energy Analyzer (Figure 2), to minimize the energy consumed. "From the energy analysis, sixty potential energy-saving ideas were generated. Based upon the operational feasibility, commercial validity and available plant space, twenty of these ideas were selected for operational analysis," she says. "Application of the selected ideas resulted in a reduction in plant energy consumption of 3 to 4%, which provided an estimated profit of $10 million."

Among the tools offered for integration with aspenONE Engineering and Aspen Plus for modeling and simulation are Aspen Energy Analyzer, Aspen Economic Evaluation, Aspen Equipment Design and Rating and Aspen Basic Engineering.

Computational fluid dynamics

Often, CFD simulations are used for design and engineering of products and equipment, but also are now commonly being specialized for and employed by chemical processors to solve problems involving flow of fluids or solids, heat transfer and stress within the process, according to Ravindra Aglave, director of chemical processing with CD-adapco (Melville, N.Y.; www.cd-adapco.com), which provides STAR-CCM+ engineering simulation products (Figure 3).

Ed Fontes, chief technology officer with Comsol (Boston, Mass.; www.comsol.com) agrees. "The first benefit this type of software provides is a quick understanding of the process," he says. "Without simulation, you would need to run a variety of time-consuming experiments just to find out how the process truly operates.

"Once you have the model that describes the true reality, the next step is to use that model in combination with experiments to get the actual parameters from the process, including things like mixing properties or transport properties," he explains. "Once you have those, you can begin to experiment using parameters that are outside of these actual conditions and see if you can optimize the equipment. Perhaps you can design a reactor with a different shape that will enhance the process based upon the models and conditions you've created," he says.

"Using simulation in this way allows equipment to be optimized for specific conditions in the real process," he says. "It is no longer just for general design purposes."

Because chemical processors are constantly challenged with improving their processes and, therefore, their equipment, Comsol now offers packages specifically tailored for chemical engineers within its Multiphysics Software Product Suite.

Among them is the CFD Module, which is a platform for simulating devices and systems that involve fluid flow models. The Chemical Reaction Engineering Module models mass and energy balances and chemical reactors to help optimize chemical reactors, filtration equipment, mixers

AspenTech

FIGURE 2. Among the tools offered for integration with aspenONE Engineering and Aspen Plus for modeling and simulation are Aspen Energy Analyzer (shown here), Aspen Economic Evaluation, Aspen Equipment Design and Rating and Aspen Basic Engineering

and other processes. And, the Optimization Module is an add-on package that can be used to improve on the design of the equipment.

Aside from equipment optimization, CFD simulators can also be used for troubleshooting, adds Aglave. "There are very few ways to look inside a piece of complex equipment, so that's where simulation comes in," he says. "It lets you peer into the heart of reactors and other equipment to analyze the flow distribution and see if there's something that's not functioning the way it should be. And, once you know the root cause as to why the equipment isn't functioning properly, you can use that information to take corrective actions. Further, with that basis established, you can examine alternative designs that might better serve the process."

He adds that this type of simulation can also help processors investigate the effects of increasing capacity. "In sophisticated chemical facilities, it isn't as easy as putting in twenty percent more materials to get twenty percent more product. And, experimenting with the 'what ifs' isn't feasible in a large, operating plant," Aglave explains. "CFD simulation can give you a complete analysis of what happens when you increase capacity in a reactor. In this way, this type of simulation provides informed data that helps processors make decisions based upon business and safety criteria."

Reliability software

Also available is modeling and simulation software that focuses on facility reliability, availability, maintainability and cost, known as RAM-C, says Bob Bartlett, senior reliability analyst with Booz Allen Hamilton (McLean, Va.; www.boozallen.com), which provides its Raptor product for this purpose.

"No company can afford to continuously throw money away on unreliable components or operating strategies, including spare parts and preventive maintenance strategies," says Bartlett. "So we use modeling and simulation software to create analytical models and make decisions

CD-adapco

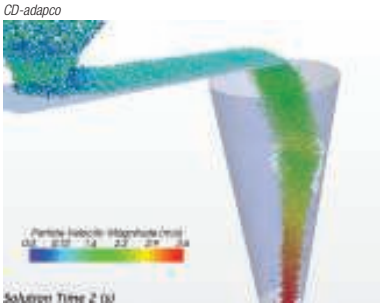


FIGURE 3. Shown here is the transport of particles on belts, conveyors and hoppers as depicted in STAR-CCM+ engineering simulation software.

based on rational analysis, which can detect unnecessary operational costs and unneeded logistics support. The software analyzes cost, capacity, sparing and maintenance concepts and accounts for issues including cold and hot standby with priority, redundancy, components that can change behavior with phases of operation, multi-distribution systems and cascading features."

This, he says, means users receive hard data that take into account the actual way a processor handles its business so that informed decisions can be made about components with the highest failure rates or about the entire process.

Operator competency

"Competent, well-trained operators are safer, more efficient and more reliable and, as a result, may im-

Honeywell

FIGURE 4. The UniSim Competency Suite provides highly accurate representations of the plant to allow effective transfer and evaluation of knowledge, which helps boost efficiency at startup and prepares operators for situations that may develop during plant operations

prove plant operations, efficiency and safety," says Martin Ross, product manager for Honeywell Process Solutions' (Houston; www.honeywellprocess.com) UniSim Competency Suite of products. "So the challenge becomes how to create that competency? How do you make sure the people you put in front of the console to start up a new plant or operate an existing plant are actually competent?"

"Competent, well-trained operators are safer, more efficient and more reliable and, as a result, may improve plant operations, efficiency and safety."

Martin Ross, Honeywell Process Solutions

Ross believes a training simulator, which operates much like a flight simulator for pilots, is the answer. Honeywell's UniSim Competency Suite (Figure 4) enables processors to plan, deploy and manage a structured program for operator competency. It offers solutions to train plant employees for safe, incident-free and efficient startups, as well as for maintaining operator skills in an established plant, he says.

"The only way to really represent the response of the plant is to build a sophisticated mathematical replica of the plant that includes all the process chemistry and physics, so you have the correct plant response for each operational interaction," Ross explains. "You need to suspend disbelief that this is a drill via a high-fidelity simulation of the plant using accurate flashes, alarms, reactions and, even, an accurate representation of the control console. Highly accurate representations of all situations allow for effective transfer and evaluation of knowledge, which helps boost efficiency at startup and prepares operators for situations that may develop during plant operations. An informed, practiced operator is the safest operator."

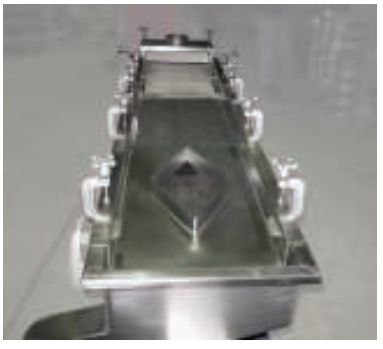
Final remarks

With the penetration, availability and ease of use of modeling and simulation software found on the desktops of many plant engineers and operators, it makes sense that they are using simulation to optimize everything from equipment to processes to reliability to training. "Simulation of any form, be it for process or equipment design or optimization, troubleshooting or training, is a major time and money saver," notes Aglave. "And every day a plant is not running optimally, it is losing money. Simulation is a way to recover that lost money and work toward optimization goals."■

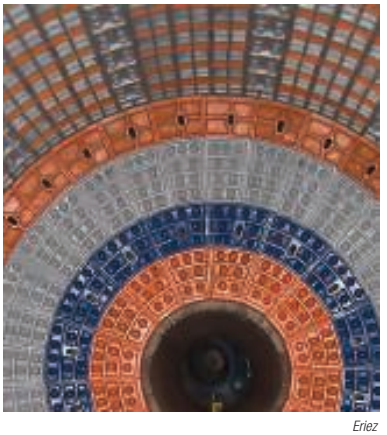
Joy LePree

Grinding, Milling & Screening

Sturtevant



The Witte Co.



Eriez

Stedman Machine

A mill for when every micron matters

Designed with the same configuration as larger production mills, the Qualification Micronizer jet mill (photo) allows laboratories to develop powder formulations with desired fine particle sizes on a small scale before proceeding to trial and production quantities. Built for experimental batches of 5–20 g, the versatile Qualification Micronizer can mill up to 0.5 lb/h of material, but can also handle feedrates as low as a few grams per hour to maximize sample recovery. The fines produced have a narrow particle-size distribution and can be milled to diameters as small as a few microns. Compressed air or bottled gas is used to create a high velocity vortex within the micronizer that causes the particles to collide and disintegrate into tiny spheres. This process generates no heat, the company says. — *Sturtevant, inc., Hanover, Mass.*
www.sturtevantinc.com

Diamond deck classifier design makes blockages easy to find

A new, diamond, double-deck plastic-pellet classifier design (photo) features diamond-shaped openings in the first stage "overs" screening deck that provide constant access to the pellet flow in the second stage "overs" screening deck below to monitor the flow during operation. Any blockages cay be quickly found and removed. Available on the company's 700 Series classifiers, the diamond, double-deck design screens the product twice through dual, perforated decks for superior removal of off-spec pellets, while the company's proprietary vibratory technology quiets the pellets into a single layer to help prevent "short-longs" (pellets that meet diameter specifications, but not length) from contaminating the end product. — *The Witte Co., Washington, N.J.*
www.witte.com

Magnetic mill liners reduce grinding media and power

This company's Magnetic Mill Liners (MMLs; photo) combine all of the best qualities of steel and magnetic liners to provide unmatched performance and protection. The wear-resistant steel-encased magnet, designed for both secondary and regrind ball mills, lines the shell and mill heads to improve grinding efficiency and reduce power consumption while maintaining mill throughput. A magnet holds the metal magnetic liner to the shell and retains ball chips and magnetic minerals to form a solid protection layer, which serves as the wear liner. The ball chips and magnetic minerals are contained continuously. This state-of-the-art design enables the liner to last for many years without requiring maintenance. MMLs can effectively lower energy and medium consumption. — *Eriez, Erie, Pa.*
www.eriez.com

Economically grind materials with this vertical roller mill

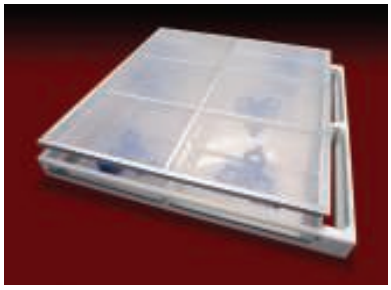
The Vertical Roller Mill (VRM) is an air-swept fine grinding system that is said to produce an improved particle-size distribution when compared to a traditional ball mill or old style vertical roller mill. Consistent wear and long-life grinding-zone components allows this VRM fine grinder to deliver consistent results, crucial to maximizing efficiency and profitability of end products. The new VRM air-swept fine grinding system has been designed to economically grind a variety of materials including: rock dust (as defined by the Mine Safety and Health Admin.; MSHA), activated carbon, calcium carbonate, coal, lime and petroleum coke. Four sizes are available from 10 to 150 hp. — *Stedman Machine Co., Aurora, Ind.*
www.stedman-machine.com

Sieve tray frames fabricated from food-grade HDPE

The Lift-Out Tray Frame is available for the Model 200, 300 and 400 Tru-Balance sifters, which are used in applications throughout mill processing and quality assurance applications. The Nova sieve can now be fabricated with food-grade high-

Note: For more information, circle the 3-digit number on p. 102, or use the website designation.

Great Western Mfg.



density polyethylene (HDPE), and works with existing Nova aluminum trays. Advanced manufacturing processes provide a simpler, more sanitary Nova sieve design (photo) with the same benefits of the traditional wooden Nova sieve including: sturdy metal tray; elimination of backwire; optimum screen tensions; high net screen area; one piece pan and screen cleaner with high cleaner performance; and reduced sieve heights, which allow for increased number of sieves in a stack or increased sieve heights. — *Great Western Mfg. Co., Inc., Leavenworth, Kan.*
www.gwmfg.com

Three-roll mills for laboratory and production requirements

Charles Ross & Son

Three-roll Mills are offered in a wide selection of capacities and features for handling virtually any laboratory application all the way to pilot- and full-scale production requirements. One popular model (photo) is the 5 in. × 12 in. machine with hardened carbon-steel 52100 precision ground rolls, each cored for water cooling and heating. Standard handwheel controls feature a quick release/reset engagement mechanism for easy operation and accurate repeatability, while a trip switch across the top of the mill helps ensure operator safety. Mounted to a heavy-duty freestanding base, this mill comes with adjustable bronze endplates and stainless steel apron. Options such as hydraulic roll adjustments, hardened stainless-steel rolls, coated rolls (aluminum oxide, chromium oxide or tungsten carbide), Teflon endplates, special roll-setting gages, analog position indicators, stainless steel sheathing and explosion-proof controls are available. — *Charles Ross & Son Co., Hauppauge, N.Y.*
www.mixers.com

Pharma-grade pin mill reduces friable solids

Munson Machinery

The pharmaceutical-grade pin mill, model CIM-18-S316 (photo) grinds friable powders, flakes and granules into controlled particle sizes ranging from coarse to fine. Unlike conventional pin mills in which the static outer disc is remov-

Circle 16 on p. 102 or go to adlinks.chemengonline.com/56202-16

Franklin Miller

Pallmann Maschinenfabrik

Fritsch GmbH

able but the inner rotating disc is not, the outer and inner discs can swing away from the unit on cantilevered arms, providing full access to both sides of both discs and the mill housing for rapid cleaning and sanitizing. Setting the infinitely variable rotor speed between several hundred and 5,400 rpm provides the flexibility to use the machine for coarse grinding and de-agglomerating as well as for fine grinding down to 400 mesh. Constructed of 316 stainless steel, the unit features a sanitary butterfly valve on the air intake, sanitary fittings at the material intake and discharge and a wash-down-duty motor. — *Munson Machinery Company, Inc., Utica, N.Y.*
www.munsonmachinery.com

This machine crushes large volumes of materials

The Delumper Triple-LP Crusher (photo) is engineered to reduce massive quantities of plastics, minerals, chemicals, lumps, chunks and agglomerates to controlled output sizes. Designed with a unique ability to handle sticky, wet, moist substances as well as dry caked solids, the Triple-LP Crusher features a heavily constructed body and low-friction cutter design with three parallel shafts of individual replaceable cutters mounted in a staggered pattern around the shaft diameter. Each shaft has heavy outboard bearings and a shaft seal to protect the bearings and retain the product in the cutting area. The Triple-LP is available in two series: LP standard crushers are designed for high capacity on light- to medium-weight materials, and HD units are designed for continuous, high-load operation with heavy materials at a rate of up to 38,000 ft^3/h (1,080 m^3/h). — *Franklin Miller, Inc., Livingston, N.J.*
www.franklinmiller.com

A robust granulator for efficient PET bottle recycling

This company has recently extended its range of Panther recycling granulators, by adding a granulator that has been specially designed for recycling reusable materials from polyethylene terephthalate (PET) bottles (photo). Individual PET bottles are continuously fed into the cutting chamber, by means of a conveyor belt. Massive, angled rotor knives work with a very close cutting gap against opposing slanted counter knives and cut the bottles into flakes. The lower part of the housing is fitted with a large screen, which holds the PET flakes in the cutting chamber until they are discharged through the screen holes. The mesh size can be selected, which determines the size of the flakes and throughput rate of the granulator. Throughput rates of up to 3.5 ton/h are possible with a flake size of approximately 14 mm and the appropriate machine size. — *Pallmann Maschinenfabrik GmbH & Co. KG, Zweibrücken, Germany*
www.pallmann.eu

A laboratory mill with a high-speed rotor

The Variable Speed Rotor Mill Pulverisette 14 premium line (photo) offers impact, shearing and cutting comminution in one instrument. The machine has a higher performance, better cooling and is significantly quieter than comparable instruments, says the manufacturer. Its powerful motor is ideal for the particularly fast comminution of soft to medium-hard, brittle as well as fibrous materials and temperature-sensitive samples with an extremely fast sample throughput of up to 15 L/h and more, depending on the material and parameter settings. A high-speed motor with ceramic bearings ensures a particularly high impact and rotor speed up to 22,000 rpm. Particles with a fineness down to $d_{50} < 40$ µm are achieved. — *Fritsch GmbH, Idar-Oberstein, Germany*
www.fritsch.de

A universal milling platform with five heads

The FreDrive multifunctional milling platform can accommodate up to five different grinding heads, providing primary crushing, de-agglomeration, granulation, fine grinding or control screening. Intended for use in the chemical, pharmaceutical and food industries, the FreDrive can process sticky, hard or crystalline powders with varying product characteristics. The FreDrive can be mounted on a mobile lifter, and users have the option to dock the mill anywhere in the production area to bring the device to a desired height. — *Frewitt SA, Granges-Paccot, Switzerland*
www.frewitt.com

Achieve finer PSDs with this conical mill

Quadro Engineering

The H^{20} Comil (photo) is said to redefine conical milling by pushing the capabilities of cone mill technology toward finer particle-size distributions, making it ideal for active pharmaceutical ingredients (APIs) and fine chemical products. With its re-engineered drives and milling efficiency improvements, the H^{20} provides superior performance over jet mills, pin mills or hammer mills without the need for expensive additional containment or air-handling systems, says the company. The system achieves 30–70% finer particle-size distributions (PSDs) than traditional conical mills, and has the ability to control and shift PSD targets for coarser or finer results, says the manufacturer. — *Quadro Engineering Corp., Waterloo, Ont., Canada*
www.quadro.com

Two mills in one laboratory device

This company has built its first combination mill comprised of an S1 batch mill combined with an SDM-05 mill designed to operate as a bead mill. Being able to process both fine and coarse materials without purchasing two complete mills to accomplish this, the S1/SDM-05 combination laboratory mill provides the option to run at slower speeds (approximately 100 to 500 rpm) and uses media ranging from 1/8 to 3/8 in. The SDM option runs at higher speeds (approximately 300 to 2,000 rpm). The system utilizes grinding media as small as 0.25 mm, and as large as 2 mm. — *Union Process, Inc., Akron, Ohio*
www.unionprocess.com

Rotor mills with variable speed and large sample volumes

The new generation of rotor mills SR 300 and SK 300 has been greatly improved with regard to performance, handling and flexibility, says the manufacturer. The speed of the rotor beater mill SR 300 has been substantially increased and can be set between 3,000 and 10,000 revolutions per minute (rpm), thus allowing for optimum adaptation to application requirements. It is therefore ideally suited for use in pharmaceutical and food laboratories. The new cross beater mill SK 300 now also operates with higher speed, which can be set from 2,000 to 4,000 rpm. Both mills can be equipped with an optional cyclone, which improves material discharge, particularly for very fine particle sizes, and provides additional cooling of the sample. — *Retsch GmbH, Haan, Germany*
www.retsch.com

Gerald Ondrey

Filters and Membranes

Lanxess AG

Membrane elements desalinate seawater and brackish water

The Lewabrane Series membranes (photo) use reverse osmosis to desalinate seawater and brackish water. Water is forced through the semi-permeable membrane at high pressure, to remove salts and other unwanted substances, including borates, nitrates, arsenates and silicates. Depending on the intensity of use, these spiral-wound, thin-film composite membranes can last for several years, says the company. The Lewabrane RO membrane elements for applications with standard pressure (15.5-bars test pressure) are offered in two types: HR (high rejection) and HF (high flow). The HR-type elements are designed to provide extremely low salt passage under normal operating conditions (yielding >99.7% salt rejection, and optimal removal of other target ions, measured at standard test conditions). The HF-type elements allow for increased water productivity coupled with a slight increase in permeate salinity. —*Lanxess AG, Cologne, Germany*

www.lanxess.com

Hayward Flow Control

Compact, back-washable sand filter resists corrosion

The LS Series Backwashable Sand Filter (photo) is designed for sensitive aquatic environments and saltwater systems that are maintained in science and research facilities, and for for aquatic life support and aquariums. It is available in two sizes: 31-in. width (99 gal/min) and 36-in. width (130 gal/min). All wetted hardware is made from Type 316 stainless steel. Gasket seals are made from EPDM, and 2-in. NPT connections are standard. Other features include a corrosion-resistant flanged cover for internal visual inspection, thermoplastic housing and base, an integral molded drain plug and multi-lateral underdrain assembly. — *Hayward Flow Control, Clemmons, N.C.*

www.haywardflowcontrol.com

TriStar Ltd.

One-stop shopping for natural gas filtration products

A broad range of filtration, separation and coalescing equipment and replacement filter elements for gases and fluids is available online, for use in the natural gas industry. Among the many filter elements available are high-efficiency coaslescing elements that are designed to replace conventional elements to effectively remove higher concentrations of aerosol mists and particulate matter in natural gas filtration applications that have low tolerance for carryover. —*Clark Reliance Corp., Strongsville, Ohio*

www.clark-reliance.com

Design improvement optimizes this vacuum drum filter

This company has improved its Pre-Coat Rotary Vacuum Drum Filters (RVDF) with the introduction of the EDG-trac Knife Advance System (photo). It is designed to improve filtration performance and reduce energy costs. Ideal solids penetration into a pre-coat filter is two to five thousandths of an inch. The EDG-trac system removes as little as 1.4 thousandths of an inch per revolution, at a drum speed as low as 0.2 rpm. This helps to extend the pre-coat life by not cutting away clean pre-coat while maintaining acceptable solids separation and improving liquid throughput, says the company. An efficient, single motor with variable frequency drive (VFD) reduces energy use and cost, while fully automated PLC controls provide precise control and critical information for operators. The company is offering retrofits of existing units (at the owner's facility, or at the manufacturer's facility). Independent testing of a recent installation showed that the EDG-trac system was able to increase filtration throughput by 700% and reduce energy consumption by 87% on a per-gallon filtered basis, says the company. — *TriStar Ltd., Buffalo, N.Y.*

www.tristarltd.com

Note: For more information, circle the 3-digit number on p. 102, or use the website designation.

Water-treatment membranes resist solids buildup

Koch Membrane Systems

The Puron MBR ultrafiltration membrane bioreactor series (photo) is designed for use in industrial and municipal wastewater-treatment applications. It has a single-header design, and its patented module houses reinforced polyvinylidene fluoride (PVDF) hollow fibers that are fixed only at the bottom, virtually eliminating the buildup of hair and fibrous materials that typically clog the upper ends of other modules, says the company. Solids and particulates, including bacteria, remain on the outside of the fibers, while permeate is drawn through the membrane to the inside of the fibers. The robust braided membrane fibers resist breakage and downtime, says the company, and the system is said to have one of the lowest energy demands among comparable products on the market. Aeration nozzles scour the entire length of the fibers to manage solids with minimal energy consumption, says the company. — *Koch Membrane Systems, Wilmington, Mass.*
www.kochmembranes.com

Metal felt fiber give these filters the edge in extreme conditions

The high-pressure T-Type filter assemblies (photo) feature all stainless-steel construction for both the filter housing and filter elements. With working pressures up to 20,000 psi (1,378 bars), these filters are designed for extreme environments, such as those found in the offshore oil industry, chemical processing, hydraulics, power generation, automotive and other demanding applications. The FJV-3 Series high-pressure filters use porous-metal-felt filter elements that employ filter media of thin filaments of non-woven stainless steel, making them ideal for highly corrosive, highly viscous or radioactive applications, says the company. Because it is highly porous (up to 85%), metal felt media provides very high flowrates of up to 20 times those of other media while maintaining very long operating life. — *Swift-JB International LLC, Houston*
www.swift-jbinternational.com

Swift-JB International

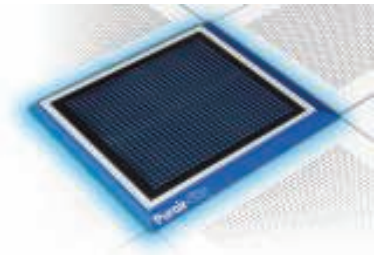
Separate unwanted solids from fluid streams

Eriez

This company's Solids-from Liquids Centrifuges (photo) provide continuous filtration to remove both metallic and non-metallic solids from industrial fluids without the use of disposable media. They are avail-

Sartorius Stedim Biotech

Camfil APC



Air Science USA

Porvair Filtration Group

able in two designs — a manually cleaned basket style (with a reusable liner), and a fully automatic, self-cleaning version. The centrifuge can be mounted on a single machine, or used as a component within a facility-wide filtration and recycling system. They can also be used to supplement existing systems, to remove solids that may have been missed by other barrier filtration methods. — *Eriez, Erie, Pa.*
www.eriez.com

Advances improve membrane chromatography performance

The Sartobind membrane chromatography adsorber capsules have recently been redesigned to improve binding capacities, reduce void volumes, reduce buffer consumption and lower operating costs. These membrane chromatography capsules are used to recover large-molecular-weight proteins, such as blood factors and conjugated proteins, viruses and virus-like particles. Several capsule sizes, with a 4-mm bed height, are now available, from a 1-mL nano unit up to the newer 2.5-L version. The capsules' upstream flow channels have been optimized and an internal core forms a miniaturized downstream channel. Unlike traditional membrane adsorbers, the Sartobind membrane capsules take into account specific chromatographic process parameters, such as back-mixing effects and elution volumes, providing substantial performance advantages, says the company. — *Sartorius Stedim Biotech, Göettingen, Germany*
www.sartorius.com

Dust-collection filters are undaunted by high moisture

The HemiPleat Synthetic dust collector filter cartridges (photo) combine a high-efficiency filter media with proprietary open-pleat technology, to provide reliable service in harsh, humid environments. The washable media is resistant to moisture and can handle heavy dust-loading conditions, as well as hygroscopic or sticky dusts that are generated in many food, pharmaceutical and chemical process applications. It uses a lightweight, 100% spunbond polyester media in a pleated design, which maximizes surface area while maintaining open pleat spacing. It functions reliably at operating temperatures to 160°F. It is available in a standard version, or a nanofiber media version. The added nanofiber layer provides enhanced filtration efficiency. The standard media is rated at MERV11 filtration efficiency, and the nanofiber media is rated at MERV15 filtration efficiency, based on the ASHRAE 52.2 test standard. These filter cartridges are designed for the Farr Gold Series dust collectors, and can be retrofit on most major brands of competitive cartridge dust collectors, says the company. — *Camfil APC, Jonesboro, Ark.*
www.camfilapc.com

Ceiling-mounted air-filtration units protect personnel

The Purair Sky ceiling-mounted filtration units (photo) are designed to protect laboratory personnel in environments in which hazardous substances are being handled. It provides a dynamic filtration chamber with its sliding filter clamp, which allows for simple, quick filter changes. It includes an electrostatic prefilter trap and an epoxy-coated steel support frame with LED lighting and wall-mounted controls. The SKY-24 requires an opening of 22.75-by-22.75 in., while the SKY-48 requires an opening of 45.5-by-22.75 in. — *Air Science USA, Fort Myers, Fla.*
www.airscience.com

Leaf disc filters benefit from recently improved filter media

This company offers an array of porous metal and plastic materials and systems for filtration and separation, for use in chemical-process, water-treatment, energy and pharmaceutical applications. The company's leaf-disc filter cartridges incorporate recently improved filter media (photo). The filter leaf discs are available in a range of filtration ratings, from 5 to 40 microns. The leaf-disc capsule filter uses a hard hub that is designed to maximize the available filtration area, leading to lower pressure drop, shorter residence times and reduced risk of degradation. — *Porvair Filtration Group, Ashland, Va.*
www.porvairfiltration.com ■

Suzanne Shelley

New Products

This HT-resistant silicone resin cures at room temperature

Silkophen AC 950 is a new high-temperature (HT) resistant, high-solids silicone resin intended to provide protective properties in industrial applications. No toxic substances are released during curing, making application of the resin possible in enclosed spaces. Smoke formation and volatile-organic-compound (VOC) content are significantly lower than traditional bake-cure silicone resins, allowing Silkophen AC 950 to meet requirements for eco-friendly coatings systems. It cures at ambient temperatures, utilizing a catalyst, which provides additional advantages, says the company. The resin displays high and early resistance to aromatic and aliphatic solvents, in addition to impact resistance. — *Evonik Resource Efficiency, Essen, Germany*

www.evonik.com

An industrial tablet PC for use in hazardous areas

The Agile X industrial tablet PC (photo) is said to be the world's thinnest, purpose-built UL Division 2 and ATEX Zone 2 device for enterprise use in rugged environments. Wireless LAN and optional LTE modules on the Agile X provide realtime data transfer and uninterrupted connectivity, enabling field workers, including technicians, engineers and managers, to bring their office to the Ex area. In addition to the integrated barcode scanner, the tablet PC also features a rear-side expansion slot, allowing the tablet to be extended with further data capture options, such as a radio-frequency identification (RFID) reader. — *Bartec GmbH, Bad Mergentheim, Germany*

www.bartec-group.com

Extreme pumping tasks solved with this ceramic vortex pump

The ceramic RCFKu vortex pump (photo) reliably pumps high-temperature (up to 180°C) fluids of an aggressive nature or those that contain solids. All RCFKu parts that come into contact with fluids, such as the impeller and volute casing, are made of solid Frialit 99.7 material. This aluminum-oxide ceramic is said to be one of the hardest and most wear-resistant materials in ceramic-pump production, and is fully resistant in processes where hydrochloric acid and ferrous chloride are present. RCFKu impellers are made of polymer carbide and are adapted to suit each pumping application. The composite of silicon carbide and vinyl-ester resin is a high-tensile-strength material that is resistant to wear, high temperatures and in media with high levels of solids. — *Friatec AG – Division Rheinhütte Pumpen, Wiesbaden, Germany*

www.rheinhuette.de

A precise piston pump with minimal energy expenditure

The new piston diaphragm pumps of the model series R 509.1 (photo) add to the sera dosing-pump product repertoire with eccentric screw adjusters. The operating range of the new 509.1 piston diaphragm pumps varies from 6.5 to 81 L/h at counterpressures of up to 300 bars. The pump's design minimizes the energy expended adjusting the stroke length, while at the same time increasing precision during operation, as well as during idle time. The stroke can be continuously adjusted from 0–100% using a handwheel or a servomotor. For use in petroleum refining, pumps are available in both an explosion-proof version and a version that is compliant with API standards 674 and 675. — *Sera ProDose GmbH, Immenhausen, Germany*

www.sera-web.com

This density meter is an alternative to nuclear devices

The Ultimo Density Meter (photo) is an alternative to nuclear-based densitometers for applications where the material is abrasive, caustic or has high solids content, and where the regulatory requirements for nuclear operations may be burdensome. Trial units have been evaluated and purchased by some large mining companies with the expressed intent of qualifying a replacement for legacy nuclear densitometers. Prior to the emergence of this device, nuclear densitometers were the only non-invasive option in these applications, says the company. — *Ultimo Measurement LLC, Scituate, R.I.*

www.ultimompd.com

Bartec

Friatec

Sera ProDose

Ultimo Measurement

Assured Automation

WIKA Alexander Wiegand

Mettler Toledo

ENMET

Prüftechnik Dieter Busch

Improved fire safety for pneumatic control systems

Now FM-approved, FireChek thermal shutoffs with resettable memory-shape alloy (photo) can be used to automatically shut down a pneumatic control system when a nearby fire occurs, or when the ambient temperature reaches 135, 150 or 165°F. The testing and resetting abilities of the FireChek make it a preferred choice over emergency isolation valves that rely on fusible links or plastic burn-through tubing, says the manufacturer. The FireChek is available in three different configurations: a single FireChek, which is directly mounted between the pneumatic supply and spring return actuator via two NPT threaded connections; FireChek with Quick Exhaust, which provides a larger exhaust port; and FireChek Plus Pilot Valves, which include the FireChek thermal shutoff with a SIL Class III pilot valve. — *Assured Automation, Clark, N.J.*

www.assuredautomation.com

A new controller for a pressure range up to 210 bars

The CPC4000 pneumatic pressure controller (photo) was designed for a wide range of calibration applications. Within the company's product portfolio, the CPC4000 replaces the CPC3000 high-speed pressure controller, offering additional functions, including a relatively fast control speed of up to 10 s. The new controller has an extended pressure range of up to 210 bars (3,045 psi), and can be fitted with two reference pressure sensors, which are controlled automatically in accordance with the calibration task. The sensors also work with an improved accuracy of 0.02% full scale or, optionally, 0.02% IS-50. The device has a 7-in. LCD color touchscreen. — *WIKA Alexander Wiegand SE & Co. KG, Klingenberg, Germany*

www.wika.com

Reactor control for automated laboratory processes

The new RX-10 Reactor Control system (photo) connects and automates jacketed laboratory reactors and controls thermostats, stirrers and pumps with a single touchscreen interface that provides a consistent platform across all laboratory reactors. RX-10 controls jacketed laboratory reactors with third-party heating and cooling systems, liquid addition, stirrers and process analytical technology (PAT) tools. Operating with a touchscreen walk-up interface allows scientists to consistently control reactors on any scale from milliliters to multiple liters — reducing human error and training cost, says the company. RX-10 Reactor Control reduces the time needed to merge and process analytical data, visualize and identify key reaction events and create smart reports. — *Mettler Toledo, Greifensee, Switzerland*

www.mt.com

Wet-well analysis for CH_4, O_2 and H_2S gases

This company's Wet Well Monitoring System (photo) is designed for monitoring methane, oxygen and hydrogen sulfide in a hazardous wastewater-treatment-plant environment. The system incorporates the CP-60 controller with three remote 4–20-mA (24 V d.c.) sensor/transmitters in Explosion-proof Class I Div. 1, Group B, C and D enclosures. The CP-60 controller provides 24 V d.c. power, audio and visual alarms, alarm relays and other features. — *ENMET, Fairfield, Conn.*

www.enmet.com

Next-generation software for condition monitoring

Omnitrend Center is a modern, powerful and user-friendly software platform (photo) for this company's Condition Monitoring system. It communicates with all of the company's latest offline and online systems. Omnitrend Center is available in single-user or client-server versions, is ready for cloud solutions, and provides powerful aids, such as knowledge-based machine templates, and online and offline device managers. Statistical post-processing methods help to monitor the health of even the most complex machines. The operator can quickly receive an overview about the status of a machine using interactive asset reports. — *Prüftechnik Dieter Busch AG, Ismaning, Germany*

www.pruftechnik.com

No special cleaners needed to remove this compact ink marker

Dura-Ink WashAway is a high-visibility, no-smear jobsite marker that can also

be washed away from work surfaces. These industrial markers are engineered with a special ink formula that is bright and highly visible, and dries quickly, but can be removed from all non-porous surfaces with water or detergent. Dura-Ink WashAway removes completely without traces of ghosting or residue and will not interfere with top-coat primers, paints or powder coating. Dura-Ink WashAway is suitable for quality control, metal fabrication, power coating, glass production and in steel mills and warehouses, and is effective for marking on steel, iron, glass, aluminum and other materials. — *Markal, Elk Grove Village, Ill.*
www.markal.com

These process-control systems conform to safety standards

SysCon control systems (photo) can be custom-designed for virtually any industrial process, including mixing, pumping, chemical dosing, dilution, heat exchange, separation, drying and waste treatment. Based on process-logic control schemes, these systems are routinely supplied with a recipe-sequencing program, calibration menus, trending screens, data-acquisition (SCADA) packages, operator-friendly alarms and advanced safety features. Process variables are controlled and displayed from a responsive color touchscreen, and can be automatically stored for seamless monitoring and reporting. All SysCon control systems are built to conform to NFPA 79 standards. Enclosures and cabinets are compliant with NEMA 12 for non-hazardous environments, NEMA 7 and 9 for explosion-proof requirements or NEMA 4X (stainless steel) for washdown applications. — *Charles Ross & Son Co., Hauppauge, N.Y.*
www.mixers.com

This rotary jet mixes, cleans and more

The Rotary Jet Mixer (photo) effectively handles liquid and powder mixing, gas dispersion and cleaning-in-place (CIP) while reducing time, energy and costs. In many applications, the mixer provides faster and more efficient mixing than conventional methods, says the company. It combines high blending precision with minimized mixing times and up to a 50% reduction in energy requirements. Based on rotary-jet head technology, it can be used in tanks between 100 and 800,000 L in size. Equipped with two or four nozzles, the Rotary Jet Mixer is positioned below the liquid level in the tank. Liquid is withdrawn from the tank outlet by a pump and circulated via an external loop to the mixer. A single Rotary Jet Mixer can handle liquid-mixing, gas-dispersion and powder-dispersion applications — plus tank cleaning — without requiring separate equipment for each process, thereby delivering significant savings, says the company. — *Alfa Laval AB, Lund, Sweden*
www.alfalaval.com

Solid stainless-steel connections for the pharma industry

Inoxline (photo) is a complete assortment of stainless-steel connections for compressed air, vacuum, gases, liquids and cooling water. The products include threaded connections with no dead zones or joints that are designed according to stringent hygiene requirements and for easy cleaning. They are ideal for circuits with sensitive substances or frequent changing of media. All connections are manufactured from stainless steel 1.4301/1.4307, which offers excellent protection against corrosion and high chemical resistance (for example, against many acids). On request, they can also be equipped with FDA-compliant seals to fulfill special hygiene requirements. On the side with the screw-in threads, the push-in connectors are sealed with an enclosed O-ring. — *Eisele Pneumatics GmbH + Co. KG, Waiblingen, Germany*
www.eisele.eu

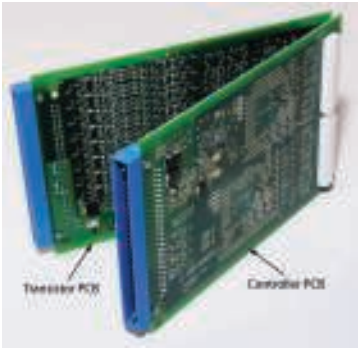
Rotary-screw compressors for indoor or outdoor use

The new UP6S Series fixed-speed rotary screw compressor features O-ring face seals to reduce leak points and a totally enclosed fan-cooled (TEFC) motor. The unit's TEFC design reduces the risk of particulate matter entering the motor, while also keeping it cool, making the compressor suitable for use in harsh environments,

Charles Ross & Son

Alfa Laval

Eisele Pneumatics



Rockwell Automation

either indoors or outdoors. The new Tri-Voltage motor enables the UP6S to adapt to a variety of applications, including powering pneumatic tools and many other equipment types. The UP6S Series also features spin-on filtration and separator cartridges to allow for easy maintenance. The compressor comes standard with a new controller that allows for simple diagnostics and remote start and stop access capabilities. — *Ingersoll Rand, Davidson, N.C.*

www.ingersollrand.com

This process-safety system has a very small footprint

The new AADvance Eurocard process-safety system (photo) is ideally suited for industry applications with restrictive physical-space requirements. The AADvance Eurocard system can be custom configured to meet different levels of safety and each user's specific system requirements. The system is specifically designed for functional safety and critical control applications, providing a flexible, scalable, distributed solution for a wide range of process industries. The system is certified by Exida for functional safety and adheres to the latest safety standards. The system meets the functional safety requirements for safety integrity level 3 (SIL 3) and is compliant with IEC 61508. — *Rockwell Automation, Milwaukee, Wis.*

www.rockwellautomation.com

Blackmer

Form agglomerates on a controlled basis with this system

The Vibro-Bed fluidized-bed agglomerator (photo) employs a spraying system that introduces moisture to powdered material as it is fluidized and dried, forming agglomerates on a controlled basis. Equipped with imbalanced-weight gyratory motors and mounted on a spring suspension, the fluidized-bed chamber vibrates as a column of heated air flows upward through a fine-mesh screen, causing particles to separate and become airborne as they are sprayed with liquid. The vibratory motion of the processor also serves to convey the material along a defined pathway. Units are offered in diameters from 18 to 84 in. (460 to 2,135 mm), encompassing batch and continuous applications from low-capacity laboratory and pilot-plant testing to medium-high volume production. — *Kason Corp., Millburn, N.J.*

www.kason.com

Kason

Twin- and triple-screw pumps for a variety of fluids

The S Series line of self-priming double-ended positive-displacement pumps (photo) includes twin- and triple-screw designs that provide complete axial balancing of the rotating screws. The pumps' timing technologies eliminate metal-to-metal contact. S Series pumps are ATEX-certified for use in explosive or dangerous environments. The triple-screw models are specifically designed for handling clear, lubricating liquids without solid content. The twin-screw models are available with or without a non-timing gear transmission. The models with the non-timing gear transmission are suitable for handling higher-viscosity fluids, such as bitumen and residual oil, at medium or high temperatures. — *Blackmer, Grand Rapids, Mich.*

www.blackmer.com

New gas-mix software eliminates flowmeter recalibration

This company's QuadraTherm 640i/780i thermal mass flowmeters (photo) now come equipped with new gas-mixing software, called qMix. The qMix software is a user-customizable gas-mix feature that allows engineers and operators to create custom gas mixtures to compensate for gas compositional changes in the field without accuracy loss. Since engineers can create and upload unlimited gas mixtures onto a single meter, recalibration costs are avoided, as there is no need to send units back to the factory if the gas composition changes. QuadraTherm meters have an accuracy of ±0.5% of reading above 50% of full scale for flowmeter air measurement and other gases, and built-in flow conditioning in the inline version. These meters also have high turndown capabilities to handle low and high flows during upset conditions. — *Sierra Instruments, Monterey, Calif.*

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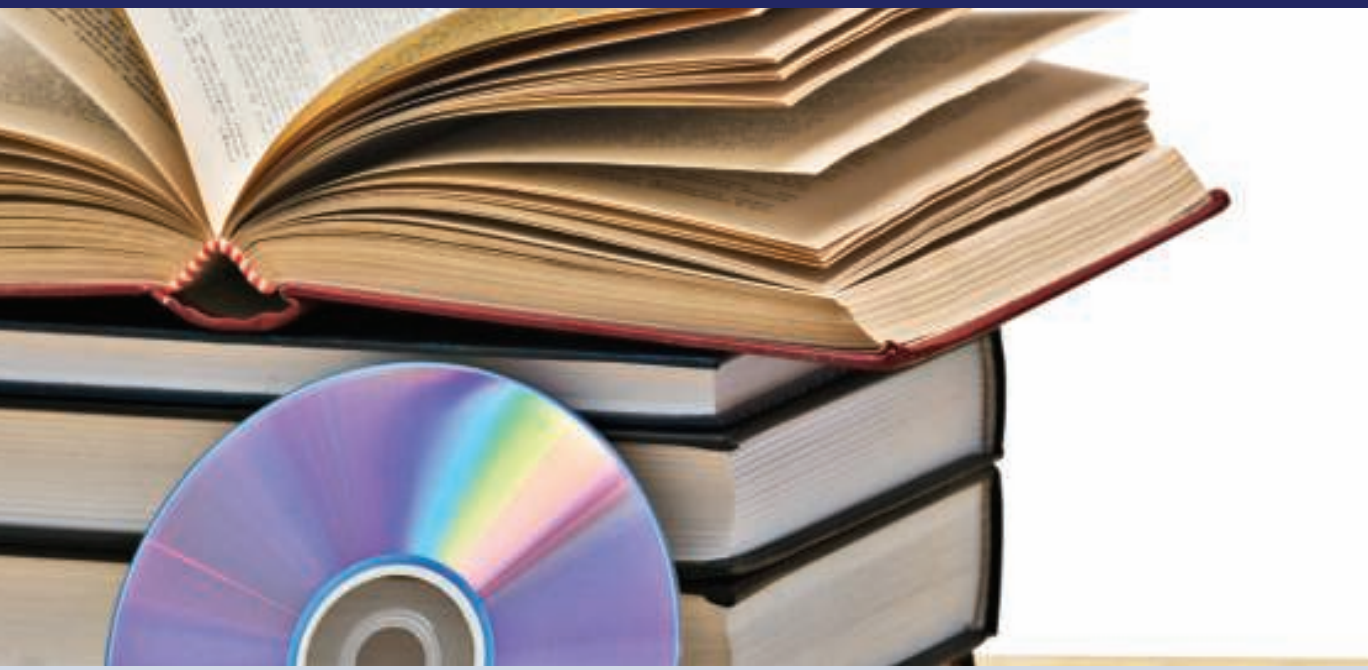

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Industrial Adsorbents

Department Editor: Scott Jenkins

Industrially, adsorbent materials are used in a wide range of applications, including purification, separations, drying, spill management, catalysis, pollution control and others across a large number of industrial sectors. This column provides an overview of the major classes of industrial adsorbents, and some of the specific adsorbent types in each category.

Adsorption processes

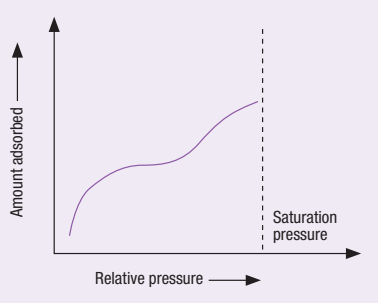
Adsorption refers to the surface-based process in which molecules, ions or atoms accumulate on the surface of a material. Adsorption is driven generally by the reduction in surface tension between the fluid (liquid or gas) and the solid adsorbent that results when the adsorbate molecule adheres to the surface of the adsorbent. Adsorption differs from absorption in that adsorption describes accumulation of molecules at the interface between the solid and fluid phases, while absorption involves one substance entering the bulk or volume of another.

Classification

Adsorbents can be classified according to their structures, as well as according to their behavior toward water. Zeolites are examples of adsorbents with crystalline structure, while activated carbon and polymers have amorphous structure. Silica gel and activated alumina are also considered to have amorphous structures, but they are separated from activated carbon because they have a hydrophilic character, while activated carbon is considerd hydrophobic. Adsorbents are available in several forms, including powders, granules, pellets and others.

Characterization

Adsorbents are often characterized by their pore-size distribution. Pore sizes are divided into three general categories: micropores, mesopores and macropores. Micropores are small enough so that molecules that diffuse into the pore are attracted to both sides of the pore wall at the same time. They are considered to be 2 nm or smaller. Mesopores are generally in the range of greater than 2 nm but smaller than 50 nm. Macropores are those greater than 50 nm in size. Macropores are important in industrial practice for providing a pathway for relevant molecules to diffuse into a particle of adsorbent material.



Effective industrial adsorbents are resistant to abrasion, have good thermal stability and large exposed surface area (and therefore, high capacity for adsorption). The adsorbents must also have a distinct pore structure that enables fast transport of the molecules of interest.

Broad classes

The following sections describe several of the most common broad classifications of adsorbent materials, and include some examples of each type.

Aluminas. Made of aluminum oxide (Al_2O_3), adsorbents in this group are used as desiccants for drying gases and air, as well as for removing fluoride from drinking water and as catalysts. Aluminas used as fluoride sorbents have pore sizes around 7 nm and surface areas of 0.32 km^2/kg. Dessicant aluminas have average pore sizes between 4 and 14 nm and surface areas between 0.25 and 0.36 km^2/kg.

Silicates and aluminosilicates. This class of adsorbents includes both naturally occurring zeolites (such as mordenite and chazabite) and synthetic zeolites, as well as silica gel, clay and diatomaceous earth, among others. Zeolites are valued for their uniform pore sizes that can be tuned to be highly selective. Many materials with molecular sieve properties fall into this category. Clays are mineral absorbents that are used as spill-cleaning agents, sealants and packing materials because they are inexpensive, inert, and have a quick capture rate. Fuller's earth is an activated, natural clay-based adsorbent with low costs. Silica gel is a common desiccant used in food preservation, humidity control and various medical devices.

Carbons — The class of carbon adsorbents includes various activated carbons. Activated carbon is organic material (such as coconut shell, bone, wood, and so on) that undergoes a partial oxidation process to form porous granules (see *Chem. Eng.*, August 2014, p. 32). Activated carbons are versatile and inexpensive adsorbents that are available in many sizes and are used in a wide range of applications from gas, water and metal purification to air filtration.

Organic polymers. A wide range of adsorbents made from organic polymers are available. They are used in size-exclusion chromatography and gas-separation processes, where they can exhibit high retention power and selectivity. Most polymer adsorbents do not require disposal and the regeneration process is generally environmentally friendly.

Adsorption isotherms

When adsorption processes are studied mathematically, adsorption isotherms are often used. The term refers to a plot, at constant temperature, of the amount of adsorbate (molecules being adsorbed) adhered to the surface of an adsorbent as a function of pressure (in the case of a gas adsorbate) or concentration (if a liquid adsorbate). The figure depicts a Type IV isotherm, one of five typical isotherm shapes into which most adsorption processes fall. This description is an offshoot of the BET (Brunauer-Emmett-Teller) theory of adsorption. ■

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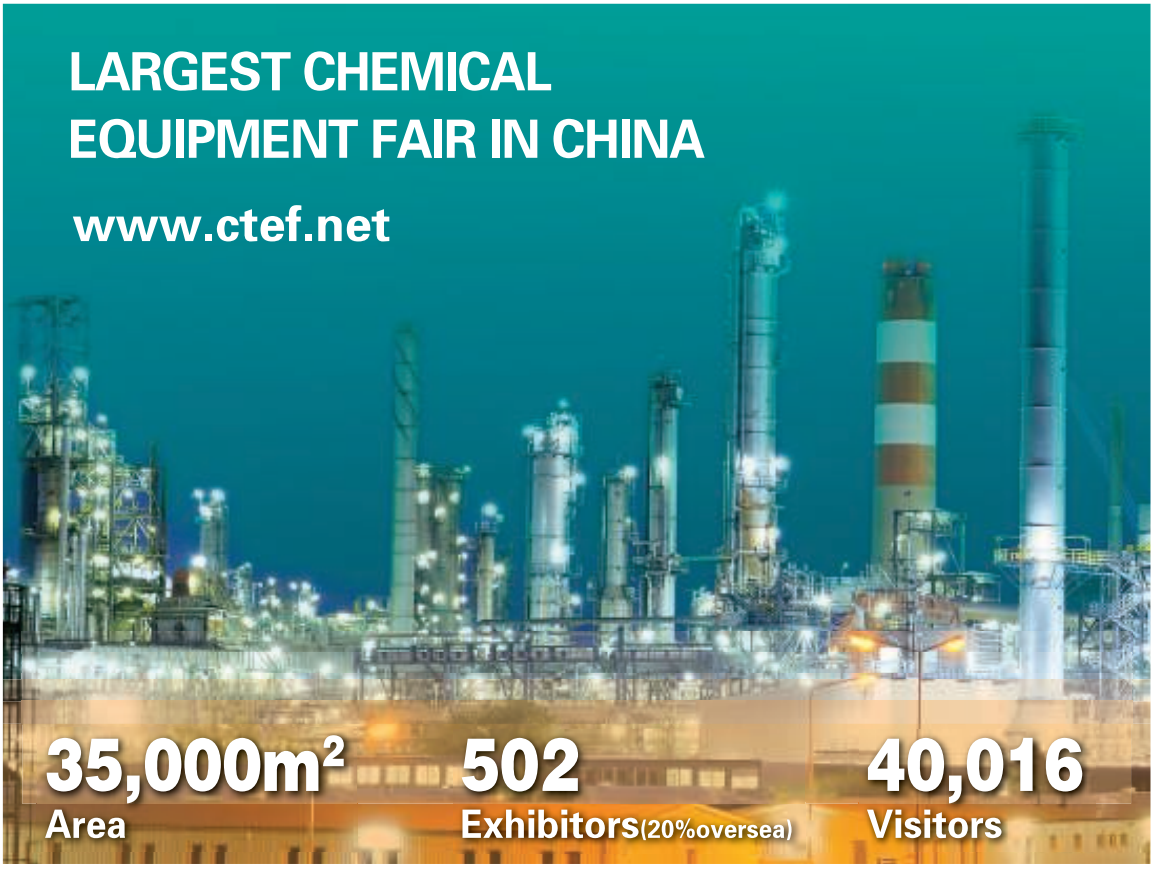

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Ethylene Glycol Production

By Intratec Solutions

Monoethylene glycol (MEG), also known as ethylene glycol (EG) or simply glycol, is a diol mostly used for the production of polyester fibers and polyethylene terephthalate (PET) resins. It is also used in antifreeze applications and in pharmaceuticals and cosmetics. MEG is conventionally produced through the hydrolysis of ethylene oxide (EO), which itself is obtained via ethylene oxidation.

FIGURE 2. PLANTS USING SHELL OMEGA TECHNOLOGY

Company	Location	Capacity (1,000 ton/yr)	Start-up year
Lotte Chemical	Daesan, South Korea	400	2008
Petro Rabigh	Rabigh, Saudi Arabia	600	2009
Shell	Jurong Island, Singapore	750	2009

The process

Figure 1 depicts MEG production from ethylene via a process similar to the OMEGA catalytic process from Shell Global Solutions (The Hague, the Netherlands; www.shell.com). In the described process, MEG is produced via EO, which is manufactured in an integrated plant utilizing Shell EO technology. An important feature of the process is the negligible production of diethylene glycol (DEG) and triethylene glycol (TEG), which occur as byproducts in other ethylene glycol production processes.

Ethylene oxide production. Ethylene and oxygen are fed to a multi-tubular reactor, forming EO. This exothermic reaction, conducted in fixed beds in the reactor tubes, occurs in the gaseous phase with the use of a silver catalyst supported on alumina. Steam is generated by the heat of reaction.

Ethylene oxide recovery. The reactor product stream is fed to the EO absorber for lights removal by water quenching. Part of this gaseous overhead stream is recycled to the reactor, while the other part is sent to a carbon-dioxide-removal unit composed of an absorber and a stripper. In this unit, CO_2 is separated to be used in ethylene carbonate production.

A diluted EO stream removed from the absorber is fed to the EO stripper, where it is concentrated and recovered in the overheads. The crude EO stream is condensed. Residual light gases are recovered from it and recycled to the reactor. The resulting EO stream is directed to the next section.

Ethylene glycol production and purification. Ethylene oxide is reacted with CO_2, forming ethylene carbonate, which is then hydrolyzed to form MEG and CO_2. Both reactions are carried out in the liquid phase using homogeneous catalysts.

CO_2 streams from the reaction steps are recycled to the ethylene carbonate reactor. MEG is purified in two distillation columns where water is removed, leading to the final MEG product. The catalyst is separated and recycled to the ethylene carbonate reactors.

Economic performance

An economic evaluation of the process was conducted based on data from the first quarter of 2015, assuming a facility with a nominal capacity of 750,000 ton/yr of MEG constructed on the U.S. Gulf Coast.

Estimated capital expenses (total fixed investment, working capital and initial expenses) to construct the plant are about $630 million, while the operating expenses are estimated at about $620/ton of MEG.

Global perspective

Shell OMEGA is the first process to enable ethylene glycol production via a fully catalytic process. According to the licenser, the process is able to achieve EO-to-EG converstion and selectivity near 100%, leading to production of MEG only.

However, although 40% of worldwide ethylene glycol production is derived from processes using Shell technologies, only three plants in the world use the new Shell OMEGA technology (Figure 2). As can be seen, two of these plants are located in Asia, which is the region of the world responsible by the major share of MEG global consumption. China alone accounts for about 45% of global demand for MEG. ■

Edited by Scott Jenkins

Editor's Note: The content for this column is supplied by Intratec Solutions LLC (Houston; www.intratec.us) and edited by *Chemical Engineering*. The analyses and models presented are prepared on the basis of publicly available and non-confidential information. The content represents the opinions of Intratec only. More information about the methodology for preparing analysis can be found, along with terms of use, at www.intratec.us/che.

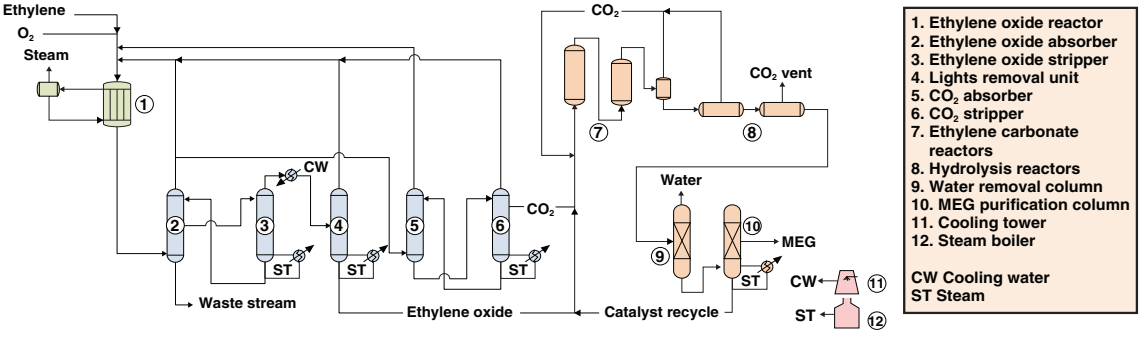

FIGURE 1. Monoethylene glycol (MEG) production, according to a process similiar to the Shell OMEGA process

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What is Your Engineering Ethics IQ?

These seven-steps form a guideline for handling ethically challenging situations in technical jobs

Karl Stephan
Texas State University

IN BRIEF

Exercising sound ethics in the chemical process industries (CPI) surely requires a large dose of technical know-how, but it also requires a set of good ethical practices that are employed when confronting ethically charged questions. This article provides guidance to help engineers prepare for identifying and resolving ethical questions in their professional setting.

Doing the right thing

On December 3, 1984, the Union Carbide pesticide plant in Bhopal, India released a cloud of toxic methyl isocyanate gas into the air around the facility. Over 2,000 people died and many thousands more were injured in one of the worst industrial disasters of all time. On March 23, 2005, a cascade of errors, broken instrumentation, and ignored safety procedures resulted in the deaths of 15 people at a petroleum refinery in Texas City, Tex. then owned by BP. In the incident, hot liquid hydrocarbons overflowed and exploded, destroying some temporary office trailers that housed contract workers.

While the hazards of making pesticides and gasoline seem obvious, dangers can also be found in innocuous products such as ice cream. In April 2015, the Texas ice cream maker Blue Bell announced that it was shutting down production at all its plants after three deaths were linked to bacterial contamination in the firm's products.

What can you as a chemical engineering professional do to keep your name, your coworkers' names and your company's name from being associated with incidents like these? Technical knowledge is certainly necessary, but it is not enough just to "do things right." You also have to "do the right thing." Doing the right thing in engineering is the main focus of the field known as engineering ethics. To some extent, mistakes are inevitable in any human organization, but dangerous situations and adverse outcomes can be drastically minimized if all people involved deal with a problem in accordance with a set of good ethical practices. Armed with these good ethical practices, you can help minimize the chances that a particular ethical situation will snowball into a situation that generates negative consequences.

In the course of teaching and researching in the field of engineering ethics, I have developed a seven-step guideline that anyone facing an ethically challenging situation in a technical job should consider following.

Unlike the "hard" sciences, ethics is a field in which there is rarely one right answer to a problem. But the ambiguity that sometimes characterizes ethical dilemmas does not mean that your skill in handling these situations cannot be improved. You can im-

prove your "ethical IQ" by training yourself to identify ethical problems, and by practicing a set of steps that should be followed when one arises. Like a fire extinguisher, these steps are better to have and not need than to need and not have. Practicing the steps may never do anything more for you than give you a sense that you are prepared for a situation where ethical questions must be considered. But when such situations do occur, it is better to be prepared.

Seven steps to ethical preparedness

The following represent a set of processes that you can use to better navigate situations in the professional engineering world in which ethics is a key component.

1. Know what you believe. Doing the right thing, ethically, in an organization is not always welcome and is rarely without costs. While some supervisors will listen to your arguments if something is wrong and needs to be corrected, others will tell you to keep quiet, or may even try to enlist you in a cover-up. Because of this eventuality, you should ask yourself the following soul-searching question: "Would I insist on correcting an ethical problem even if it cost me my job?"

The answer to this question draws upon more than your technical knowledge — it goes to the heart of what you believe about who you are and what your purpose is, both on and off the job. Your religious faith, if any, your philosophy of life, and your conscience are resources you can draw upon when facing a serious ethical problem that threatens your organization in a major way.

"Whistleblowing," — meaning to report an ethical problem to authorities outside of an organization entirely — is a last resort in resolving ethical issues. Not only does whistleblowing have unpredictable results, it usually gets the whistleblower ostracized or fired. But there are times that such a price must be paid. So before being faced with a critical emergency, engineers would be advised to spend some time imagining an ethical situation that they would be willing to lose their job over, and decide in advance what they would do.

2. Recognize ethical problems. This step takes some imagination and effort, but that effort can pay off by fostering the ability to identify problems that can either be avoided or minimized before they reach a state where they can cause major trouble. If your company manufactures products for consumer use, for example, how well do you know and understand your customer base? Are they likely, in general, to use a product in ways that are not intended by the manufacturing company? Could anyone be injured if the product was used in that way? If your customers are other manufacturers, are your specifications written in an unambiguous way, or is there "wiggle room" that could be used to gain an unfair advantage? In 2007, numerous cases of pets becoming ill from certain brands of pet food were traced to a wheat-gluten product that was apparently adulterated with melamine to increase the nitrogen content of the ingredient indicated by a food-quality test. While such intentional deception is rare, quality control tests can be biased even without malicious intent. A healthy skepticism toward any test results that have not been confirmed independently, combined with an effort to think like your customers, can be helpful here.

While everyone in an organization has a responsibility to recognize ethical problems, the particular things that you can look for depend on your role within the organization.

While everyone in an organization has a responsibility to recognize ethical problems, the particular things that you can look for depend on your role within the organization. Technicians and other "hands-on" employees, for example, can be the first to notice leaks, mechanical failures in instrumentation, maintenance lapses and other issues on the plant floor that can cause problems in the future.

In a well designed plant, every piece of equipment was put there for a reason. If a system or piece of equipment doesn't work, or doesn't work correctly, it needs to be reported and addressed, especially if it is safety-related.

Farther up the management chain, supervisors can consider how well safety- and quality-related tasks are performed by their workers, and what mistakes are typically made. For every destructive disaster, there are usually several minor incidents that people manage to catch before they turn into big problems. But repeatedly fixing minor incidents without identifying the root cause

ETHICS HOTLINE USE INCREASING

In its 2014 Ethics and Compliance Hotline Benchmark Report, the international consulting firm NavexGlobal (Lake Oswego, Ore.; www.navexglobal.com) reported that the median rate of ethics hotline use per 100 employees for firms they surveyed increased by 30% from 2010 to 2013, from 0.9 to 1.2 per 100 employees. They attribute this rise to several factors, including improved communication of hotline availability and increased confidence employees placed in the reporting systems. For more information, see Reference 1. ❑

of the matter should not become a habit, because the chances are high that sooner or later, the temporary fixes will fail and a much larger problem will occur. Doing this is like playing "Russian roulette" — pulling the trigger with temporary fixes until something different, and usually worse, happens.

Managers responsible for an entire unit or plant have to be concerned more with organizational effectiveness. Do your employees follow well-designed procedures? Can you trust them to report problems? If a problem or issue suddenly goes away, does that mean it was fixed, or simply that the people involved are no longer reporting it? Questions like these can sometimes keep plant managers awake at night, but if addressing these questions ultimately leads to safer and more ethical operations, the lost sleep was worth it.

3. Identify stakeholders. Once you face an ethical problem, you should take the time to carefully consider everyone who is likely to be affected by the outcome, including the result of doing nothing, which can itself be a decision.

Making a list of stakeholders is a good exercise that can help you avoid overlooking unintended consequences of a decision. For example, raising the required purity level of an ingredient may make it easier to synthesize or safer to use, but could give your purchasing department fits if they cannot find a viable supplier who offers the ingredient at that level of purity.

If costs are involved in a decision, economics comes into the equation. Who will pay for a change? Who will benefit? Who will be affected in other ways, by schedule changes, delays, and availability of products? This is an area where an ethical problem can get complicated. But neglecting a thorough consideration of who the stakeholders are can cause unexpected problems after a decision is made.

4. Analyze interests. Every stakeholder has a different interest in the outcome of an ethical decision. As accurately as possible, you should anticipate the interest of each stakeholder in the possible outcomes. In the example of the Blue Bell ice-cream shutdown, stakeholders included Blue Bell's employees, its suppliers, its management team and company owners, as well as its wholesale customers (food stores and restaurants) and its ultimate retail customers — the consumers of the ice cream. Employees and managers were interested in keeping their jobs. The owners were interested in running a profitable business. The wholesalers wanted to sell ice cream at a profit, and the consumers wanted to eat a trusted brand of ice cream without worrying about coming down with a possibly fatal illness.

As accurately as possible, you should anticipate the interest of each stakeholder in the possible outcomes.

After the recall and plant shutdown, it is hard to think of a stakeholder who has not lost something by the outcome, unless you count lawyers. While the law can be a big factor in ethical engineering, simply obeying laws and ensuring "compliance" are not enough. There are many actions that you can take that are technically within "the letter of the law," but that are nonetheless unethical. You should understand reasonably well how every stakeholder may be affected by the possible outcomes of an ethical situation before you proceed to the next step, in which specific actions are considered.

5. Examine alternatives. At this step, you should know enough about the situation to have some ideas about possible actions you can take. When considering possible actions, always include doing nothing as one of the possibilities. Depending on the resources needed to do something, doing nothing may be the only choice, at least for a time, and understanding the consequences of inaction are as important as examining specific actions and their effects. It is helpful at this stage to invite outsiders to contribute ideas,

with proper regard given to confidentiality, of course. Close involvement may cause you to miss a potential solution that someone who is less involved in the situation may be able to see at once.

Make a list of all reasonable actions that can be taken to deal with the problem. Then examine the outcomes of each action for each stakeholder. Some actions may be ruled out immediately if they are expected to lead to sufficiently adverse outcomes for some stakeholders. Other actions may lead to outcomes that are nearly equally good (or bad), and so a decision may have to be based on other factors, such as cost. It is in this step that the real work is done in developing possible action plans and in evaluating each one.

6. Execute decision. Once all the reasonable alternatives have been considered and the best one selected, your decision should be implemented as well as possible. At this stage, you should notify anyone who you can reasonably expect to be affected by the decision. If this involves admitting a mistake or error to superiors, these admissions may be the hardest part of the process. But in general, trying to hide errors or mistakes only makes things worse later when the truth is discovered, as it usually, eventually is.

Depending on your position in the chain of command, your ability to fix the problem may be limited, and if the appropriate action is not taken, you may have to go over the head of your immediate supervisor or use an ethics hotline, which many medium-size and larger firms offer to all employees (see sidebar, p. 48). Except in unusual situations, however, dealing with your immediate supervisor first is the best initial step in executing your decision to do something to address a problem. Ideally, he or she will be involved in the decision-making process and will engage upper management as much as needed to fix the problem.

7. Document everything. From the moment you suspect something unethical may be going on, you should begin collecting a paper trail so that if needed, you can document the entire process of how you learned about the situation, what evidence you gathered, who knew what and when they knew it, what decisions were made and by whom, as well as what actions were taken.

This documentation should include writing down your personal notes of important conversations and other events that were not already documented. There are several reasons for this. If your organization chooses to investigate the issue, you will need this documentation to show the investigators what you are talking about. If the ethical issue involves parties outside your organization, these documents may become significant from a legal point of view if a lawsuit is filed. And finally, no one's memory is perfect, and having everything important written down makes it easier for you to recall details and base decisions on complete and accurate information.

Concluding remarks

In your career, you may never encounter a situation that sets off any ethical alarm bells. In well-run organizations that implement clear rules about what is ethical behavior, such situations tend to be rare. But by training yourself to be aware of the ethical implications of your job, you can increase the chances that, if you run across a situation that is ethically dubious, you can deal actively with it in a way that avoids worse problems and saves your organization's money and reputation. ■

Edited by Scott Jenkins

Reference

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Engineering Ethics Survey: What's Your Opinion?

Let us know how you would respond if faced with these hypothetical situations involving ethical questions in the CPI

Scott Jenkins
Chemical Engineering

IN BRIEF

Although not an everyday occurrence, ethical questions, large and small, confront each of us in our professional lives. For professionals in the chemical process industries (CPI), ethics issues can take on added importance because of the potential safety, environmental and quality-control hazards associated with industrial-scale chemical processes.

While laws, regulations and codes of ethical conduct are all in place, often the nuances of particular cases make it difficult to determine the best course of action. In the past, *Chemical Engineering* magazine has conducted ethical-related surveys in order to generate information and discussion about how peers in the CPI would handle ethically charged situations. An ethics survey was last conducted in 2007 (see *Chem. Eng.*, April 2007, pp. 50–53 and *Chem. Eng.*, October 2007, pp. 60–67).

The editors of *CE* are now revisiting the topic of engineering ethics in the CPI with a new survey. We are seeking input from our readers. A user-friendly survey has been set up online. Please consider the following scenarios and the associated ethical questions, then visit the following URL to participate in the survey:

www.surveymonkey.com/Ethics2015_CE

All opinions and comments on the specific hypothetical situations presented here, as well as thoughts and opinions about the current state of ethics in the CPI in general, are welcome and encouraged. The results from the survey will be published in a future issue of this magazine.

The survey includes a set of general ethics questions that are repeated from past *CE* ethics surveys, to allow comparisons of the responses over time. The general questions are followed by a set of ethics cases designed to explore opinions about possible actions. The sources of the ethics scenarios are as follows: Cases 1–4 are from *Chemical Engineering*'s past engineering ethics survey. Cases 5–8 are adapted from cases created by the Western Michigan University Center for the Study of Ethics in Society (see sidebar, p. 55).

Thank you very much for your consideration and participation. Stay on the lookout for the results in a few months.

General questions

The questions in the box on page 52 seek to assess readers' opinions about the general state of the ethical culture among companies and professionals in the CPI. Similar questions were first asked in an ethics survey that last appeared in 2007.

Hypothetical cases

Case #1. A Pinch of Poison *(from previous 2007 and 1980 CE surveys)*

Jeremy's company has been using a flavor additive in one of its products, but there have been problems with the flavor's stability. One of Jeremy's chemists accidentally finds that the flavor can be stabilized by adding a mixture of tin and lead salts in very small quantities. This product enhancement would likely increase sales and profits. Although both the lead and tin are recognized poisons, the chemist points out that the amounts added are no more than might be leached out from

the soldered seams of common tin cans used for a multitude of food products. The new product will be packaged in glass, so no further addition of heavy metals will occur. What do you think Jeremy should do?

1. Report the findings, but recommend that the additive not be used at all, because it is unethical to add poison no matter what the quantity?
2. Prevent any further consideration of this dilemma by suppressing the findings?
3. Recommend the open use of this heavy metals-stabilized additive?
4. Recommend that it be used, but that the deliberate addition of heavy metals be considered a trade secret, and be kept from leaking to the public because "it would only cause unnecessary worry?"
5. Other? (Please specify)

Case #2. "To err is Human" *(from previous 2007, 1987 and 1980 CE issues)*

Emily is the plant manager of a facility in which organic syntheses are performed. In one of the operations, an aqueous solution of sodium cyanide is reacted with another material to form the desired end-product. One night, on the midnight shift, an error is made, and too much cyanide is added to the water. There is not enough room in the mix tank to make an adjustment, so the shift foreman has the tank emptied into drums and starts another batch. Two weeks later, there is a lull in production, and the dayshift foreman decides to use the time in reworking the erroneous cyanide batch. No one can find the drums that the batch should be in. Upon questioning the night foreman, Emily finds that the batch has been illegally dumped into the sanitary sewer, rather than saved in drums as dictated by the company policy. Emily severely disciplines the night-shift foreman for his action. Upon making discreet inquires of friends at the sewage plant, the health department and the river-monitoring authorities, Emily finds that no apparent harm resulted from the dumping. What do you think Emily should do?

1. Inform government authorities about the incident, as required by law, even though no apparent harm resulted?
2. Keep the incident quiet (in violation of the law) since no harm resulted, the foreman has been punished, and a report would only cause trouble for the company, without doing the public any good?
3. Let the corporate management make the decision?
4. Other?

Case #3. Missing Gasket *(from previous 2007 CE issue)*

Albert is supposed to perform one final batch run at his multipurpose pilot plant before shutting down the unit for good. The reaction involves the use of an extremely toxic chemical that can also ignite spontaneously in air. It is Friday afternoon; the test results from the pilot plant are needed by his superiors the following Monday in order to bid on a project involving a large sum of money. After cleaning the reactor vessel from the previous batch, Albert begins to reconnect the flanges when he discovers that there is no replacement available for a critical gasket; the procedure for this particular reaction specifies that the gasket not be used a second time due to the hazards involved. Because it is Friday afternoon, there is no chance of obtaining another gasket until the following week. On the other hand, Albert knows from experience (involving less-hazardous reactants) that this type of gasket can often be used more than once without leaking. What do you think Albert should do?

1. Finish the pilot test, using the old gasket on the basis that it will probably not leak?
2. Order a new gasket, send the assistants home early and email the superiors explaining that the test will have to be postponed until a new gasket is available?
3. Skip the test completely and extrapolate the existing data to make up for the missing data?
4. Other?

GENERAL ETHICAL QUESTIONS FOR THE SURVEY

1. In the last 6–10 years, do you think have people in general:
a. become less ethical
b. become more ethical
c. remained the same

2. Have you ever done some-thing unethical at work that could (or did) have a harmful effect?
a. Yes
b. No

3. Do you know of anyone at your company who has done something you consider unethical?
a. Yes
b. No

4. Have you ever felt "punished" (loss of a promotion, job or pay increase) for making an ethical, but unpopular decision in your workplace?
a. Yes
b. No

5. Do pressures at work (time, profitability) ever cause you to seriously think about doing something you would consider ethically wrong?
a. Yes
b. No

6. How would you rate the following groups in your workplace on their handling of ethics? (1 = very ethical; 2 = average; 3 = somewhat unethical)
_____ technical staff
_____ upper management
_____ human resources
_____ administrative staff

7. Ethical decision-making is always good for business.
a. Strongly agree
b. Somewhat agree
c. Neither agree nor disagree
d. Somewhat disagree
e. Strongly disagree

8. Social responsibility and ethics are symbiotically related
a. Strongly agree
b. Somewhat agree
c. Neither agree nor disagree
d. Somewhat disagree
e. Strongly disagree

9. Do you have any general comments that you would like to add?

Case #4. Insider information *(from previous 2007 and 1987 CE issues)*

One day, Ursula, a process engineer in an acrylonitrile plant, runs into a former classmate at a technical society dinner. Her friend reveals that he is now a regional compliance officer with OSHA and, after several drinks, confides, much to Ursula's surprise, that there will be an unannounced inspection at Ursula's plant on the following Tuesday.

Ursula believes that unsafe practices are too often tolerated in the plant, especially in the way that toxic chemicals are handled. However, although there have been many small spills, no serious accidents have occurred in the plant during the past few years. What do you think Ursula should do?

1. Nothing, so as to not violate the trust of her friend.
2. Nothing, so that the consequences of the inspection will bring about improvements in the plant's safety practice
3. Inform the plant safety director of the impending inspection, knowing that the director is only likely to patch things up for the inspection.
4. Anonymously inform OSHA that she has been told about the surprise inspection, without revealing her source
5. Other

Case #5. Vendor Incentives. (*Used with permission from Michael Pritchard, Center For the Study of Ethics in Society, Western Michigan University. Originally created with support from the National Science Foundation (NSF) grant no. #DIR-8820837.)*

Scott Bennett is the engineer assigned to deal with vendors who supply needed parts to the Upscale Company. Larry Newman, sales representative from one of Upscale's regular vendors, plays in the same golf league as Scott. One evening they go off in the same foursome. Sometime during the round Scott mentions that he is really looking forward to vacationing in Florida next month. Larry says his uncle owns a condominium in Florida that he rents out during the months he and his family are up north. Larry offers to see if the condo is available next month — assuring Scott that the rental cost would be quite moderate. Larry tells Scott he can rent his uncle's condo for $100 a week. "My uncle," Larry says, "gets nervous when he

rents to total strangers. He likes to have reliable people stay in his condo; the condo is paid for, and my uncle is not interested in making money on it — he just wants a little help meeting basic operating expenses and the taxes." Scott accepts the offer and begins making plans for his vacation. Just before leaving, an Upscale vice president sends out a new policy statement that says, among other things: "Accepting incentives from vendors is strictly prohibited." What should Scott do?

1. Cancel the vacation plans and tell Larry he can longer accept the offer
2. Continue with the vacation, since he is helping Larry's uncle
3. Discuss the situation with company management and let them decide
4. Other

Case #6. Internal Dissent. (*Abridged version used with permission from Michael Pritchard. Original version appears in Pritchard, M.,"Teaching Engineering Ethics: A case study Approach," Center for the Study of Ethics in Society, Western Michigan University, 1992.)*

A recent graduate of Engineering Tech, Bernie Reston has been employed in the research and development (R&D) Chemical Engineering Division of Larom, Inc. for the past several months. Alex Smith, the head of Bernie's unit, showed immediate interest in Bernie's research on processes using a particular catalyst (call it B). However, until last week, his work assignments at Larom were in other areas.

A meeting of engineers in Bernie's unit is called by Alex. He announces that the unit must make a recommendation within the next two days on what catalyst should be used by Larom in processing a major product. It is clear to everyone that Alex is anticipating a brief, decisive meeting. One of the senior engineers volunteers, "We've been working on projects like this for years, and catalyst A seems to be the obvious choice." Several others immediately concur. Alex looks around the room and, hearing no further comments, says, "Well, it looks like we are in accord on this. Do we have consensus?"

So far Bernie has said nothing. He is not sure what further testing will show, but the testing he has been doing for the past week provides preliminary evidence that catalyst B may actually be best for this process. This is also in line with what his research at Engineering Tech suggested with somewhat similar processes. If catalyst B should turn out to be preferable, a great deal of money will be saved; and, in the long run, a fair amount of time will be saved as well. Bernie somewhat hesitantly raises his hand. He briefly explains his test results and the advantages catalyst B might provide. Then he suggests that the unit might want to delay its recommendation for another two weeks so that he can conduct further tests.

Alex replies, "We don't have two weeks. We have two days." He then asks Bernie to write up the report, leaving out the preliminary data he has gathered about catalyst B. He says, "It would be nice to do some more testing, but we just do not have the time. Besides, I doubt if anything would show up in the next two weeks to change our minds. This is one of those times we have to be decisive — and we have to look decisive and quit beating around the bush. They are really getting impatient on this one. Anyway, we've had a lot of experience in this area."

Bernie replies that, even if the data on B are left out, the data on A are hardly conclusive. Alex replies, "Look, you're a bright person. You can make the numbers look good without much difficulty — do the math backwards if you have to. Just get the report done in the next two days!"

Bernie likes working for Larom, and he feels lucky to have landed such a good job right out of Engineering Tech. He is also due for a significant pay raise soon if he plays his cards right.

What do you think Bernie should do?

1. Write up the report as Alex says.
2. Refuse to write up the report as Alex says, saying he will have no part in falsifying a report.
3. Other.

Case #7. Getting Acquainted. (*Abridged version used with permission from Michael Pritchard, Center For the Study of Ethics in Society, Western Michigan University. Originally created with support from NSF grant #DIR-8820837.)*

Despite relatively little practical experience in engineering, Carl Lawrence was made supervisor of several acid and caustic distribution systems after joining the company. Plant manager, Kevin Rourke, gave Carl a tour of the facilities and introduced him to the workers he would be supervising. Carl was pleasantly surprised when he was introduced to Rick Duffy, a friend of Carl's family when the two were in school as children. Rick had taken a job at the chemical plant as a lead operator when he returned from the Army. Now married with two small children, Rick is anxious to move ahead. So he is enrolled in night classes at the local university.

When Kevin Rourke finished showing Carl around the facilities, he asked Rick to show him how the distribution systems worked. As Carl and Rick moved from the acid- to the caustic-distribution system, Carl noted a striking difference. The acid-distribution piping has spring-loaded valves that close automatically when not in use. To pump acid into a remote receiving tank, a pump switch must be activated at the remote location. The pump switch has to be held on by the operator while the tank is filling. The penalty for propping the switch on by other means is immediate dismissal. In contrast, no similar precautions are taken with the caustic system.

One of the two caustic tanks in Carl's area is equipped with a high-level alarm. The other, located in a less used area of the building, is not. Both tanks have vents piped to trench drains in the floor that are connected to the publicly owned wastewater treatment works (WTW). Because of the many low-volume caustic-use points throughout the area, the distribution system is kept pressurized by an air-operated diaphragm pump. So, if there is no caustic demand, the pump expends no energy. But it immediately acts to restore the line pressure if any valve is opened or if there is a leak in any of the pipes.

Carl asks Rick why the caustic system is so different. Rick shrugs and says, "I don't really know. It has been this way at least as long as I've been here. I suppose it is because the acid-distribution system is used so much more." Carl then asks if the lead operators have written procedures for filling the caustic tanks. Rick says he has never seen any — nor has there been any review of the practice during the four years he has been an operator. "Are you satisfied with this setup?" Carl asks. "Well, I don't have any problems with it. Anyway, that is somebody else's concern, not mine. I suppose they don't want to put out the money to change it," Rick replies.

Several months later, Carl Lawrence is alarmed by Kevin Rourke's urgent, early afternoon message: "All supervisors immediately check for open caustic valves. Supply tank is empty. Pump still running — either an open valve or a leak. Emergency order for caustic has been made." Carl immediately tells his lead operators to make a check. They report that everything is in order. However, by mid-afternoon it is evident that the problem is still unsolved. The supply tank is steadily emptying even though apparently all the valves are closed and no leak has been discovered. At 4:00 p.m., a lead operator who has just arrived for the afternoon shift notices an open valve in a seldom used area of the facility. Carl had forgotten that no one was working on that side of the building during the early afternoon. So, the seldom used valve wasn't checked. Now, however, Carl remembers that Rick Duffy was assigned that area during the previous shift.

The valve is immediately shut off. Then Carl phones Rick: "Rick, you left the C-2

Several months later, Carl Lawrence is alarmed by Kevin Rourke's urgent early afternoon message: "All supervisors immediately check for open caustic valves. Supply tank is empty. Pump still running — either an open valve or a leak. Emergency order for caustic has been made."

ENGINEERING ETHICS RESOURCES.

- Online Ethics Center for Engineering and Science (www.onlineethics.org)
- The Center for the Study of Ethics in Society at Western Michigan University (www.wmich.edu/ethics)
- The National Society of Professional Engineers (www.nspe.org/resources/ethics)
- American Institute of Chemical Engineers (www.aiche.org/about/code-ethics)
- American Chemical Society (www.acs.org)
- Institution of Chemical Engineers (www.icheme.org)
- Ohio University (engineeringmastersonline.ohio.edu/articles-and-resources)

valve open; and we've got a real problem on our hands. We lost a lot of caustic down the drain. What time was it when you opened the valve?" Rick answers, "Carl, I don't remember. I have been real tired all day. Pulled an all-nighter getting ready for my exam tonight, and I was just wiped out when I went to work. I think I turned it on near the end of my shift, but I just cannot be sure. I can't believe I forgot to turn it off!" Rick pauses and takes a deep breath, "Man, I can't afford trouble right now. Jan's pregnant again, and I have another semester to go."

Now that Carl has located the problem, what should he say to his plant manager, Kevin Rourke?

1. Acknowledge responsibility for failing to have C-2 checked earlier?
2. Identify Rick as the one who left the valve open?
3. Other?

What should Carl Lawrence do about Rick Duffy? If propping open a pump switch of an acid tank warrants immediate termination, should Carl fire Rick for leaving open the caustic valve?

Yes or No?

To what extent, if any, should Carl be influenced by his friendship with Rick?

None? Some?

To what extent should Carl be influenced by his knowledge that Rick needs to keep his job? None ? Some?

Case #8. Chemical Waste Handling. *(Used with permission from Michael Pritchard, Center For the Study of Ethics in Society, Western Michigan University. Originally created with support from the NSF grant #DIR-8820837.)*

ABC's chemical waste is stored in a warehouse at an off-site location. While inspecting the warehouse, engineer Scott Lewis notices several leaking drums. He calls Tom Treehorn, head of ABC's Division of Chemical Waste. Tom responds, "I will be right over with a crew to bring the leaking drums over here." Scott points out that the law forbids returning chemical waste to the "home" site. Tom replies, "I know, but I don't have any confidence in the off-site folks handling this. We know how to handle this best. It might not be the letter of the law, but our handling it captures its spirit."

Scott believes that Tom Treehorn is serious about preventing environmental problems — especially those that might be caused by ABC. Still, he knows that the Environmental Protection Agency will be upset if it finds out about Tom's way of dealing with the problem; and if anything goes wrong, ABC could get into serious legal difficulties. After all, he thinks, ABC is not a waste disposal facility.

What should Scott do at this point?

1. Tell Tom that he will inform Tom's superior if Tom goes ahead with his plan.
2. Inform Tom that he will not interfere with Tom's plan, but he will not help him with it either.
3. Advise Tom not to go ahead with his plan, but not interfere if Tom insists on going ahead anyway.
4. Say nothing, and help Tom with his plan.
5. Other?

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Emissions Regulations and Control

Harnessing new technologies for best practices in pollution control could lead to a more ideal framework of policies and programs

Jim Drago
Garlock Sealing Technologies

IN BRIEF

Fugitive emissions are managed in a variety of ways around the world, ranging from detailed prescriptive control to suggested guidance. Motivating industrial sites to reduce pollution are government enforcers, the public and media. A combination of qualifying equipment, best available control technology and vigilant maintenance all work toward minimizing emissions. The advent of new technologies is also giving rise to new ideas for more effective pollution control. Knowledge of the regulations and of past outcomes combined with a view toward new technologies in monitoring, leak control and data acquisition can help lead to an optimized global approach for emissions control and regulations based on best practices.

With the exception of global initiatives, such as the United Nations Framework Convention on Climate Change, regulating industrial pollution has largely been relegated to individual national governments. Informing my point of view on this issue have been many years of employing sealing products to stop fugitive emissions, observation, involvement with leak detection and repair (LDAR) programs and study of U.S. and other countries' regulations. My initial foray into the world of pollution control was with a company that manufactured flyash handling systems. These systems conveyed ash particles captured by electrostatic precipitators, baghouses and cyclone dust collectors. The sole purpose of these systems was to prevent millions of tons of ash particles from entering the air we breathe and sequestering them for safe storage, a business owing its existence to the Clean Air Act of 1970 [*1*].

My introduction to fugitive emissions came when I began working in the sealing industry. Fugitive emissions, as the term implies, are unintentional releases, unlike process emissions that are known and expected. Fugitive emissions include leakage from valve stem seals, flange joints, pressure relief valves, compressors, threaded connections and other sources. These leaks are relatively small, but subject to a multiplier effect from some 10,000 chemical and petroleum refinery sites, each with tens of thousands of point sources and nearly a million pipeline compressor-pumping stations, tank terminals and natural-gas well heads, each with hundreds of point sources of fugitive emissions [*2–3*].

Development of a patented low-emission valve stem seal [*4*], motivated by the California Clean Air Act (CCAA) [*5*], marked the beginning of products and services for achieving low to zero emissions from the millions of point sources in U.S. Government policy and laws aimed at protecting public health and the environment.

This article compares worldwide emissions regulations and describes an "idealized" fu-

gitive emissions plan. Six general concepts to assure a balanced approach are discussed, including: clear regulatory objectives; equipment qualification; preventive and sustaining maintenance; documentation useful to meeting objectives; use of best available control technology; and a three-pronged approach to leak detection.

Regulatory overview in U.S.

In the 1990s, the U.S. Environmental Protection Agency (EPA) concluded that LDAR programs at petroleum refineries existed in name only, or were minimally managed and implemented. As a result, the EPA mounted a full enforcement effort, and by 2010 petroleum refineries under consent decrees far outnumbered those that were not. The mandate evolved from compliance with the regulations for leak detection and repair to leak prevention today. Regulators now want chemical process industries (CPI) plants to use the best available low-emission technologies to stop leaks from occurring in the first place. This approach is termed, "Enhanced LDAR." Although not formally part of U.S. regulations, it is mandated via consent decrees whenever the EPA finds deficiencies in LDAR programs.

In the U.S., leaks are monitored using flame or photo-ionization detection equipment and quantified in parts per million by volume (ppmv). This measure is the concentration of a volatile organic compound (VOC) categorized as a hazardous air pollutant (HAP) at the point of the equipment being monitored. These data are put into equations that approximate the rate of mass loss in pounds or kilograms per hour [*6*]. The method of gathering leak data as ppmv in the field is given in Method 21 [*7*].

In December 2008, another method of monitoring leaks was allowed — the "Alternative Work Practice to Detect Leaks from Equipment" (AWP) [*8*] uses forward-looking infrared (FLIR) instruments resembling handheld video cameras. Specialized infrared (IR) sources are tuned to make hydrocarbon gases visible. This monitoring method indicates only the presence of a leak, but not the quantity. It is commonly accepted that FLIR-type devices can detect leaks of 5,000 to 10,000 ppmv and above.

TABLE 1. EMISSIONS REGULATIONS OF SELECTED COUNTRIES

Fugitive-emission control technology	Country	Motivation to control fugitive emissions
None specified. Plant sites are expected to use best practices	Thailand	• Corporate social responsibility, media and public pressure • Future regulations will impose more formal rules
	India	• Access to bank guarantees • Citizen complaints leading to litigation
	People's Republic of China	• Financial penalties, risk of shut down, media and citizen pressure • Unique law objective: recognition of environment and economic needs
	Singapore	• Corporate social responsibility, media and public pressure • Risk of shut-down of operations
	Kingdom of Saudi Arabia	• Violators face fines or imprisonment
	Taiwan	• Prosecution by government agencies and suspension of operations
Uses accepted technical practices	Japan	• Corporate social responsibility, media and public pressure
Best available control techniques are published and expected to be used	E.U.	• Action by local authorities, media and citizen pressure
LDAR programs are minutely defined and regulated. Low emission packing and valves and their performance requirements are specified	U.S.	• Fines and prosecution leading to consent decrees requiring special projects, equipment installation, extra rules and fines

The U.S. is notorious for rigorous, detailed regulations. The administering agency, the EPA, has fostered a culture of doing only what is necessary to comply, no more or less. In recent years, enforcers have promoted prevention via the latest technology, expressed as "Next Generation Compliance" [*9*].

A December 2012 workshop [*10*] attended by regulators, policy makers and environmental law academics presented ways to more effectively enforce existing regulations via technology, increased citizen involvement, traditional and social media, more efficient rules and increased transparency.

Worldwide regulations

A survey of selected, industrialized regions of the world provides insight into different ways of mitigating and minimizing air pollution.

Thailand. Thailand, for example, extensively monitors ambient air in areas of concentrated industrial activity, such as Rayong Province. While there is no strong central enforcement authority, social pressure motivates polluters to comply.

Japan. Japan has a similar approach, but with stronger enforcement. The country assigns maximum emission levels to each site based on atmospheric air monitoring. Each site is responsible for self-monitoring and using the best technologies to limit emissions. Corporate responsibility motivates plant sites to do the right thing, and media attention and popular indignation are effective motivators.

India. In India, plant sites are motivated by high litigation costs and financial sanctions, which take the form of limiting or denying access to bank loan guarantees and subsidies. While monitoring is not mandated, it must be done as a consequence of the requirement to report each year's emission quantities.

China. China has a tradition of citizen action via a system of letters and visits for making complaints about polluters. Chinese pollution laws seek to balance environmental protection, public health and economic development. In other countries this concept is understood in practice, but not codified. At present, enforce-

TABLE 2. ELEMENTS OF AN IDEALIZED FUGITIVE EMISSIONS REGULATORY PLAN

1. Define the hazardous air pollutants (HAPs) to be regulated
2. Define the different types of equipment and connecting devices with the potential to leak to be regulated
3. Specify methods to qualify equipment performance
   a. Define leak levels for what is considered tight for each equipment type
   b. Define method(s) of measuring leaks for this qualification
   c. Require performance to be checked after initial installation
   d. Develop a lexicon of recommended practices and equipment designs to guide users to the best available technology

4. Define maintenance programs
   a. Codify practices for equipment installation and maintenance
   b. Audit to assure compliance practices are followed
   c. Require reporting

5. Define air-pollution monitoring methods; a combination of available types can be used to assure protection of the environment and near and remote populations. Combinations of the following could be used:
   a. Discreet monitors
      i. Flame ionization detectors (FID) or optical photo-ionization detectors (PID) toxic vapor analyzers (TVA). This is the USA Method 21 approach
      ii. Discreet sensors mounted at each potential leak point of interest
         1. These could be accessed wirelessly or by wire for continuous or periodic monitoring
   b. Mobile IR monitoring (technicians, motor vehicles, aircraft)
      i. FLIR camera allowed by the EPA Alternative Work Practice to Method 21
   c. Stationary fence-line monitoring using IR, ultraviolet (UV), specialized laser optics
      i. U.S. EPA has ordered the installation of such systems at various plant sites to develop and validate the efficacy of the leak control technology
   d. Ambient-air monitoring stations near population centers, schools and fragile or highly valued environmental regions
      i. Used extensively in E.U., Singapore and Thailand

6. Repair procedure code
   a. Assure that problems found are fixed correctly and in a timely manner

7. Documentation
   a. All of the above
      i. Regulated HAPs at the site
      ii. Inventory of regulated equipment
      iii. Equipment qualification certification
      iv. Maintenance program
      v. Monitoring methods and data
      vi. Repair records

8. Enforcement
   a. Assignment of an entity that answers to the general public and government authorities, not plant owners
   b. Enforcers would be allowed to audit and levy fines within a defined schedule and initiate prosecution to bring the plant site into compliance
   c. All enforcement actions would be published and made available to the general public and media outlets
   d. Private citizens would have a voice in reporting suspected pollution events

ment is weak and at the discretion of regional authorities.

Singapore. Singapore requires monitoring by qualified providers. Like Thailand and Japan, performance is assessed from atmospheric air monitoring at specific locations. Sites are encouraged to use best available technologies (BAT), and a central authority can inspect and demand compliance if levels are beyond allowable limits.

Saudi Arabia. The Kingdom of Saudi Arabia manages air pollution by measuring air quality, and enforcement is at the discretion of a designated agency.

Taiwan. Taiwan has a central enforcement authority and regulations defining the use of BAT. It embraces technology to electronically report air-monitoring data and uses computer simulations to model air quality.

European Union. In the E.U., best available control technology (BACT), flexibility and public participation are foundational. Sites apply for permits to emit, which are subject to authorities' discretion, taking into account the site's performance record, location and local environment. Equipment must be qualified before use.

Collaboration in defining and sharing BACT and best practices is ingrained in E.U. policy directives and is a hallmark of its basic approach to pollution control. It is an integrated approach that is flexible with regard to application and enforcement, inspections and public participation. BAT and best practices are developed by expert representatives from E.U. member countries, affected industries and non-governmental organizations.

Learning from world regulations

Table 1 summarizes the following policies and practices: atmospheric monitoring at significant locations in regions of low and high industrial pollution; citizens engagement; traditional media and social media as auxiliary enforcement; negative motivation for regulatory compliance; reporting to a central authority; use of BACT; and organization of non-governmental experts to define, develop and maintain BACT and inferred regulatory requirements that lead to desired behavior.

For example, a site may be required to report the amount of pollutants it is emitting without specifically having to monitor and quantify the sources of emissions. Implicit in the reporting rule is some degree of monitoring and measurement. Other practices of note include using the latest in the acquisition and transmission of data to responsible authorities and permitting institutions.

Permitting takes a variety of forms. Ambient pollution data will lead enforcers to impose emission limits on regional polluters, but enforcers defer to the polluters with regard to the technologies needed to meet these limits. A plant site can apply to the responsible authority for permission to emit a given amount of pollutant, which can be accepted, rejected or negotiated to an acceptable level. The system of permits forces transparency on the part of both polluters and enforcers; polluters must publish what they emit, and enforcers' expectations are transparent by agreeing to a level of performance.

Idealized emissions regulation

Looking at what has already been done, the basic elements of a fugi-

tive emission program are shown in Table 2.

If items 1–4 are followed, the rest will fall into place. If we know what we are guarding against (identification of HAPs), know where it is coming from (equipment and connector inventory), qualify the design before installation, check that it is performing correctly post-installation and follow a comprehensive maintenance plan, a plant's emissions cannot help but be hygienic and environmentally safe.

Plant equipment and components wear with time, so maintenance will play a major role. Some method of monitoring is needed to check performance. Having witnessed U.S. petroleum refineries and other CPI processing plants grapple with measuring and documenting leaks from tens of thousands of components multiple times a year, I would opt for a more streamlined approach.

one's leak level in a massive database using specialized software is not a valuable exercise.

The objectives of the regulatory system would be the protection of public and environmental health and milestone measures of environmental quality with recognition of economic effects. These intents would serve as check points for all the regulations. If a regulatory action does not support these objectives, it should be abandoned.

Definitions would include pollutants, leak levels, stationary industrial pollution sources, stationary small commercial sources, equipment types and performance and enforcing authorities. Pollutants would be defined as any substances that cause harm to those to be protected in the objectives. These could be broken down by general chemical categories — for example organic, inorganic, VOC

"A more balanced approach is to use single-point emission detectors, forward looking infrared (FLIR) sensor cameras and ambient air monitors located at a plant's fence lines."

A comprehensive fence-line monitoring system would indicate what and how much a plant is emitting. If this was coupled with periodic mobile IR monitoring, plant operators would know which, if any, areas contain trouble spots. These spots would be subject to discrete monitoring with Method 21 to pinpoint leaking components that need to be repaired.

An American Petroleum Institute (API) study showed that 83% of emissions come from 0.13% of components leaking greater than 10,000 ppm [*11*]. This small population of components exhibited major, not marginal leaks. This study justified the use of IR cameras under U.S. regulation. Measuring all components all the time is not necessary to assure good environmental practices. Since most are not leaking, one can conclude that measuring all components and documenting each and so on. Reference could be made to how substances are to be added or removed from the list. Some substances may be banned from production or use.

Equipment leak levels can be correlated to the degree of harm a substance can cause. What constitutes a leak would be defined as leakage above a certain level. Industrial sites owned and managed by large corporations would be categorized differently than small businesses.

The location of the sources also should be defined. Are many industries concentrated in one locale? Are there prevailing meteorological conditions that affect the movement of emissions into population centers, across international borders or into environmentally sensitive areas?

In addition, equipment and how it is qualified for service and components subject to monitoring and

maintenance need to be defined. These definitions should be based on information identifying problem equipment. Performance can be assured by qualifying equipment design for acceptable pollution levels and monitoring after the equipment has been put into service.

The responsible authority needs to be identified, together with the boundaries of its authority, the actions it can take without supervision and actions that require approval from a higher authority. Likewise, guidelines for fines and punitive actions must be determined, as well as relevant information and availability of data and reports that must be submitted to enforcing authorities.

Pollution levels are a key measure of success. The U.S. promotes measurement of every potential leak point at least once, and in some cases, multiple times a year. Each time, leak levels must be recorded and reported. The advantages of this approach are that specific components are identified and corrected. The drawbacks are the cost of deploying personnel to monitor tens of thousands of components and administering large amounts of data.

A three-pronged approach to leak detection. A conclusion that can be drawn from the above referenced API study is that repeatedly measuring and documenting the leakage of all components is not productive. When properly located, ambient-air monitoring stations can provide the type and level of pollutants reaching the public and the environment. This approach identifies entire plants or groups of plants, but not specific sources. A plant(s) can be put on notice to check the effectiveness of its (or their) air pollution controls and bring them into compliance. However, with this approach one must be vigilant that vague enforcement does not lead to vague remediation.

A more balanced approach is to use single-point emission detectors, FLIR sensor cameras and ambient air monitors located at a plant's fence lines. This involves a three-pronged approach: wide area monitoring via fence line and ambient-air station instruments; local area monitoring using FLIR instruments; and single-point monitoring to identify and quantify leaking components.

First use FLIR to perform walking or mobile surveys of all components to identify high leakers for correction. Once offending components are located, use organic vapor analyzers (OVA) to identify and document their leak levels, repair them and then use OVAs to validate that the fix is successful. This greatly reduces the number of data points to be tracked, and integrates leak data into repair actions. This gets to the heart of finding and stopping leaks. A modification to this approach would be to measure all components with single-point OVA monitoring, but record only those that are leaking so they can be noted for repair.

To monitor pollution escaping the borders of a plant site, optical instruments would be set at the fence lines. Unlike ambient air monitors, the data from these systems would be directly applicable to the plant. Data on the type and quantity of pollutants crossing the fence line can be integrated with meteorological data to triangulate the general location of the source and alert plant personnel to use the FLIR and OVA instruments to find the leak points for correction.

Maintenance is critical to preventing degradation of equipment performance and the need for repair. Practices need to be codified to assure that equipment is installed, used and maintained properly. This calls for personnel training, published requirements and recording equipment repairs. Documentation subject to audit will hold maintenance leaders accountable for acceptable equipment performance. Repairs need to be done in a timely manner within a defined period to eliminate the creation of long lists of documented problems that are never addressed. Putting more effort into preventive and sustaining maintenance rather than monitoring all potential emission points and building large databases will result in low emissions and economically profitable plant sites.

Leveraging past and present techniques together with receptivity to new ones can result in optimal policies and programs so we can all breathe a little easier. ■

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Pipe Insulation: Finding the Optimal Thickness

Avoid tedious numerical calculation by using this quick, shortcut method

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Insulated pipes are important in many applications in the chemical process industries (CPI). When it comes to the insulation itself, the two main questions are: which material should be used; and how much of it (thickness)? Three variables are considered in order to find the most economical thickness of an insulated pipe: the inner radius of pipe, the cost of energy and the cost of the insulation material itself.

Determining the most economical thickness of insulation for a pipeline is a problem of finding the right balance between using the least amount of insulating material with the least amount of energy loss. When increasing the thickness of the insulating material, the energy loss decreases, but the cost of the insulating material rises. When decreasing the thickness of the insulating material, the material cost decreases, but the energy lost rises — that translates into monetary losses.

The equation that solves this problem is complicated. It is a function of many variables, such as inside and outside temperatures, cost of energy, conductivities, nominal sizes of pipelines, the cost of insulating materials and more.

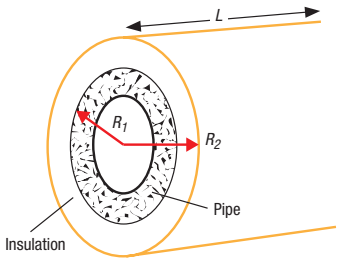

FIGURE 1. The problem is to determine the optimal insulation thickness, $R_2 - R_1$

In order to find a system's minimal cost and therefore the optimum insulation thickness, numerical methods are required. This process involves finding an equation describing the cost as a function of the variables, then setting the derivative of that equation equal to zero. Although it is possible to solve such a problem numerically, using software such as Solver for Excel, it is tedious and time consuming.

This article first outlines the numerical approach, and then presents a simple shortcut method that can be used as a quick, practical tool to determine the most economical thickness of different insulating materials. An example calculation using both methods is then given, which shows the same results are achieved.

Fundamentals

To demonstrate the complexity of the problem, we first develop the equations that need to be solved numerically. After this, a shortcut method is presented, with examples to compare the results of using the numerical versus the shortcut method.

Heat transfer. The general equation for the rate of heat transmission through a pipe having a homogeneous insulation material can be derived by starting with Fourier's law, represented by Equation (1):

$$\frac{q_i}{A} = -K\frac{dT}{dx_i} \quad (1)$$

Where:
q_i = the heat-transfer rate in the i direction, Btu/h
A = the area normal to the direction i (direction of the heat flow), ft^2
dt/dx_i = the temperature gradient in the i direction, °F/ft
K = the thermal conductivity, Btu/h·ft·°F

For an insulated pipe of length L, (Figure 1) the heat transfer is in the radial direction, R, and the area is $2\pi RL$

$$\frac{q_R}{2\pi RL} = -K\frac{dT}{dR} \quad (2)$$

Equation (2) is integrated from R_1 (inside radius of pipe insulation) to R_2 (outside radius of pipe insulation), and from T_1 to T_2, where T_1 is the temperature in the inside radius of insulation. For practical purposes, T_1 is considered the same

NOMENCLATURE

C_a	Least squares fit of mineral wool costs (Table 2)	mp	Cost of heat loss, $/ft·yr
d_0	Outer diameter of insulation = $2r_2$, in.	np	Cost of insulation per year, $/ft·yr
F_T	Adjustment factor for temperature	q_R	Heat transfer rate in radial direction, Btu/h
F_N	Adjustment factor for pipe size	R_1, R_2	Insulation inner and outer radius, ft
F_M	Adjustment factor for temperature	r_1, r_2	Insulation inner and outer radius, in.
F_D	Adjustment factor for pipe size	T_1, T_2	Temperature at R_1 and R_2, °F
h_2	$h_c + h_r$	T_a	Ambient temperature, °F
h_c	Surface heat-transfer coefficient, radiation	U_2	Heat flowrate from R_2 to outside air, Btu/h
h_r	Surface heat-transfer coefficient, convection	U	Heat flowrate (per foot) from R_2 to outside air, Btu/h·ft
K	Thermal conductivity, Btu/h·ft·°F	Y	Number of hours operation, h/yr
L	Length of pipe insulation, ft	yp	Total cost (insulation plus energy), $/ft·yr
M	Cost of heat, $/million Btu	ξ	Emissivity of insulation surface

as the operating temperature inside the pipe. This gives Equaton (3)

$$\frac{q_R}{2\pi R_2 L} = U_2 = -\frac{(T_a - T_1)}{\left(\frac{R_2 \ln\frac{R_2}{R_1}}{K} + Rs\right)} \quad (3)$$

Because we are concerned with the heat flow between the inside surface of the pipe insulation and the outside air (ambient temperature = T_a), Equation (3) is divided by the outer surface area of the insulation, and the right side expressed in terms of thermal resistances (the inverse of the heat-transfer coefficients), to which is added the thermal resistance due to surface radiation and surface convection. This gives Equation (4).

$$U_2 = \frac{q_R}{2\pi R_2 L} = \frac{(T_1 - T_a)}{\frac{R_2 \ln\frac{R_2}{R_1}}{K} + Rs} \quad (4)$$

Where:
$Rs = 1/h_2$
$h_2 = h_r + h_c$

The heat flowrate per linear foot (U, Btu/h·ft) is found by rearranging Equation (4) to give:

$$U = \frac{q_R}{L} = \frac{2\pi R_2 (T_1 - T_a)}{\frac{R_2 \ln\frac{R_2}{R_1}}{K} + Rs} \quad (5)$$

Expressions for the surface radiation, h_r, and surface convection, h_c, are given by Equations (6) and (7):

$$h_r = \frac{0.173\xi\left[\left(\frac{T_2 - 460}{100}\right)^4 - \left(\frac{T_a - 460}{100}\right)^4\right]}{(T_2 - T_a)} \quad (6)$$

$$h_c = 0.5\left(\frac{T_2 - T_a}{d_0}\right)^{0.25} \quad (7)$$

Where:
d_0 = surface diameter, in., = $2r_2$
ξ = surface emissivity (≈1)

Equation (5) can be rearranged to give Equation (8), which includes a conversion from inches to feet, since pipe sizes and insulation thicknesses are normally expressed in inches.

$$U = \frac{q_r}{L} = \frac{2\pi(T_1 - T_a)}{\frac{\ln\frac{r_2}{r_1}}{K} + \frac{1}{r_2\left(\frac{1\,ft}{12\,in}\right)h_2}} \quad (8)$$

Finally, an expression for Newton's law of cooling is given as Equation (9):

$$U = \frac{q_r}{L} = 2\pi r_2\left(\frac{1\,ft}{12\,in}\right)h_2(T_2 - T_a) \quad (9)$$

To summarize thus far, Equation (8) expresses the heat flow (per foot) from r_1 (the inner surface of the insulation, in inches) to the environment, and this should be equal to Equation (9), the heat flow (per foot) from r_2 (the outer surface of the insulation, in inches) to the environment.

Costs. If Y is the number of hours of operation per year and M is the cost of heat (in dollars per million Btu) then the cost of heat lost for the insulated pipe (mp, \$/ft·yr) can be expressed as Equation (10):

$$mp = U \times Y \times M \times 10^{-6} \quad (10)$$

The next step is to find a function that describes the cost of insulation per foot per year. This function will be named np. For this, it is necessary to find the price of different insulation materials. For each insulation material, it was found that there are tables of prices for a specific thickness and nominal pipe size. Table 1 shows such information for mineral wool, for example. These data were plotted for each pipe size, as shown in Figure 2. The y-axis is the cost per foot, and the x-axis is the thickness of the insulation. In the context of the previous discussion, $x = r_2 - r_1$.

For the case of mineral wool, the plots of Figure 2 can be fit to linear equations, as shown in Table 2. These linear relationships can be generalized as the function C_a. Multiplying this function by the the cost of installation (assume 4% per year) plus the annuity, which accounts for the annual interest, i, for amortization over a period of n years, gives the general equation for insulation costs as follows:

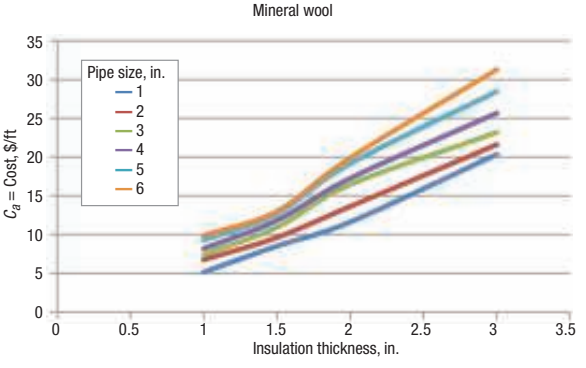

FIGURE 2. The cost of mineral wool depends on the pipe size. The data can be approximated by the function C_a (Table 2)

$$np = C_a\left[\frac{i(1+i)^n}{(1+i)^n - 1} + 0.04\right] \quad (11)$$

For example, imagine we have a pipe with a nominal size of 3 in. insulated with mineral wool. In this case, we would use the equation $y = 8.0272x - 0.5719$ for C_a. If we add 5 years as the time factor for depreciation and amortization, with an annual interest for amortization of 15% and adding cost of installation per year of 4% (20% between 5 years). Then *np* is:

$$np_{3\text{ in.}} = \left[8.0272(r_2 - r_1) - 0.5719\right]\left[\frac{0.15(1+0.15)^5}{(1-0.15)^5} + 0.04\right]$$

To summarize thus far, the costs for energy and insulation material, *yp*, is given by Equation (12).

$$yp = mp + np \quad (12)$$

Finding the economic thickness. For a particular pipe with nominal diameter of r_1, the value for the most economical insulation thickness is determined by taking the derivative of *yp* with respect to r_2, and setting this equal to zero:

$$\frac{dyp}{dr_2} = \frac{dmp}{dr_2} + \frac{dnp}{dr_2} = 0 \quad (13)$$

For the previous example of the 3-in. pipe with mineral wool insulation, Equation (13) becomes the following:

$$\frac{dyp}{dr_2} = -\left[\frac{a\left(\frac{1}{kx} - \frac{12}{r_2^2\sigma} + \frac{1.5c}{r_2^3\left(\frac{c}{r_2}\right)^{0.75}\sigma^2}\right)}{\left(\frac{\ln\left(\frac{r_2}{b}\right)}{K} + \frac{1}{\frac{r_2}{12}\sigma}\right)^2}\right] - (8.0272)\left[\frac{0.15(1-0.15)^5}{(1-0.15)^5 - 1} + 0.04\right] = 0 \quad (13a)$$

Where the following constants (*a–d*) and the expression for σ were defined to simplify *mp* in order to more easily perform the differentiation:

$$a = 2\pi(T_2 - T_a) \times Y \times M \times 10^{-6}$$

$$b = r_1$$

TABLE 1. THE COST OF MINERAL WOOL INSULATION, $/FT

Insulation thickness, in. \ Iron pipe size, in.	1	2	3	4	5	6
1.0	5.133	6.727	7.383	8.167	9.256	9.867
1.5	8.500	9.613	10.927	11.813	12.620	13.000
2.0	11.607	13.607	16.440	17.247	19.143	19.900
3.0	20.340	21.600	23.167	25.660	28.450	31.283
6.0	42.800	44.020	47.591	52.394	58.038	66.793

TABLE 2. C_a FUNCTION FOR MINERAL WOOL*

Pipe size, in.	*A*	*B*	Correlation coefficient, r^2
1	7.6133	2.88	0.9933
2	7.5474	1.2648	0.9961
3	8.0272	0.5719	0.9906
4	8.8903	0.9476	0.9968
5	9.8596	1.1194	0.9922
6	11.05	2.2071	0.9888

*Least squares fit to data in Table 1 (Figure 2): $C_a = Ax - B$

$$c = \frac{T_2 - T_a}{2}$$

$$d = \frac{0.173\left[\left(\frac{T_2 + 460}{100}\right)^4 - \left(\frac{T_a + 460}{100}\right)^4\right]}{T_2 - T_a}$$

$$\sigma = 0.5\left(\frac{c}{r_2}\right)^{0.25} + d$$

To solve Equation (13a), it is necessary to use a numerical method. This is done by varying r_2 until the expression on the left equals zero. But at the same time, one must also vary T_2 so that Equation (8) is equal to Equation (9). When all of these conditions are met, the value of r_2 found is the optimum value, and thus gives the optimal thickness ($r_2 - r_1$).

Obviously, solving Equation (13') is not an easy task. And this expression is very specific to mineral wool insulation for a 3-in. pipe. For other insulation materials, it is necessary to find equations that give the price of the material with thickness, as was done with mineral wool (Table 2). To avoid this burdensome task, we have developed a shortcut method to estimate the calculated result. This shortcut is described below.

Overview of the shortcut

To develop the shortcut method, we start with a base-case scenario in which all variables are known. Then, several graphs are generated that show how a given variable changes with respect to the others as they change from the base case. Changing only one variable at a time enables us to observe how the economic thickness behaves towards a certain variable. With this information we can generate several adjustment factors, which can be applied to the base case in order to get the values for the scenarios of interest.

TABLE 3. VALUES OF F_M							
Material \ Temperature	200°F	250°F	300°F	350°F	400°F	450°F	500°F
Mineral wool	1	1	1	1	1	1	1
Calcium silicate	1	1.02	1.02	1.02	1.01	1.01	1
Fiberglass	1	1.02	1.04	1.07	1.08	1.1	1.11
Cellular glass	1	1.08	1.13	1.14	1.15	1.16	1.15
Perlite	1	1.02	1.03	1.04	1.03	1.03	1.02

TABLE 4. VALUES OF F_D						
Material \ Nominal diameter	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.
Mineral wool	1	1	1	1	1	1
Calcium silicate	1	0.98	0.88	0.77	0.8	0.81
Fiberglass	1	0.9	0.88	0.84	0.82	0.88
Cellular glass	1	0.91	0.87	0.9	0.81	0.85
Perlite	1	0.97	0.79	0.87	0.77	0.80

The shortcut method

The shortcut method consists of using three graphs and two tables to find the optimal thickness. We consider five different insulation materials, but the the graphs and tables can be further developed to handle any type of insulation material.

The factors that we need to know for this method are the following:

- Cost of energy, $/million Btu
- Temperature at R_1, °F
- Pipe size, nominal dia., in.
- Type of insulation material

As a starting point, we choose a base case to generalize many instances graphically. We select 200ºF as the temperature at radius r_1, a 1-in. pipe and an ambient temperature of 77ºF. The graphs in Figure 3 show the behavior of the optimal thickness of insulation for a pipeline versus energy costs for the five different insulation materials for this base case.

For temperatures other than 200ºF at radius r_1, it is necessary to adjust the optimal thickness using a factor called F_T. This factor is determined from the characteristics of mineral wool and is basically a relationship between thickness at one temperature (T_1) and the base temperature of 200ºF.

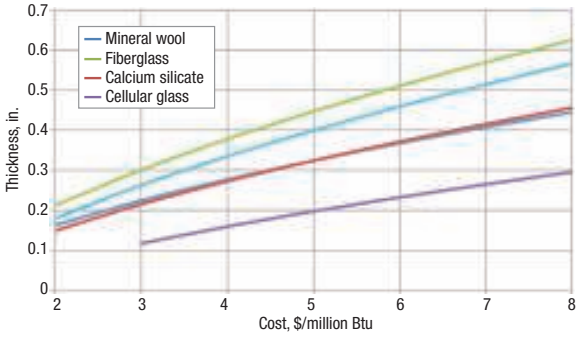

FIGURE 3. The optimal thickness for various insulation materials depends on the energy cost when compared to the base case

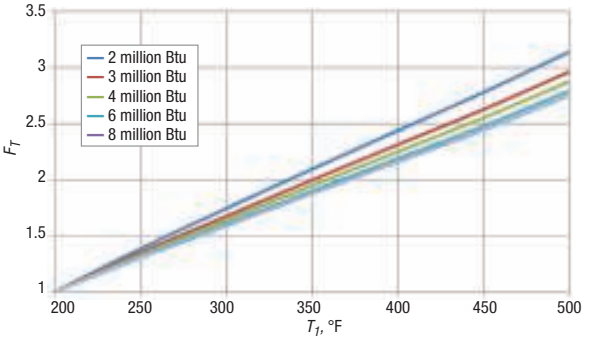

FIGURE 4. The adjustment factor for mineral wool, F_T, for temperatures other than the base case (200°F)

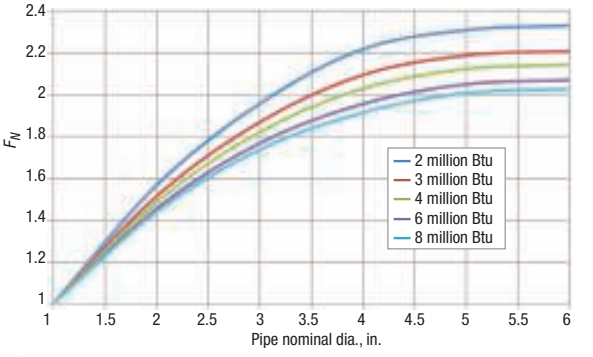

FIGURE 5. The adjustment factor for mineral wool, F_D, for pipe sizes other than the base case (1 in.)

$$F_T = \frac{\text{Optimal thickness at } T_1(°\text{F})}{\text{Optimal thickness at } 200°\text{F}} \quad (14)$$

A plot of F_T versus T_1 is shown in Figure 4 for different energy costs (mineral wool is the reference case here).

In a similar fashion, a correction factor, F_N, is determined for when the nominal pipe size is different from 1 in., in order to find the optimal insulation thickness.

$$F_N = \frac{\text{Optimal thickness for other pipe size}}{\text{Optimal thickness for 1-in. pipe}} \quad (15)$$

Figure 5 shows the behavior of F_N with nominal pipe diameter for various energy costs (for mineral wool).

Because each insulation material has different characteristics, two tables were generated to provide correction factors for estimating the optimal thickness. To correct for a material other than mineral wool, the factor F_M is used for a temperature at r_1 other than 200°F (Table 3), and F_D is used to correct for pipe diameters other than 1 in. (Table 4).

Therefore, a final equation that can be used to find the optimal insulation thickness is given by Equation (16):

$$\text{Optimal thickness} = (\text{Base case optimal thickness}) \times F_T \times F_N \times F_M \times F_D \quad (16)$$

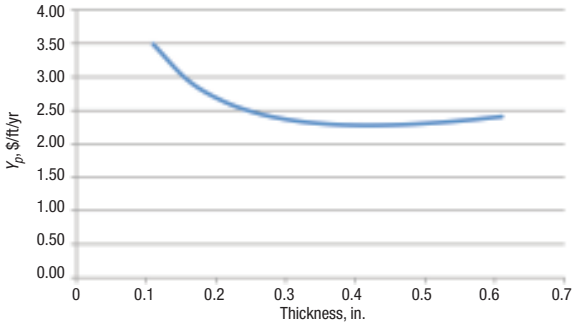

FIGURE 6. For the example problem, numerical calculations show that the total cost, *yp*, is a minimum at 0.464 in.

To demonstrate the use of this shortcut method, the following example calculation is presented, and the results are compared to numerical calculations.

Example

Consider a 2-in. dia. steel pipeline that carries steam at 350°F. The ambient temperature is 70°F. Assume the price of the energy is $2/million Btu. The time factor for depreciation and amortization is 5 years, annual interest for amortization is 15% and there is an additional cost of installation per year of 4% (20% over 5 years). Find the optimal thickness for mineral wool.

Rigorous method. First we use the numerical method discussed above. Assuming an average thermal conductivity of 0.025 Btu/h·ft·°F and solving Equation (8) for r_2 such that Equation (8) equals Equation (9) gives an optimal value for r_2 of 1.65 in., and the temperature T_2 is found to be 125.7°F. That means the optimal thickness is $r_2 - r_1 = 0.464$ in. For these optimal values of r_2 and T_2, the heat loss, U, is equal to 95.3 Btu/h·ft. A plot of Equation (12) shows that the total cost of insulation plus the cost of heat loss, y_p, is minimized to $2.63/ft at a thickness of 0.464 in. (Figure 6).

Since we cannot buy insulating material of 0.40 in.-thickness, we would need to purchase the next available size, which is 0.5 in.

Shortcut method. Next, we solve the same example problem, but using the shortcut method.

Step 1. Obtain the base case optimal thickness from Figure 3. For the *x*-axis value use the given cost of energy ($2 /million Btu) and intersect it with the line that corresponds to the desired material, which in this case is mineral wool. From the graph we find that the base case optimal thickness is 0.16 in.

Step 2. From Figure 4, determine the value of F_T to correct the pipe temperature (T_1) from the base temperature of 200°F. For x = 350ºF, the intersection of the line that corresponds to the given cost of energy ($2/million Btu) is at $F_T = 1.75$.

Step 3. From Figure 5, determine the value of F_N to correct the pipe diameter from the base size of 1 in. For x= 2 in. the intersection of the line that corresponds to the given cost of energy ($2/million Btu) is at $F_N = 1.56$.

Step 4. Use Table 3 to obtain the value for F_M. For mineral wool, $F_M = 1$.

Step 5. Use Table 4 to find the value for F_D. For mineral wool, $F_D = 1$.

Step 6. Use Equation (16), *and* multiply the factors found in the previous steps by the base case optimal thickness to obtain the optimal thickness = $0.16 \times 1.75 \times 1.56 \times 1 \times 1 = 0.4368$ in.

Compared to the rigorous numerical method, the shortcut method gives an error around 5.8%. And since insulation with 0.4369 in. thickness is not available, we would need to purchase the next available size, which is 0.5 in — the same result as calculated numerically.

Concluding remarks

The shortcut method presented here has been shown to be much simpler and faster that the rigorous numerical method for determining the optimal insulation thickness. The method can also be expanded to include other insulation materials and a wider range of pipe sizes. ■

Edited by Gerald Ondrey

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Using Laser Diffraction to Characterize Heterogeneous Catalysts

The capabilities of laser diffraction systems go beyond particle-size analysis to also predict a catalyst's propensity to experience attrition

Alan Rawle
Malvern Instruments

Heterogeneous catalysts, where the catalyst is in solid form, enhance many of the gas- and liquid-phase reactions that underpin common operations in the chemical processing industries (CPI). Prime examples include Raney catalysts for the hydrogenation of liquid fats, fluid catalytic cracking (FCC) catalysts for hydrocarbon processing and three-way catalysts for the in-situ treatment of car exhaust fumes. The extent to which such catalysts enhance reaction rates is directly dependent on the specific surface area they present to the reactants, which for particulate catalysts is a function of particle size. Mass for mass, samples with a finer particle-size distribution present a higher surface area and promote faster reactions.

In many instances, tailoring particle size is an important part of the development and manufacture of heterogeneous catalysts. While finer particles may be advantageous from the point of view of reaction potential, downsides include health and safety issues, poor fluidization properties and a tendency to agglomerate, which inhibits the reaction. Optimizing particle-size distribution is therefore essential.

This article examines the role of both wet and dry laser-diffraction particle-size measurement techniques, highlighting the useful information that can be generated within this context. Strong correlations between Brunauer-Emmett-Teller (BET) physisorption data, which are widely used for catalyst characterization, and surface area values derived from particle-size measurement strengthen the applicability of laser diffraction in this area. However, the application of laser diffraction systems (Figure 1) extends beyond size and surface area measurements. Assessments of the tendency of a material to break up or attrite during fluidized-bed processing, for example, are also among the potential applications.

FIGURE 1. By enabling the close control of dispersion conditions during measurement, a laser diffraction system generates accurate particle-size data and also allows an assessment of the propensity of catalyst particles to undergo attrition

Particle size in catalyst analysis

A catalyst is defined as a material that can be used to alter the rate of a reaction without itself being changed. In heterogeneous catalysis, liquid or gas reactants come into contact with the solid surface of the catalyst, lowering the energy required for a reaction to take place and stimulating increased rates of reaction. Crucial to the success of many industrial processes, the production of effective heterogeneous catalysts relies on closely tailoring a catalyst's physical properties to meet the requirements of specific reaction chemistry. Within

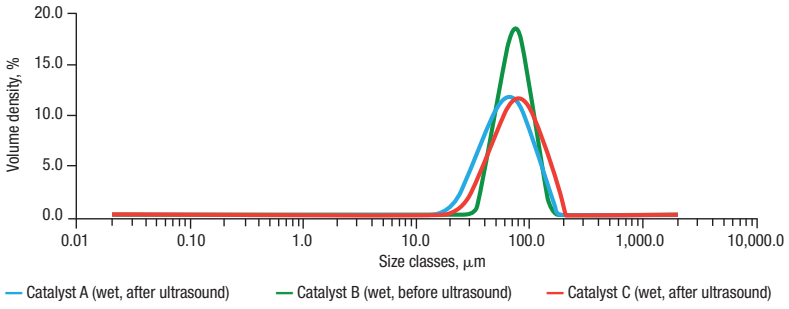

FIGURE 2. Particle-size distributions for FCC catalyst samples A, B and C measured with wet dispersion show sample B to have a much narrower particle-size distribution

this context, particle-size information is recognized as critical to attaining the desired performance.

The fact that a decrease in particle size results in a directly proportional increase in surface area is of great importance in heterogeneous catalyst properties. It is for this reason that the majority of these catalysts exist in powder form, maximizing the material's surface area. However, while reducing particle size is an important strategy for increasing catalyst reactivity, not every effect will be beneficial.

Creating a catalyst with too fine a particle size may lead to significant operational issues. Excessive fines are a common cause of poor fluidization behavior, and tend to increase the risk of contamination or pollution issues, in both gaseous and liquid-phase processes. Any resultant catalyst loss also has economic consequences, since catalyst materials often include expensive metals and can carry significant unit cost. In addition, fine particles may be associated with uncontrolled agglomeration, effectively reducing the material's surface area. Thus, catalyst production is often an exercise in compromise, balancing the need to maximize efficacy with the need to reduce the risk associated with overly fine particle size.

Specific surface area (SSA) is a critical measurement for defining catalyst activity and achieving an optimal particle-size distribution. Traditionally, this has been performed using BET physisorption techniques. However, catalyst specialists are increasingly turning to particle-sizing techniques for fast and efficient assessment. To this end, laser-diffraction particle sizing is finding widespread application for the characterization and development of catalyst powders. Beyond particle-size measurement, this technology has broader applications for optimizing activity through the understanding it provides of the propensity of particles to experience attrition under operational conditions.

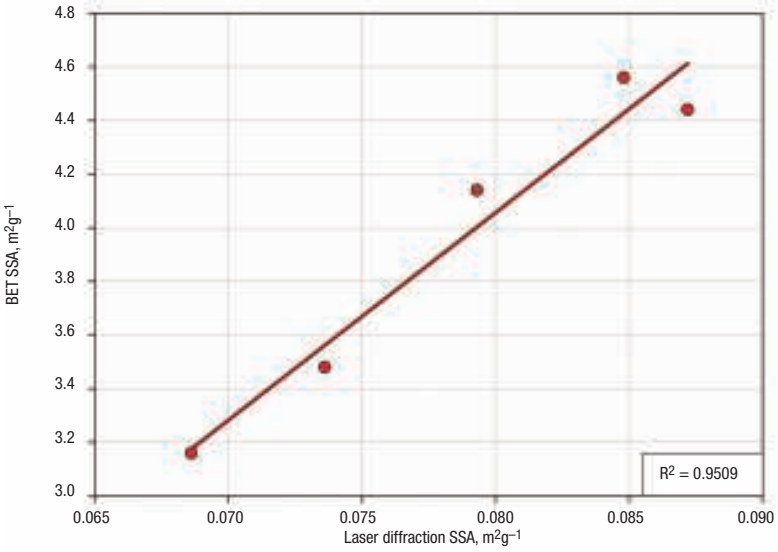

FIGURE 3. A comparison of specific surface area (SSA) derived with Brunauer-Emmett-Teller (BET) data and laser diffraction indicates linearity, confirming laser diffraction as a viable alternative to BET

Wet and dry dispersion

Laser diffraction is an ensemble particle-sizing technique that delivers a particle-size distribution for the entire sample. Particles illuminated by a laser beam scatter light over a range of angles, with large particles generating high scattering intensity at narrow angles. Smaller particles result in a lower-intensity signal at much wider angles. It is therefore possible to calculate the particle-size distribution of a sample from the scattered light pattern through the application of an appropriate model of light behavior, ideally the Mie theory [*1*]. For catalyst applications, the particle-size data that are generated can be used to calculate the SSA distribution for the product.

An important element of laser-diffraction particle-size measurement is to ensure that the sample is dispersed appropriately for the measurement application. This requires taking into consideration the degree to which agglomerates are formed within the sample and whether the measurement data required are for those agglomerates, or, as is more usually the case, for the primary particles in their de-agglomerated state. Applying appropriate dispersion methods ensures that the data generated are truly representative of the powder, within the given application.

Wet dispersion is one technique used to disperse agglomerates within a sample. It involves wetting the powder with a suitable liquid to lower the surface energy between particles. Agitation or ultrasound techniques are then applied to promote agglomerate separation. This technique gently but effectively disperses a sample, and the results provide a baseline for laser diffraction measurements.

The alternative is dry dispersion. This method avoids the use of solvents and wetting agents, making it inherently more environmentally benign and also much faster. Here, dispersion is achieved by entraining particles in a compressed stream, inducing de-agglomeration through

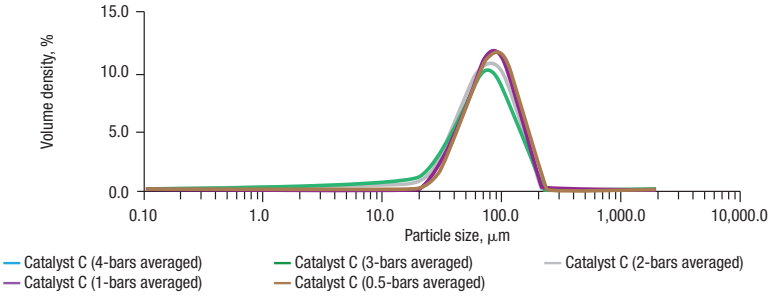

FIGURE 4. Particle-size distribution data for FCC catalyst C measured using dry dispersion laser diffraction at a variety of pressures show that at 1 bar pressure, the particle size corroborates with data derived from wet dispersion for the same powder, indicating complete dispersion

particle-particle collision, particle-wall collisions, or by agglomerate shearing during rapid particle acceleration and deceleration.

As with wet dispersion, the target is to disperse the sample to an application-relevant degree, but no further. However, dry dispersion has the potential to cause destructive particle breakup and attrition if excessive pressure is applied to the sample. This potential is recognized in the recommendation to perform a "pressure-particle size" titration, as part of dry-method development, to identify an operating region over which particle size is constant and closely comparable to results from wet measurements [*2*].

Interestingly, this capability of the dry-dispersion engine within a laser diffraction analyzer to quantify the level of particle breakup over a range of pressures raises the possibility of using a laser diffraction analyzer to assess the risk of attrition and predict the life of a catalyst under operational conditions in a fluidized-bed reactor, for instance. The development of precise dry powder-dispersion systems that offer sensitive and repeatable dispersion control over a range of pressures delivers enhanced performance in this area, thereby increasing the potential value of laser diffraction systems for catalyst producers.

Measuring specific surface area

The particle-size distributions of three different FCC catalysts were measured using wet-dispersion laser diffraction on a commercially available laser diffraction instrument. The dispersion conditions for these samples were optimized following standard wet-method development strategies [*3*].

The results (Figure 2) show how the samples, which all have a median particle size between 60 and 80 µm, differ in terms of their particle-size distributions. While catalyst A and C are relatively similar, catalyst B has a markedly narrower size range. Table 1 shows the SSA of the three FCC catalysts tested, as determined from the laser diffraction data.

These results indicate that the SSA of catalysts A and C are similar, whereas catalyst B has a much smaller SSA. The higher SSA for samples A and C are attributed to the higher levels of fine material present within these products, which are absent from catalyst B.

Figure 3 shows a comparison between the laser diffraction SSA results and analogous data produced using BET techniques. The results show excellent correlation with one another, indicating that laser diffraction can be used in place of BET to predict likely catalytic activity or provide a method for quality-control analysis.

TABLE 1. COMPARISON OF THE SAUTER MEAN DIAMETER (*D*) AND SSA OF FCC CATALYSTS TAKEN WITH WET-DISPERSION LASER DIFFRACTION

Catalyst	*D* [*3, 2*], µm	SSA, m^2/kg
A	40.9	54.4
B	74.8	33.2
C	38.5	57.7

Predicting attrition

Further investigation of the catalyst samples was carried out to demonstrate the ability of the dry dispersion engine of the laser diffraction instrument to quantify the propensity of the catalysts to undergo particle attrition.

Figure 4 shows the results of a pressure titration for FCC catalyst C. At low pressure, the results show large agglomerates, meaning full dispersion has not been achieved. As the pressure is increased, there is a clear decrease in particle size. At 1 bar pressure, the results show excellent corroboration with the wet dispersion data, indicating complete dispersion has been achieved. Above this pressure, any decrease in particle size can therefore be attributed to particle attrition.

An important parameter in particle-size measurement is Dv10, the size below which 10% of the particle population lies on the basis of volume. The variation of Dv10 with increasing dispersion pressure is most

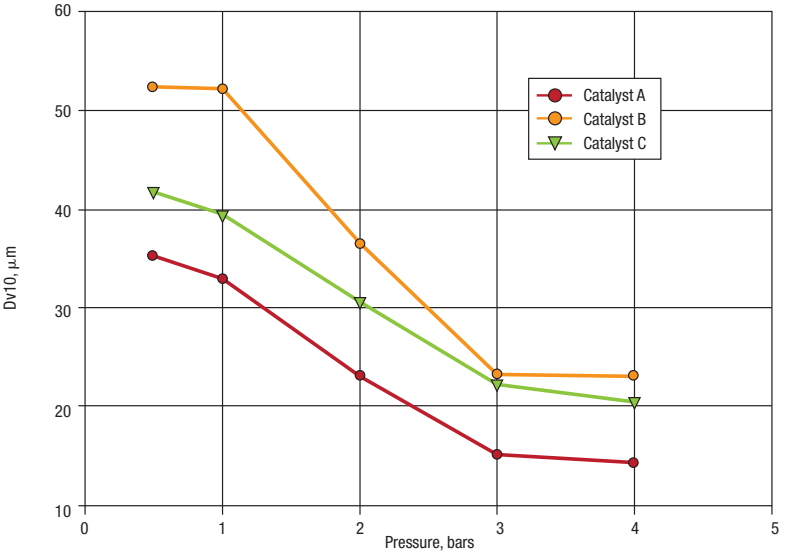

FIGURE 5. Dv10 versus pressure data for catalysts A, B and C show the attrition of particles at increasing pressures

TABLE 2. ATTRITION INDEX (AI) VALUES FOR FCC CATALYSTS CALCULATED FROM DRY DISPERSION DATA	
Catalyst	**AI, µm/bar**
A	–6
B	–8.4
C	–6

critical, as Dv10 is the most sensitive marker of increases in fine particle fraction caused by attrition. Figure 5 shows Dv10 as a function of pressure for each of the FCC catalysts. These data have been used to calculate an attrition index (AI), which compares the Dv10 measurement at low pressure to that measured at high pressure.

Table 2 shows the AI values calculated for each of the FCC catalysts. These results confirm that A and C exhibit similar attrition behavior, suggesting that they would be likely to have a similar lifetime within a fluidized bed. Catalyst B, on the other hand, displays a more negative AI, suggesting that is more prone to attrition and is likely to have a shorter lifetime than A or C.

Final remarks

These results demonstrate that while calculating specific surface area, laser diffraction analyzers with sufficiently sensitive dry-dispersion engines also offer a valuable opportunity to quantify relative attrition rate, providing useful information for assessing the likely performance of a catalyst within a fluidized bed.

Understanding particle size and specific surface area is crucial to optimizing catalyst activity and efficacy, a necessity that is increasingly being supported by laser diffraction technology. Additionally, the ability to easily monitor the reduction of particle size caused by dry dispersion under different conditions has led to the application of this technique to assess particle attrition to simulate catalyst behavior under operating conditions. In combination, these two capabilities make modern laser diffraction systems a valuable proposition for heterogeneous catalyst characterization as the presented data demonstrate. ■

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In this role, he is responsible for customer support, including training, provision of application notes and other materials, such as peer-reviewed papers. He has more than 30 years of experience in various aspects of particle-sizing technology, and has spent many years working on the ISO TC24/SC4 (Particle Characterization) committee, which has been responsible for standards dealing with laser diffraction and dynamic light scattering. He also led a small international group that developed the international standard for small-angle X-ray scattering (ISO 17867:2015). Rawle is currently co-chair of E 56.02, the characterization subcommittee of the ASTM E 56 Committee on Nanotechnology. In 2014, he was awarded an ASTM Distinguished Service plaque for exemplary leadership. He is also a Fellow of The Royal Society of Chemistry and holds a Ph.D. in supported metal catalysis.

Optimizing Flare Operation Through Proper Design

Flare problems are often caused by the seal systems that are designed to control air ingress. Follow these troubleshooting guidelines to improve design and ensure safe, reliable flare operation

Hyunjin Yoon
SK Energy

Flares are used to dispose of unwanted hydrocarbon gases. One common definition of a flare's primary function is "to convert flammable, toxic or corrosive vapors to less objectionable compounds" (API 521, Paragraph 6.4.1) [*1*]. During operation, if the flow of offgas to the flare stack stops for some reason, there is a possibility of air ingress into the flare system. This can result in a potentially explosive mixture of air and hydrocarbons in the flare system, which can be catastrophic. To reduce this risk, many elevated flares are purged continuously with a proper amount of offgas in order to protect them against the possibility of flame flashback and explosion that could result from unwanted air ingress.

Seal systems

In most flare systems, either a molecular seal (also called a buoyancy seal), or a velocity seal, is used at the base of the flare tip, to ensure a minimum continuous flow of purge gas (Figure 1). This helps to avoid air ingress to the flare, preventing the opportunity for a potentially explosive mixture to develop in the system.

Molecular seal systems rely on the difference in densities between the purge gas and ambient air to prevent the air from entering the flare system. The most common seal is an inverted can device that causes the gas that normally flows in an upward direction to be directed through a 180-deg turn at the exit flow. When this happens, gases lighter than air will tend to collect in the upper bend of the apparatus, sealing off the stack against any backflow of air. Meanwhile, heavier gases will tend to settle in the lower part of the bend, with the same effect. Molecular seals normally require a purge rate of 0.003 m/s to be effective.

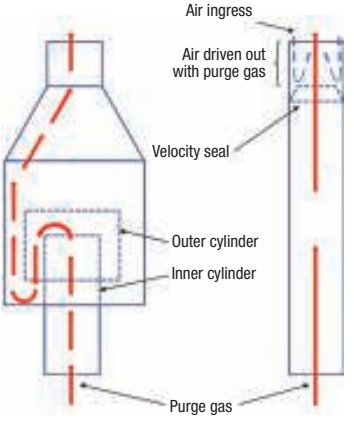


FIGURE 1. Shown here is a diagram of a molecular seal (left) and a velocity seal (right) installed in a flare stack. The molecular seal drum uses several concentric baffled cylinders to direct the exit gas and prevent air ingress. By comparison, the velocity seal is a cone-shaped obstruction (orifice) that is placed inside the flare tip, to prevent the infiltrating air from hugging the inner wall. Velocity seals require a purge rate about 2–4 times higher than that of a molecular seal

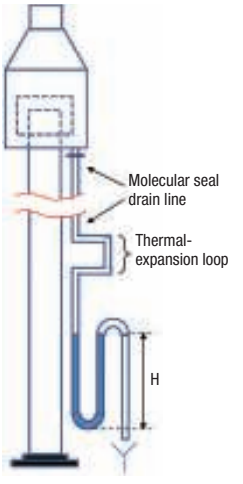
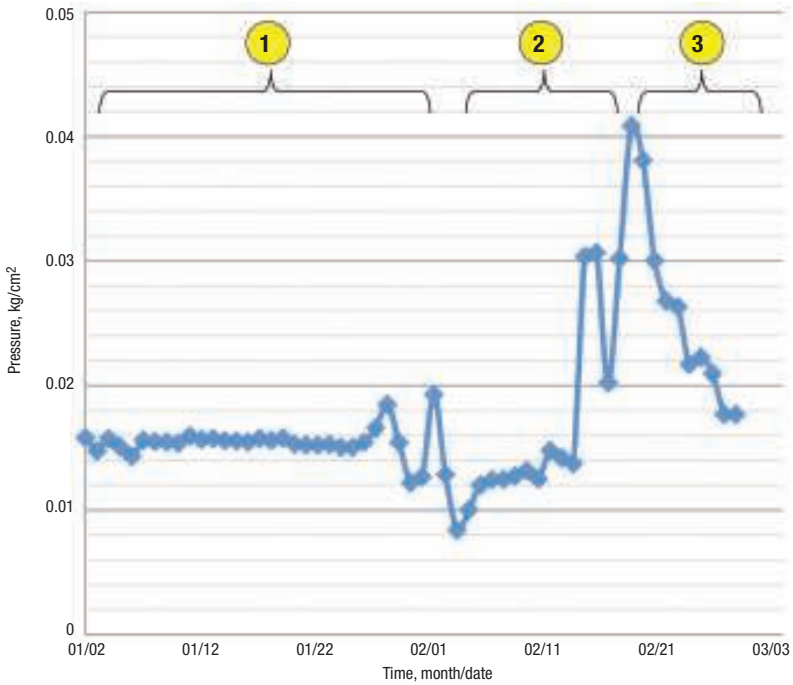


FIGURE 2. If the molecular seal drain line is not properly designed or maintained, air can enter the flare stack, causing internal combustion. If the drain line becomes frozen and does not allow the offgas to pass through, a dangerous situation can arise, leading to numerous problems in the flare and associated chemical process unit operations. As per API Standard 521 Annex D, Figure D.1, the seal height (H) should be designed for a minimum of 175% of the maximum operating pressure

By comparison, velocity seals present a reduced diameter (such as an orifice), or a series of conical baffles, in the lower part of the flare tip, to prevent the infiltration of air. These purge-reduction devices are easily installed inside of the flare tip. The flow of purge gas (offgas) coming through the cone or baffles sweeps away the infiltrating air. This type of seal typically requires a purge rate of between 0.006 m/s and 0.012 m/s.

With rising energy costs, the ability to reduce the volume of purge gas required is a high priority for many operations — as long as the safety concerns of air ingress in the flare system are not compromised. Taking this into account, it is likely that molecular seals are preferred, as they require a lower minimum required purge gas flow compared to velocity seals.

In recent years, there have been many advances in molecular seal systems (in terms of both the molecular seal drum and the drain line; see Figure 2), such as drastic reductions in the purge gas requirements, and greater reliability against severe atmospheric conditions. However, one remaining drawback of using a mo-



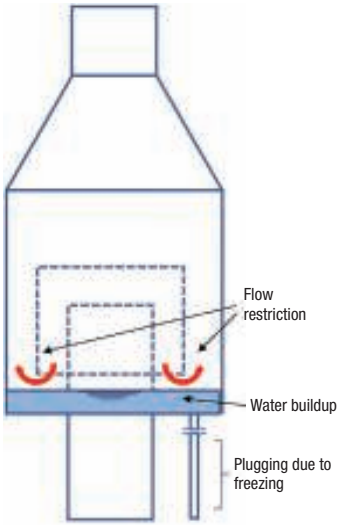


FIGURE 3. The graph (above left) shows the pressure profile of a flare header (which remained fairly static at first, but then rose suddenly). The figure (above right) shows the water buildup in the flare molecular seal. As the graph indicates, water was building up in the molecular seal drain line during the month of January (the portion of the graph labeled 1). An abrupt increase in the flare header pressure during the middle of February (graph segment 2) indicated the presence of plugging due to freezing. By March, the pressure had returned to normal, once the ice had been cleared (graph segment 3)

lecular seal is the possibility of plugging in the bottom of the seal drum, due to either icing of the drain line or debris falling from the castable refractory in the flare tip (or both). During normal operation, particular attention should be paid to preventing the blockage or icing of the seal drain line — because once plugging occurs, it is too late to take proper countermeasures.

The flare system is the last front line of defense for most chemical process plants. When it is not functioning properly, a malfunctioning flare system can cause the shutdown of the entire facility. One of the worst scenarios a petroleum refinery or process engineer may experience is a complete flare-system shutdown.

During the design process, it is crucial to understand that it will be very difficult to add equipment, or modify and repair flare components, once the system is in operation, because flares are very infrequently out of service. And because they typically serve many process units, the unscheduled shutdown of a flare system for modification or repair will likely impact all related units.

Pressure buildup in the flare header, due to problems in the molecular seal system, may lead to blockage of offgas, and this may result in the release of unburned toxic gases, which can lead to the loss of property as well as the potential for injury to personnel. The safety and effectiveness of the flare system is dependent upon the performance of the molecular seal system, which must remain free from any blockage along the offgas route, and reliably prevent air ingress to the flare system.

Many flares run for long periods of time without being shut down, so the operators tend to forget important steps in the sequence. From our experience, it is interesting to recognize that most of the incidents result from a lack of operator awareness or from the fact that the facility is unattended, rather than the direct result of complex technological matters. Especially for the flare, it is very hard to detect symptoms of problems during operation, but sometimes it is too late to recover once severe problems occur.

Compared with primary design aspects of the flares themselves, such as the overall flaring efficiency, proper operation of pilots, and ability to meet emissions limits, the molecular systems that are used to prevent air ingress often receive very little attention from operators, and thus their inherent importance is often overlooked. If problems associated with molecular seal systems are not detected in a timely fashion, they can lead to total process unit shutdown.

Table 1 provides troubleshooting recommendations to help operators with early detection of problems in a molecular seal system at the earliest stage. For instance, by monitoring both the amount and the color of water at the bottom of the molecular seal drain line, operators can detect

TABLE 1. MONITORING WATER AT THE BOTTOM OF THE MOLECULAR-SEAL DRAIN LINE

Water at the bottom of molecular seal drain	Amount	Water (resulting from condensed steam) should be freely drained through the drain line; even small amounts can create ice buildup and plug the drain line. To verify whether the drain line is plugged or not, nitrogen can be connected at the bottom of the drain line. If the line is clear, then the nitrogen will reach the open end. If the line is plugged, then the nitrogen will stay within the closed loop
	Color	Black means soot is generated due to incomplete combustion at the molecular seal drum (indicating the presence of air in the system)

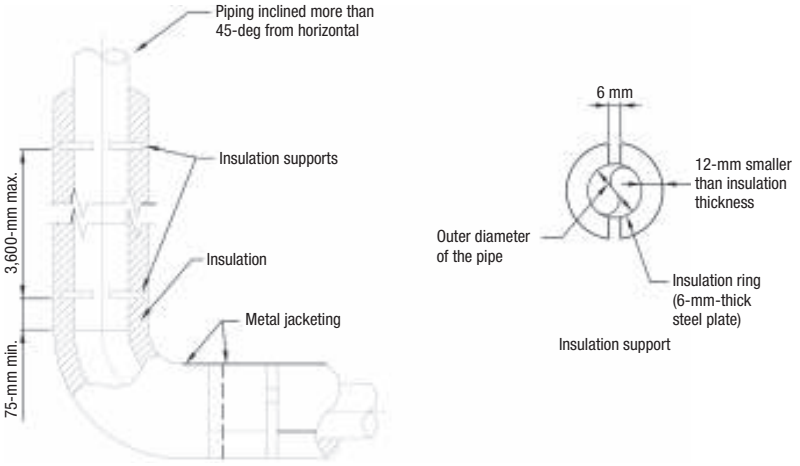


FIGURE 4. Shown here are recommended specifications for installing insulation to the molecular seal drain line. On vertical or inclined lines (more than 45 deg from horizontal), an insulation support should be provided at the bottom and every 3.6 m, where straight runs exceeds 3.6 m

FIGURE 5. The castable refractory shown here is partially heat damaged and has become loose at the inside of the flare tip (top). The excessive build-up of refractory debris and unburned coke amounted to about half of the height of the 24-in.-dia. manhole (bottom)

the earliest signs of critical failures and take action to prevent the emergency shutdown of the entire plant.

Case history examples

To help reduce the risks of fatal or unwanted shutdowns of the whole plant, this article presents three cases in which the molecular seal system failed, and provides recommendations to increase the overall integrity of the molecular seal system design in order to increase reliability, operability and the run length for the flares. It is important to learn lessons from prior failures that have been thoroughly investigated. Each of the following case history examples is characterized by the failure mode in the molecular seal system.

1. Freezing of the molecular seal drain line. In this case, freezing of the molecular drain line caused a pressure increase on the flare header, and it was beginning to approach the design limit. All of the process units that feed offgas to the flare had to prepare for potential shutdown (since none would be allowed to operate without proper waste gas disposal). When analyzing the pressure data on the header, it was found that the pressure had been relatively static for nearly a month and a half, although a slight upward trend was barely noticeable until it suddenly increased sharply (Figure 3).

The abrupt spike shows that there was no gradual increase; rather, the drain line was plugged. If the pressure had been rising slowly and continuously then steps could have been taken to shut down all related process units feeding the flare.

We had two options — one was to prepare an unscheduled plant shutdown, and the other was to clear the pressure buildup problem over the course of one week while the system was still operating. However, over the course of the week, the pressure could have exceeded the design limit. Unfortunately, many operators typically have no experience dealing with drain-line plugging resulting from icing.

The molecular seal drain is provided to drain water that is created during operation by steam condensation. Drain line plugging becomes apparent when the drain valve is open and no water flows at all. When operators fully understand the proper function of the molecular seal system, they will respond immediately to a pressure buildup in the header by checking the drain water to discover or rule out a blockage from ice formation. But in this case, no one at the facility had a clear understanding about the plugging of the molecular seal drain line, once the header pressure began increasing.

During the cold winter season, condensation will occur at both the center steam-injecion point and the upper steam-injection point at the flare tip. The center steam helps lift the flame and the upper steam enables smokeless flaring.

Small parts of the center steam will condense when the shell of the flare tip is cool enough and the atmospheric temperature falls. The condensate drips down along the inside shell of the flare tip and accumulates at the bottom of the molecular seal drum. If there is no proper drainage, then this condensed water can build up, freeze and eventually block the offgas route.

Upon making a close inspection all along the drain line through the stack height, there was one area (around a 1-m span out along the drain line) where the insulation had slipped away near the bottom of the thermal-expansion loop. The steam tracing was still operating, but because the insulation had slipped on a portion of it, the bare piping was still prone to icing during cold winter days (freezing temperatures of –10°C were common).

In order to melt the ice buildup, the low-pressure steam was serviced through the drain line bottom connection. However, we had to spend more than two days clearing the plugged piping while the flare was still operating. Due to the limited access near the flare tip during operation, the damaged insulation could not be repaired during this effort, so we had to rely on intermittent service of steam to periodically remove the ice buildup throughout the win-

FIGURE 6. The new design of the drain cap with legs (based on bird-cage wire mesh) prevents direct plugging due to refractory or unburned coke debris

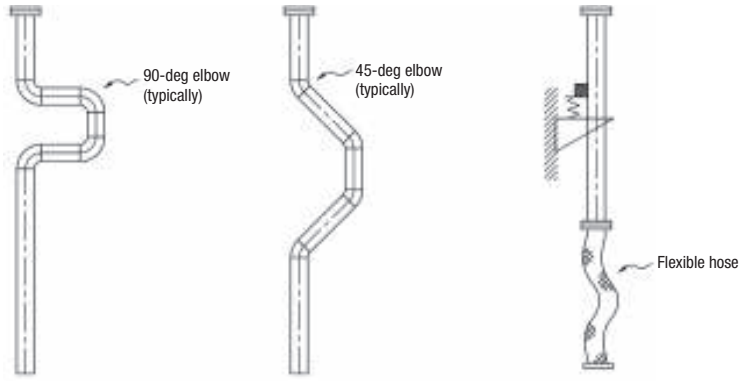


FIGURE 7. To reduce the likelihood of ice and debris formation, any thermal-expansion loop that has a 90-deg elbow, such as that shown in (a), should be modified into either a 45-deg elbow type (b), or a newer design that uses a straight line with spring support at the top and flexible hose at the bottom of the drain line (c). The 90-deg loop has additional disadvantages, in terms of potential sagging at the horizontal piping, which results in plugging of the pipe

ter season. We had to wait to repair the insulation during a scheduled turnaround, and had to spend more than $0.8 million for scaffolding work all along the 120-m stack height to access the right point.

Considering the importance of the molecular seal drain line, it is important to prepare and maintain vertical piping insulation carefully. Figure 4 shows recommended specifications for proper insulation installation.

2. Plugging of molecular seal drum drain-inlet nozzle. During the turnaround, we found excessive buildup of castable refractory debris and soot at the bottom of the molecular seal drum (Figure 5). Fortunately, the buildup only created a partial blockage where a chunk of debris was about half as tall as the height of the waste gas route. If the turnaround had been started at some time later than the scheduled one, we could have had a severe problem in terms of pressure buildup at the flare header.

A close inspection of the debris showed that the majority was fragmented refractory pieces (an estimated 80%), and soot, iron, FeS and other materials.

The castable refractory material used during the construction of flare tips must be resistant to high temperature and thermal shock. Flare tips normally experience rapid changes in temperature. Flare tips with internal refractory should also be well anchored, such as the sturdy, stainless steel hexa-mesh type. Also, it is recommended that the refractory castable material should include stainless steel needles, to help hold it in place.

Even when these requirements are met, it is crucial to understand the consequences of a refractory failure, which will cause refractory debris to collect at the bottom of the molecular seal drum, blocking passageways.

Whenever the refractory particles or debris fall inside the molecular seal drum, it increases the risk of plugging of the seal drain and may obstruct the flow of the offgas.

To prevent the plugging of molecular seal drain lines by falling castable refractory, a plugging-protection device, such as a cap with legs, should be installed at the top of the drain hole (Figure 6). Also, during operation, the drain line should be routinely checked for plugging. One way to do this is to attach a temporary nitrogen or low-pressure steam hose to the drain line to make sure the drain line is free from refractory debris plugging.

Many newer flare designs no longer use castable refractory. However, when the refractory-lined flare tip is inevitable (for instance, in older flare designs), then the size of the drain line should be increased by 4 in. or more, to reduce the risk of plugging and provide easier access for cleaning.

3. Cracks at the weld joint of the molecular seal drain line. Upon making a turnaround inspection of the flare tip, we discovered significant soot buildup inside of the flare tip. Most of the buildup was soft soot but some hard coke buildup was also strongly adhered to the inside of the flare tip shell. We presume that the soot comes from internal incomplete burning, while the hard coke is produced by the high-temperature internal burning. In order to find the root cause for this internal burning, operating data for the purge gas rate and the center steam rate were evaluated. However, there were no noticeable discrepancies in the operating data compared with the design condition — they were all within the design specifications

We also focused on the possibility of air ingress, which makes the flare gas burn incompletely inside the flare tip. If there were corrosion holes at the bottom of the molecular seal drum due to condensing toxic liquids, or if there were small openings at the molecular seal drain line, then atmospheric air would continuously enter the flare system during operation. With this assumption in mind, we finally discovered a relatively large gap (5-mm width with a length of more than 2/3 of the 3-in. pipe circumferential welds) between the weld joint of 3-in. molecular-seal drain nozzle and the molecular-seal drum bottom plate.

Note that the 3-in. drain line at the bottom plate is a relatively small nozzle connection, so any excessive external force on the nozzle could lead to damage to the nozzle or even damage to the molecular seal drum itself. To avoid this, the allowable movement and loads at the nozzle should be designed to be zero (or as close to zero as

possible; most of the movement and loads will be absorbed at the thermal-expansion loop). However, the gap was likely initiated due to some excessive external force (for instance, an external bending moment) from the molecular seal drain line. A close review of the maintenance history revealed that there had been a modification of the drain line — the original thermal-expansion loop was removed because of frequent plugging. Taking everything into account, we concluded that the root cause of the crack was excessive stress due to the removal of the thermal-expansion loops.

Since this gap had allowed for continuous air ingress to the molecular seal drum, that helped to explain the longterm internal burning that had led to coke buildup during operation. Because there had been frequent plugging due to refractory debris and ice buildup, a decision was made to remove the 90-deg elbow-type thermal-expansion loop, which is the critical point of debris collection and also critical for water collection.

FIGURE 8. The ability to eliminate air ingress through proper engineering design and ongoing maintenance and troubleshooting is an important factor in optimizing the reliability and safety of flare systems

A new thermal-expansion loop must be provided. To help reduce the risk of plugging or icing, and any such debris must be cleared as soon as it is detected, regardless of the complicated design requirements. If the drain line is straight all along the flare stack, then it can be easy for maintenance personnel to clean the pipe, even if the line is plugged or frozen. But we must consider the thermal-expansion of the drain line, which is steam-traced and insulated.

It is generally agreed today that, to improve the reliability of a flare system, special considerations are required, in addition to the installation of an insulation ring with a sloped thermal-expansion loop (rather than a potentially troublesome 90-deg elbow) on the molecular-seal drain line. One way to solve this problem is to design the thermal-expansion loop with a 45-deg elbow instead of 90-deg elbow, to reduce the oppor-

HOT PRODUCTS

Gemco Valve with Double Actuators

Pictured is a 20 inch/500 mm Gemco Valve designed to maintain vacuum on a Thin Film Evaporator (TFE) processing Glycerin/Biodiesel. It is part of a Double Dump/Airlock arrangement that allows waste salts to be discharged while maintaining vacuum inside the TFE.

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tunity for any debris or water collection at the low point (Figure 7).

Another way to reduce the piping stress is to consider the use of a spring hanger (which helps to reduce or eliminate the external force from the piping) near the drain nozzle. The straight drain line is resisted by the spring hanger at the top of the drain nozzle of the molecular seal drum, and the drain line at the bottom is connected with flexible hose, which can absorb some thermal expansion and also can make it easier to carry out steam blowing or cleaning.

Molecular seal drums are commonly made of low-carbon steel, therefore, the bottom and wall are subjected to corrosion due to the formation of condensate with corrosion particles from the off-gas. In this regard, the molecular seal drum often requires preventive repairs, as well as periodic checks of wall thickness, and removal of condensate and refractory debris from the bottom.

In order to improve the strength of the molecular seal drum, an ellipsoidal-type bottom head can be considered instead of the conventional flat-plate type. This design provides improved strength of the weld joint, as well as less plugging due to the configuration of the ellipsoidal head.

Although most flares (Figure 8) actually operate at a pressure less than 15 psig, it is not usually necessary to consider the molecular seal drum as a pressure vessel. Typically for this design, the rules of the ASME Boiler and Pressure Vessel code [*5*] can be applied, and can be used as means to ensure fabrication quality.

In order to improve operating safety, protect personnel and the environment, and avoid costly shutdowns, it is critical to design, operate and maintain molecular seal systems properly. The failure cases discussed here provide useful insight for improving the design in order to reduce losses and prevent shutdowns and flare outages. ■

Edited by Suzanne Shelley

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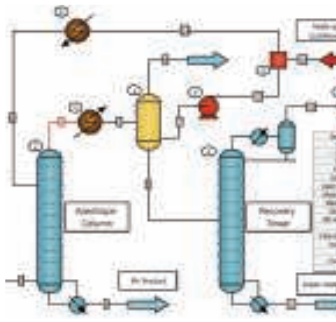



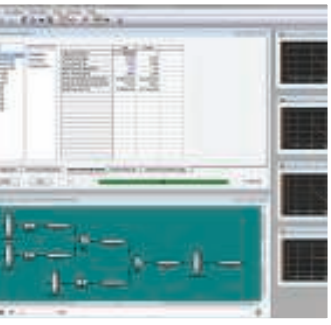









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A large selection of interfaces enables easy integration into production lines. The removable manual control element and the optional sniffer probe with LEDs make the work easier. Measured data can be recorded on an SD card. Wireless remote control enables operation from a distance of up to 100 m. Thanks to the robust design and minimal maintenance required, service costs are also reduced.

Extensive accessories, including those for the company's ASM and HLT series of leak detectors, allow the ASM 340 to be adapted to specific applications. A special transport cart also enables mobile use.

www.pfeiffer-vacuum.com
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Versatile: the ASM 340 leak detector

How to work with subcooling melts

Sandvik can make pastilles even from difficult products

Some melts remain liquid even when cooled below their melting points. The reason these "subcooling melts" refuse to crystallize is a lack of nuclei. **Sandvik Process Systems** has developed a supercooling process to solidify these difficult subcooling melts by producing a homogeneous suspension of crystal nuclei.

The process uses a scraped-surface heat exchanger, called a precrystallizer, with a cold cylindrical surface and a heated rotor. This enables the melt to be crystallized on the steel belt in a very short time, yielding product forms such as pastilles, micropastilles and flakes. Sandvik has designed, supplied and installed more than 100 of these Rotoform supercooling plants as turnkey systems.

The Rotoform $4G_{SC}$ has a heated cylindrical stator supplied with liquid product. A perforated shell rotates around the stator, depositing drops across the width of the steel belt. Baffles and nozzles built into the stator ensure a uniform pressure and hence a uniform drop size across the belt. The circumferential speed of the Rotoform is synchronized with the speed of the belt, so drops are deposited without deformation. Heat released during solidification and cooling is transferred by the stainless steel belt to cooling water sprayed underneath. This water is collected in tanks and returned to the water-chilling system; at no stage does it come into contact with the product.

Rubber chemicals, shown here, are an example of subcooling melts

The resulting free-flowing, uniform pastilles are easy to handle, bag and transport, with low dust levels. Typical applications for the Sandvik supercooling process are agrochemicals, photochemicals, plastic additives, rubber chemicals, stabilizers, pesticides, herbicides, and flame retardants.

www.processsystems.sandvik.com

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An air ejector / KLRC liquid ring vacuum pump system from Tuthill

While blower technology may have objective standards and blower packages can be more basic in design, vacuum can be more difficult to understand and requires a more customized approach to design. Tuthill serves a diverse base of customers with custom solutions, and certainly plenty of chemical processing facilities are included. Because of the variety of processes, Tuthill's Systems Engineering Group adapts standard product to meet customer needs. Custom engineered system solutions to 12,000 CFM are available with a combination of vacuum boosters/air ejectors and roughing pumps for any vacuum application with custom testing available. Tuthill can also design engineered blower packages with flow ranges to 9000 CFM with testing, certification and non-destructive examination of materials available.

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Tuthill Vacuum & Blower Systems, manufacturer of KINNEY vacuum pumps and M-D Pneumatics blowers and vacuum boosters, is a leader in the design and manufacture of high-performance, reliable positive displacement blowers, mechanical vacuum pumps, vacuum boosters and engineered systems ready to install and run. Since 1969, Tuthill Vacuum & Blower Systems has been manufacturing at its main facility located in Springfield, Missouri.

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New multi-shaft mixer for viscous applications

Ross introduces a new VersaMix multi-agitator system featuring a two-wing anchor, a gate agitator and a high-speed disperser

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VersaMix Multi-Shaft Mixers are offered from 1-gal laboratory models to 4,000-gal production models. Designed for gentle but thorough blending, the low-speed anchor agitator may be supplied with helical flights for improved top-to-bottom mixing. Hinged Teflon scrapers arranged in a staggered pattern on the anchor further optimize material and heat transfer. Like the anchor, the gate agitator also promotes bulk flow through horizontal cross bars designed to move material in the forward direction and vertical bars which induce backward flow. The high-speed shaft can include two or more adjustable disperser blade attachments to ensure rapid powder wet-out and accommodate varying batch sizes.

Some popular applications of the Ross VersaMix include sauces and syrups, beverages, liquid supplements, creams and lotions, gels, toothpaste, pharmaceutical suspensions, ointments, specialty coatings, printing inks, hot-melt adhesives, formulated epoxies, urethanes, rubber solutions, plastisols, caulking compounds, greases and lubricants, electronic pastes, and cleaning solutions. **www.mixers.com**

Pictured is a Model VMC-1000 with a working capacity of 1,000 gal. A hydraulic lift raises/lowers the agitator assembly into the vessel. The mixer also rotates 90 degrees and can be raised/lowered from that position for cleaning and servicing. This customizable product line is built for atmospheric or vacuum/pressure operation, with options for a jacketed vessel, powder loading chute, sight ports, automated discharge valves, tank lights, thermoprobes, temperature control unit, vacuum pump, discharge system, PLC recipe controls and many other features.

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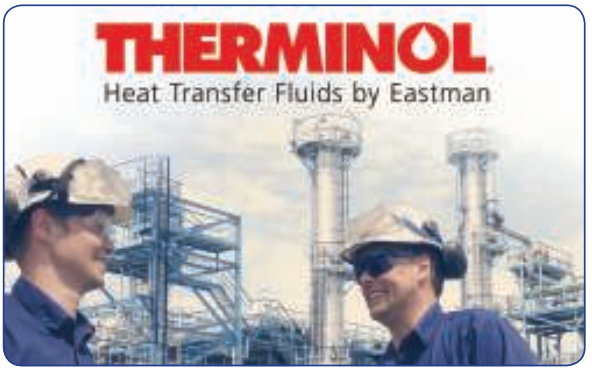

Therminol heat transfer fluids are commonly used in offshore and onshore oil and gas processing, fractionation, refining, transportation, and recycling operations. Therminol 55, Therminol 59, Therminol 62, Therminol 66 and Therminol VP1 have successfully demonstrated low-cost, reliable, and safe performance in these applications for five decades.

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- NFPA 87, Recommended Practice for Fluid Heaters
- Global Asset Protection Services, GAP.7.1.5
- FM Global Datasheet 7–99 on Heat Transfer by Organic and Synthetic Fluids: "2.5.4.1 Test samples of the heat transfer fluid for impurities and/or degradation at least yearly."

Eastman provides heat transfer fluid testing and analysis to help detect fluid contamination, thermal degradation, moisture, and other issues that can help avoid corrosion, heat transfer decreases, start-up issues, blockages, fouling, freezing, pump cavitation, fire, and other performance issues.

Eastman provides complimentary Therminol fluid sample collection kits. Each kit includes a collection bottle, instructions on safe sampling, and shipping documents to return the sample to one of Eastman's in-house ISO-certified laboratories on four continents. There, expert lab technicians analyze each sample for key quality indicators, and send back a detailed report with suggestions for corrective action, if needed. The Eastman technical team will also answer any questions that may arise. **www.therminol.com**

A choice of solutions for pressure regulation

Cashco has launched three new devices for the control of gas pressure

Cashco ULR-1

The new ULR-1 ("Un-Loading Regulator") valve from **Cashco** is more than an enhanced product. It also brings clarification and new information, says Clint Rogers, General Manager of Cashco's Valve Division.

The ULR-1 was originally marketed as the U1 by Kaye MacDonald, which Cashco bought in 1999. Unfortunately, the only documentation for the U1 and similar products was the original schematics, which showed how the tubing and fittings were to be installed, Rogers says.

"Previously, a customer would have had to locate the technical bulletin, work their way through its product coder and then a separate product coder for the correct bill of materials for the hookup," Rogers explains. "Not any more. With these new products, all of the information is in the technical bulletin and the operating manual."

As Rogers explains, the ULR-1 is a DA4 regulator with a Cashco CA1 back-pressure valve mounted onto it. Using the inlet pressure from the valve, the CA1 is set to control the outlet pressure of the main valve. Because the outlet of the CA1 constantly exhausts into the atmosphere, the media through the valve must be environmentally safe gas such as oxygen or nitrogen.

For even more choice in pressure regulation, Cashco has also introduced the SLR-1 and SLR-2 Self-Loading Regulators. The SLR-1 is a high-performance, pressure-loaded, pressure-reducing regulator with a self-contained regulator mounted onto it. Inlet pressure from the main valve is diverted to the pilot, which, in turn, reduces the loading pressure to the cover dome in order to maintain the set point of the main valve. The pressure inside the dome is static, so gas is only released to atmosphere when the outlet pressure setting is reduced or the system is shut down.

Cashco SLR-1 (left) and SLR-2 (right)

The new SLR-2 self-loading regulator is similar to the SLR-1, but its loading valve is not self-relieving. Instead, the cover dome bleeds through a filter and check valve back into the outlet of the main valve. This feature allows the SLR-2 to be marketed for hydrogen gas, natural gas and sour gas (NACE) applications.

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Diamond Refractory Services differentiates itself through certification, quality, and expertise, and is known especially for its rapid-response service

For Houston-based **Diamond Refractory Services**, one measure of the company's success is the percentage of business that engages the organization on multiple projects. For the last 15 years, Diamond has enjoyed a customer retention rate of 85%, showing how seriously it takes client needs.

Diamond is known for providing a critical service to the petrochemical industry: rapid deployment in response to emergency refinery shutdowns. Some of the biggest names in refining and processing regularly rely on Diamond to provide repair, revamp, and construction services for FCCUs, sulfur units, acids plants, furnaces, and heaters.

Within a highly competitive industry, Diamond has risen to the top by boasting a safety record that includes zero recordable injuries for three consecutive years.

Comprising refractory specialists, alloy welders, nozzlemen, safety professionals, skilled laborers, forklift drivers, and other dedicated employees, Diamond vaunts an entire management team that is API 936-certified.

Since 1989, API's Individual Certification Programs have provided the petroleum and petrochemical industries with an independent and unbiased way to evaluate the knowledge and experience of technical and inspection personnel.

Earning API 936 certification has significantly bolstered Diamond's service offering. The certification virtually guarantees they will provide educated, specialized management to each site, and that they have established a minimum standard of knowledge and skill for their personnel. Similarly, being certified means Diamond provides a higher level of management control over quality inspection practices, while simultaneously maintaining a high level of safety and performance, and reducing the potential for downtime due to equipment failure.

Also qualified for rapid arc welding, Diamond's team is well versed in this fast, reliable, and accurate method of welding refractory anchors.

Diamond's team of refractory specialists have completed 98 FCCU turnarounds to

A Diamond Refractory specialist works on the flue gas inlet of an FCCU

date, and have accumulated an astounding 1.68 million labor hours worked. With over 200 years of combined refractory experience, Diamond Refractory's management team is uniquely positioned to lead the company and tackle the industry's most difficult refractory challenges.

www.emcorgroup.com

Turn your phone into a portable water monitor

Combining portability, power and ease of use, pen-type measuring instruments from Myron L Company connect wirelessly to Apple devices

Myron L Company has released three UltraPen PTBTx Bluetooth-enabled Pocket Testers for use with Apple iOS 7 and iOS 8 mobile devices. These instruments are accurate, fast and simple to use in diverse water quality applications, the firm says. Features include automatic temperature compensation; highly stable microprocessor-based circuitry; user-intuitive design; and rugged, waterproof housing.

The PTBT1 measures conductivity, total dissolved solids, salinity, and temperature. Users may select from three solution types that model the characteristics of the most common types of water. The PTBT2 measures pH and temperature with 1-, 2-, and 3-point calibration options. The PTBT3 instrument measures ORP and temperature.

The PTBTx Pocket Testers replace the standard LCD display typical of most pen-type meters with large, easy-to-read characters via a free app that takes full advantage of the Apple iOS graphical user interface (GUI). Communication with the Apple device is via low-energy Bluetooth (BLE). Wireless

iOS devices provide large, clear displays for PTBTx portable water monitors

operation makes it easy to move quickly from sample to sample, and allows the mobile device to be held safely away from the liquid samples being measured.

Each PTBTx can be given a unique user-programmable name, making it easily identifiable no matter what mobile device it is used with. Locations can be programmed into the app, either selected automatically via the Apple device's built-in GPS, or set manually for sampling sites that are too close together to be reliably distinguished via GPS.

Each measurement can be saved to the mobile device's memory. Saved records include measurement data, sensor settings, temperature, location, and the name of the PTBTx device used.

Records can be exported via the mobile device's e-mail function in various file formats: CSV, MS Excel, or Myron L Company's proprietary .mlc encrypted format.

Stored measurements are easily sorted, filtered, e-mailed, or deleted without affecting other records stored in the device's memory.

The PTBTx combine accurate measurement capabilities with the up-to-date GUI and computing power of a mobile device to provide a powerful tool for both field and laboratory applications. **www.myronl.com**

Process simulation gets debottlenecked

Chemstations releases CHEMCAD Version 7.0, an extension of chemical engineers' thought processes

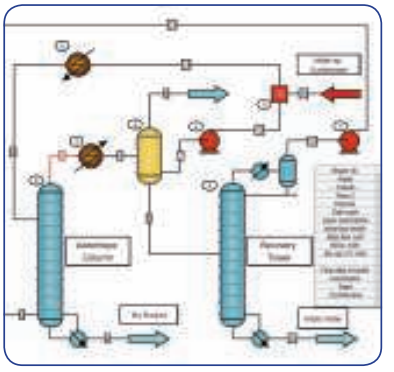
It's 2015, so why would an engineer choose to make calculations on the back of an envelope or in a spreadsheet when they have the power of simulation software on their desktop? The answer often is that the overhead of setting up "simple" problems in software is too great.

"If users don't use the software for every applicable chemical engineering challenge, we know it's become an underutilized asset, and there is an inefficiency in the overall workflow of an organization," says Steve Brown, Chief Operating Officer at **Chemstations**. "Engineers should not feel there is a barrier to using rigorous calculation tools, regardless of the size of problem being solved, and yet we see it every day."

For over 25 years, Chemstations has been meticulous in collecting and refining user feedback regarding process simulation software usage. Users have given direct commentary about "likes" and "dislikes"; Chemstations' staff has conducted interviews to learn about users' workflow; and Chemstations engineers have built tens of thousands of flowsheets to determine best practices. The result is CHEMCAD version 7.0, which represents the next step in the evolution of graphical user interface design. Its ultimate goal is to fit seamlessly into the chemical engineering computing environment and workflow.

Users have often stated that there is a significant difference between solving engineering problems and being an expert in building flowsheets in simulation software, and they view maintaining proficiency in their software tools as an expensive requirement. CHEMCAD has always had a reputation for intuitiveness, and version 7.0 continues this tradition.

"We set out to break that barrier to using simulation software for any problem size and for any stage of process work. Our users have had this incredibly powerful tool at their disposal, and now it's easier than ever to apply whenever an engineering question or challenge comes up," says Aaron Herrick, Manager of Development at Chemstations. "There is a direct analogy to the way our users work when they improve their chemical processes. From making commonly used functions more obvious to reducing the number of mouse-clicks, version 7.0 was a ground-up rethink of the interface." **www.chemstations.com**



"CHEMCAD has always had a reputation for intuitiveness"

Turnkey systems for efficient solidification

Pastillation specialist SBS and steel belt expert Berndorf Band work together to provide dust-free handling of wide range of products

SBS Steel Belt Systems Srl is an Italian company, founded in 1984, which produces steel belt machinery and turnkey plants for a wide range of industries: chemical, petrochemical, food, rubber and Powder Coatings.

SBS is a partner of the multinational **Berndorf Band Group**, whose headquarters are in Austria. SBS itself is located in Venegono Inferiore (Varese), a small town close to Milan's Malpensa airport.

Leaders in pastillation for sulfur and other products: SBS and Berndorf Band

SBS Steel Belt Systems Srl and its partner SBS Steel Belt Systems Inc. (USA) have pioneered the development of pastillating units for a wide range of products.

In recent years SBS Group has moved into sulfur solidification technology, providing several oil refineries and gas fields with turnkey solutions complete with:

- liquid sulfur pumps and piping;
- water cooling systems;
- sulfur solidification units equipped with continuous Berndorf steel belts;
- solid sulfur belt collectors and silos;
- bagging equipment and truck loaders.

The SBS pastillation head, known as ACCUDROP, has recently been upgraded through the use of a very effective rotating outer shell. With its high pipe wall thickness and innovative drilling pattern, ACCUDROP now has the ability to produce pastilles with a diameter of around 4 mm, better spherical shape, and higher mechanical strength.

These characteristics help to reduce a well-known problem in the pastillation industry: dust. Caused by abrasion during handing (for instance in packing, unpacking, loading, and unloading), dust formation is influenced by the properties of the product. Small, smooth and strong pastilles produce only a negligible amount of dust, thus resulting in an eco-friendly product.

The combination of an ACCUDROP pastillation head and a Berndorf steel belt provides an efficient and secure process. Excellent flatness of the belt and regular service from both SBS Steel Belt Systems Group and Berndorf Band ensure long operating life and lower maintenance costs.

In recent years SBS Group has collaborated with some of the largest engineering and construction companies to supply refineries in southern Italy, Spain, Serbia, Turkey, Russia, Indonesia, Saudi Arabia, Qatar, Jordan and many other countries all over the world. **www.berndorf-band.at**
www.steelbeltsystems.com
Booth 511 at the Chem Show

A breakthrough in antioxidant protection for hot oil

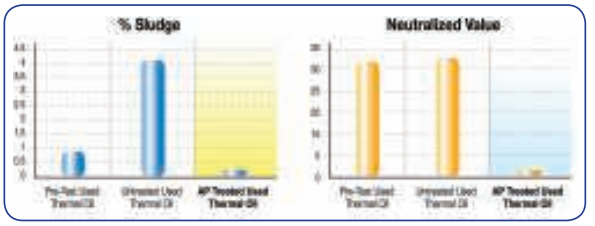
Heat-transfer specialist Paratherm has launched a new additive that it says rejuvenates oxidized hot oil by halting the formation of damaging sludge

Jim Oetinger

Usually, a new product from **Paratherm** is a heat transfer fluid, or sometimes a liquid for cleaning out deposits of sludge and carbon that form inside the system when the fluid deteriorates. The company's latest product for hot oil systems doesn't fit either of those categories, however. Paratherm AP (Antioxidant Protection) is instead designed to be added to operating hot-oil systems to extend the oil's useful life.

"Acids are the cause of the most common hot-oil system problem: sludge" says Jim Oetinger, technical director for Paratherm (photo, above). "When expansion tanks are installed and operated properly, the oil stays cool and acid formation is very slow. However some expansion tanks aren't installed properly. Sometimes the expansion line is insulated or is less than 4 ft. long. Warm-up valves are left open or sunlight hits a tank that is painted a dark color. These can cause the tank to run hot enough to form acids when the oil reacts with oxygen. And once the acid number reaches 0.3–0.4, carbon starts to form."

Incorporating a sacrificial antioxidant, Paratherm AP prevents the acids from converting to sludge. Paratherm AP is not a permanent cure – sacrificial additives become depleted over time and eventually the protection stops. So antioxidants don't eliminate the need for preventive maintenance, they just reduce or delay the need for oil change-out.



In accelerated oxidation testing, 10% Paratherm AP added to used thermal oil stops sludge generation in its tracks.

Periodic testing is the only truly accurate way to tell whether the additive is still present. "In 20+ years of analyzing samples and advising customers I've seen more problems from oxidation than from overheating or any other single issue," says Oetinger.

Before this product came on the market, the only alternative to an elevated acid number was to change out the fluid, entirely or in part. But Paratherm recognizes that change-out isn't always convenient, or even possible, in certain processing situations. In particular, seasonal operations like asphalt production have no time for downtime when the paving push is on.

Paratherm AP is now available in 55-gal. drums. For smaller systems, 5-gal. pails may also be introduced. **www.paratherm.com**

Total solution for emissions

Scrubber packages from Bionomic Industries are flexible yet cost-effective

Bionomic Industries, Inc., a leading manufacturer of air pollution abatement, product and heat recovery technologies, has launched its new ScrubPac custom skid-mounted scrubber.

According to the company, ScrubPac is the only packaged system available that is engineered to meet the exact demands of each customer's application, yet still cost-effective. Recirculation pumps, piping and valve networks, exchangers, instrumentation, controls, and other essential items are all included.

Systems are available for batch, continuous, semi-automatic and fully-automatic operation, along with pretreatment equipment, a choice of instrumentation and control options, special spill containment skids, and modularized assemblies for large systems in hard-to-fit spaces. Factory-assembled and tested, the systems require only process and utility connections. They are available for gas flows from 100 acfm through 150,000 acfm.

www.bionomicind.com

Dryer simplifies scale-up

A new lab-size dryer from Wyssmont Co. eases the design of full-scale plant

Wyssmont Co. is exhibiting its test model H-10 TURBO-DRYER at the 2015 PBE Southeast Powder Show, Atlanta, Ga., October 6–8. Test results from this unit are directly scalable to larger capacities. The dryer is designed for easy cleaning between products and is used to dry water-wet or solvent-wet materials with solvent recovery and without the need for vacuum.

The benefits of the full-size TURBO-DRYER models include the ability to dry to extremely low moisture, gentle handling for fragile materials with negligible particle breakage and very low dust carryover, automatic operation, unparalleled product uniformity, and low horsepower and heat requirements.

The TURBO-DRYER principle is based on a stack of slowly rotating circular trays; wet material enters at the top and falls to the tray below after one revolution. Diameters of production-scale dryers range up to 35 ft. **www.wyssmont.com**

Booth 502 at the 2015 Southeast Powder Show

Fundamentals of blast-resistant building design

Ali Sari, Ph.D., PE, Structural Analysis Manager with Genesis Oil and Gas Consultants, explains the basics of designing blast-resistant buildings for petrochemical facilities

When we design a blast-resistant building, we start with a framework similar to that of the human rib cage. You can appreciate the strength of this natural construct if you have ever seen slow-motion video of a boxer taking a punch to the side of the body. His ribs compress in a way that dissipates the energy of the punch over a large surface area, protecting the vital organs inside. The same is true of the steel stiffeners we place at intervals of 11–12 in. in the frame of a **RedGuard** blast-resistant building. When we weld steel walls around these "ribs" we have a structure more redundant and reliable than a traditional building. The interior walls are often made from oriented strand board, which minimizes the likelihood of wall shrapnel breaking free and injuring personnel.

We equip every blast-resistant building with battery-powered emergency lights, smoke detectors and a fire extinguisher. Broken glass is a huge danger in a blast, so we use tamper-proof fluorescent light fixtures. They have hard plastic diffuser housings with shielded fluorescent tubes inside. If a tube breaks, the glass is safely contained inside these two protective layers.

Electrical and communication wiring conduits are deliberately left exposed so any damage incurred in a blast will be visible, and personnel will know not to turn power on until it's repaired.

Various engineers performed analysis on our design, trying to predict how it would behave in a blast. Some said it would slide significantly or roll across the ground. My analysis indicated that it would not do so, but with all our analysis and real-world observation, we were not really sure what would happen until we tested it.

We detonated 1,250 lb of high-explosive ANFO charge at a standoff distance of 110 ft from the building, which created a blast load far in excess of the ratings required to meet ASCE medium response standards. The building suffered no structural damage. It did not roll, and slid less than an inch. The furnishings, equipment and test dummy inside also sustained no damage. **redguard.com**

Plain exterior conceals careful design within: A proven blast-resistant building from RedGuard

Fluoroether lubricant aids safe chlorine handling

Krytox performance lubricants supplied by Miller-Stephenson Chemical Co. helped a major chlorine supplier improve the safety of its rail transportation by replacing PTFE tape

Transferring chlorine and other reactive materials from manufacturing sites to railcars and tankers relies on systems to ensure safe handling – and in this respect a major North American chlorine supplier faced a challenge.

The company was using PTFE tape to seal pipe threads on the "stabber" pipes used to transfer chlorine from its plant to railcars. Analysis of some of the railcar breakaway couplings revealed PTFE tape residues that could compromise the operational safety of the internal valves, potentially resulting in a chlorine release. This resulted in the company issuing a safety mandate requiring implementation of an alternative solution that would meet the critical criteria for this procedure.

After evaluating several products, the company qualified and implemented Krytox Thread Sealant grease supplied by **Miller-Stephenson Chemical Co.** to replace the PTFE tape. To date, the Krytox product has performed 100% leak-free on all railcar stabbers. Key benefits include:

Unlike PTFE tape, Krytox lubricants create no risk of valve leaks due to residues

- cost-effective – only a small amount of sealant needed per application;
- fast and easy to apply, even while wearing protective gloves;
- unlike PTFE tape, which should be removed before reapplication, Krytox Thread Sealant can be reapplied over existing Krytox grease;
- allows for easy disassembly and reassembly due to its lubricating nature;
- Krytox TS3 sealant is non-reactive, non-toxic, non-flammable, non-corrosive and compatible with most seal, O-ring and valve polymers;
- no auto-ignition at temperatures up to 482°C (900°F) in oxygen;
- industry-approved: the Chlorine Institute (Pamphlet 164) rates Krytox lubricants a "1" on its safety scale;
- tested to 400 psig with air on 1-in. NPT Schedule 80 pipe (SA-1068) and 1-in. NPT CL 3000 fittings.

Founded in 1955, Miller-Stephenson supplies solvents, lubricants, release agents, coatings, and epoxies for a wide range of industrial applications.

www.miller-stephenson.com

Handle virtually any bulk solid material

Flexicon stand-alone equipment and automated plant-wide systems convey, discharge, condition, fill, dump and weigh batch bulk materials dust-free

Flexicon engineers and manufactures a broad range of equipment that handles virtually any bulk material, from large pellets to sub-micron powders, including free-flowing and non-free-flowing products that pack, cake, plug, smear, fluidize, or separate.

Individual bulk handling equipment includes: flexible screw conveyors, tubular cable conveyors, pneumatic conveying systems, bulk bag dischargers, bulk bag conditioners, bulk bag fillers, bag dump stations, drum/box/container dumpers, and weigh batching/blending systems. Each of these product groups encompasses a broad range of models that can be custom engineered for specialized applications, and integrated with new or existing upstream and downstream processes and storage vessels.

All equipment is available to food, dairy, pharmaceutical and industrial standards.

For large-scale bulk handling projects, Flexicon's separate Project Engineering Division provides dedicated Project Managers and engineering teams on four continents to handle projects from concept to completion. Working with each customer's preferred engineering firm or directly with their in-house team, Flexicon adheres strictly to the customer's unique standards, documentation requirements and timelines through a single point of contact, eliminating the risk of coordinating multiple suppliers.

Flexicon's worldwide testing facilities simulate full-size customer equipment and systems, verify performance prior to fabrication, demonstrate newly constructed equipment for visiting customers, and study the performance of new designs.

Flexicon offers stand-alone bulk handling equipment as well as plant-wide systems integrated with new or existing processes

In 2015 the company doubled the size of its manufacturing facility and world headquarters in Bethlehem, PA, and also operates manufacturing facilities in Kent, United Kingdom; QLD, Australia; and Port Elizabeth, South Africa. **www.flexicon.com**

Pilot plant pump solutions

Valveless ceramic pumps from Fluid Metering are accurate and durable

Pilot plants generate vital information to be used in the design of full-scale process and production facilities. Not only do pilot plants reduce the financial risk associated with building larger facilities, but they also test process feasibility and accommodate process refinement.

Valveless, ceramic pumps from **Fluid Metering, Inc.** have proven to be ideal for pilot plant fluid control. The sapphire-hard internal components of Fluid Metering pumps eliminate accuracy drift typical of pumping systems that rely on elastomers (flexible tubing and diaphragms) to move fluid through the pump. Fluid Metering pumps' unique valveless rotating and reciprocation piston design also eliminates the need for check valves, which can clog, leak or fail over time. The result is a valveless, ceramic metering pump, which will maintain drift-free accuracy better than 1% for millions of cycles.

In addition, pilot plant operations require the ability to easily change process parameters including flowrate. Fluid Metering pumps easily accommodate that requirement as flowrates can be controlled either mechanically and/or electronically via standard industrial control protocols. Fluid Metering pumps have been used in pilot plant operations for over 55 years. **www.fmipump.com**

Radar for measuring level

The new Centurion Guided Radar from Hawk Measurement works with liquids and solids

Hawk Measurement Systems has added the Centurion Guided Radar (CGR) to its portfolio of level measurement equipment. Based on time domain reflectometry (TDR), the HAWK CGR has been developed to operate in some of the most demanding environments.

The CGR has been designed to digitize a threshold that eliminates extraneous reflections and noise, and allows the blanking area to be reduced to 50 mm. HAWK is known for high-accuracy level products in difficult applications using minimum power. HAWK's CGR was designed for easy installation and calibration, with an automatic setup routine which can be performed in wet or dry environments. The start-up menu is clear, with only a few steps to follow.

The HAWK CGR is able to provide precise and continuous measurement with extremely low-dielectric (1.5) materials. Since radar pulses are directed via a guide, factors like surface turbulence, foams, pressure, dust, vacuum, vapors, temperature, dielectric constant, and tank obstructions do not influence the measurement. The CGR offers auto-calibration to any dielectric constant ≥1.5, adjustable sensitivity and simple setup. **www.hawkmeasure.com**

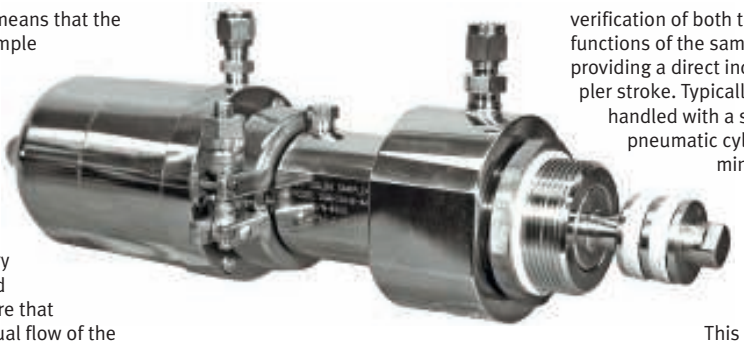
Samplers provide complete chemical solutions

The Sentry ISOLOK SAA automatic sampler ensures accurate, representative sampling of liquids – and can be customized for any application

Representative sampling means that the characteristics of one sample are the same of that of the entire batch – and the sampling methods used must be consistent, accurate and repeatable, points out **Sentry Equipment Corp.** Chemical engineers face the challenge of meet-ing stringent regu-latory requirements using validated methods, so they must ensure that each sample reflects the actual flow of the sample stream. Those seeking complete confidence in their analysis of hazardous materials know that the chain begins with a reliable, representative sample.

For example, Sentry customer requirements might include:

- double validation for each sample;
- direct indication of each sample completion, so as to fully validate the composite sample volume related to effluent flow;
- ATEX zone 2 design; and
- special alloy construction for highly corrosive materials.



The Sentry ISOLOK SAA automatic sampler is suitable for hazardous environments

To meet the application needs of specific customer, Sentry Equipment Corp. can customize the construction of its ISOLOK SAA automatic fixed volume sampler.

For one customer, for example, double validation of the sample stroke called for verification of both the extend and retract functions of the sampling process, thus providing a direct indication of each sampler stroke. Typically, this easily could be handled with a standard aluminum pneumatic cylinder. However, aluminum produces a highly exothermic reaction with iron oxide, so it is not allowed in any ATEX hazardous environment where rust is likely to be present. This particular ISOLOK SAA sampler therefore was custom designed using a 316 stainless steel actuating cylinder with embedded magnetics, along with external ATEX-approved proximity switches mounted on the cylinder, designed and built to stay within compact cylinder space tolerances.

The Sentry ISOLOK SAA automatic sampler can be designed to meet any liquid chemical sampling application, anywhere, the supplier says. **www.sentry-equip.com**

Blowdown simulation: Safe, but at what cost?

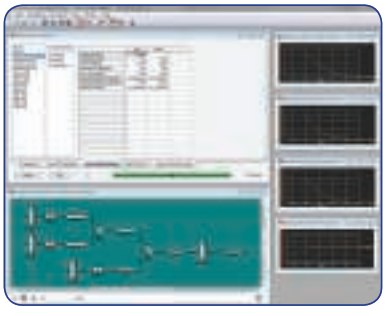
Avoiding low-temperature embrittlement when depressuring equipment may involve expensive over-design, says Honeywell, whose new design tool promises better accuracy

Depressuring process equipment in response to fires, leaks, pipe ruptures or other hazards, as well as for planned shutdowns, is critical to safe operation, notes **Honeywell**. Accurate design of blowdown systems is therefore essential. Blowdown system design focuses on two main areas:

- **sizing** of components such as relief valves, orifices, piping and vessels to allow safe and rapid depressuring; and
- **selection** of construction materials for pipes and vessel walls, which have to withstand very low temperatures resulting from auto-refrigeration effects during rapid depressurization – further complicated by uneven temperature distribution and consequent differential expansion and contraction in pipe and vessel walls.

The second consideration requires system designers to consider the risk of brittle failure in process equipment and piping.

Process simulation tools meet these requirements to a certain extent, enabling users to predict minimum temperatures and relief loads, and select appropriate materials and component sizes. However, this approach is typically inefficient, because most models remain relatively inaccurate, lacking sophistication to model the temperature changes and loads accurately. To allow for this, designs are often overly conservative to ensure safety. Since the materials selected for resistance to very low temperatures are expensive, this over-design is costly.



The UniSim Design Blowdown Utility increases accuracy and cuts over-design

The new Blowdown Utility in Honeywell's UniSim Design Suite addresses this problem. Adopting a modeling approach consistent with the API 521 6th edition guidelines for the fire method, it improves accuracy through features including: calculations representing the non-equilibrium conditions that occur in a vessel during depressuring; flowsheeting capabilities for blowdown network design; blowdown scheduling to allow phased depressurization; and a two-dimensional (axial and radial) heat transfer model for highly accurate calculation of the temperature profile for vessel and pipe walls. The new tool has been rigorously tested and extensively validated.

Providing far more accurate models, this solution enables engineers to design safer blowdown systems and at the same time to avoid costly over-design. The UniSim Design Blowdown Utility is also the first tool in the market that gives the engineer the ability to accurately model the blowdown of a flowsheet with blowdown scheduling.

www.hwll.co/UniSim

Perfecting particle size for agricultural chemicals

The Micronizer jet mill from Sturtevant boosts reactivity by grinding particulate materials to sub-micron sizes – without the heat buildup that can harm sensitive products

The **Sturtevant** Micronizer brand jet mill reduces the particle size of pesticides, herbicides, fungicides, insecticides and other dry chemicals to narrow particle size distributions of 0.25 µm or larger without heat buildup.

The Micronizer employs high-pressure compressed air, steam or other gas to disperse and deagglomerate the particles. It consistently produces low micron sized particles, whose far greater surface area compared to larger particles increases their chemical reactivity.

The Micronizer brand jet mill utilizes a unique fluid energy grinding system to generate particle-on-particle impact without raising the product temperature. Its high-performance design surpasses the economical fineness limit of mechanical grinders.

The Micronizer's open manifold design allows complete access to the internal material grinding chamber and compressed air chamber for easy cleaning, product changeover or inspection. There are no dead zones to trap material, no moving parts, and no grinding media or lubrication to contaminate the material being milled.

Sturtevant can solve the most challenging wear and contamination problems using interchangeable wear-resistant liners such as Pureline, ShieldOx and ArmorLine, and specially engineered coatings like Lubriguard, to provide contamination-free wear protection and enhance the performance of agricultural chemicals.

Sturtevant offers a fully equipped test facility for conducting customer trials with the objective of determining the optimum equipment and system layout for each application. Sturtevant invites customers to witness testing while determining the best way to achieve fine particle sizes and understand grinding characteristics.

www.sturtevantinc.com

The Sturtevant Micronizer jet mill (right) yields particle sizes down to 0.25 µm. Its use of fluid energy allows it to out-perform mechanical grinding systems without creating undesirable temperature rise.

Remove the bottleneck from water treatment

Using long-lasting walnut shells to trap dirt and oil, the STiR backwashable filter from Filtra-Systems replaces poorly performing sand filters in multiple applications

Filtra-Systems' STiR walnut shell media filter has been selected to replace failing sand and multimedia filters across a variety of industries. In each case the original sand filter reached a point where it was backwashing so frequently the user could not get reliable performance.

The STiR walnut shell media filter has an innovative, patented, backwash design that overcomes the limitations of sand, multimedia, and disposable media filters. 100% of the media bed is cleaned at every backwash, allowing the unit to recover the captured contaminant load cycle after cycle, without increasing the time spent in backwashing or the number of cycles.

A patented backwash system stops the STiR media from clogging

Sand filters fail because their backwash is inefficient and incomplete, Filtra-Systems says. Portions of the media bed begin to plug, forming "mudballs" that are not fluidized or mixed by the backwash. This results in less filtration area and increasingly frequent backwash cycles. At a certain point, the filter needs to be drained and the media replaced – on some plants as often as once a year. Besides being time-consuming, sand replacement introduces maintenance personnel to airborne sand, an OSHA hazard.

The walnut shell media used by Filtra-Systems has a 30-year lifespan, so it never needs to be replaced. This sustainable technology is a proven solution that has been used to remove both oil and suspended solids for over 50 years. The walnut shells have a very high modulus of elasticity, so they do not degrade easily. The STiR proprietary backwash system uses the lowest possible volume of backwash water (1–2% of daily throughput), minimizing the total volume of water to be processed.

Before (l) and after (r) water samples

The STiR filter is offered in many different sizes, with single units available that can process 50 gpm (3,600 BPD) to 7,300 gpm (250,000 BPD). It has a high removal efficiency, typically removing 95–98% of suspended solids and 90–95% of free oils. Filtra-Systems has been serving the industrial water market for over 30 years. Whether the water filtration application is in specialty chemical, mining, metal working or metal finishing, or well injection, the STiR industrial water filter will provide the removal efficiency and reliable backwash needed for successful water processing.

www.filtrasystems.com

Switch designs promote longer pump life

Flow, level, and pressure switches from Plast-O-Matic signal backup protection in chemical piping systems

In the battle between media and piping systems, effective instrumentation and signal switches have been difficult to find. Metal components not only corrode, but also shed particulates into ultrapure chemicals.

Without timely signaling of unexpected conditions, pumps can quickly be damaged beyond repair. Deadheading, running dry, or running without proper pressure can all have drastic consequences on pump life – with consequences including downtime, spills, fines, and other unexpected costs.

Plast-O-Matic Valves, Inc., a U.S. manufacturer of corrosion-resistant and high-purity valves, recognized the need for switch instruments with no wetted metal parts that would provide similar operation and enhanced reliability. After successful testing and introduction of an all-thermoplastic pressure switch ten years ago, the company has developed a series of switches to protect piping systems and pumps from potentially catastrophic problems.

Flow switches are installed directly in the downstream pipeline to signal low flow, which can indicate a deadheaded pump. The advantage of a flow switch versus a pressure switch in this application is that a piping system is often fully pressurized in a low- or no-flow condition. Used with a relay, a flow switch can be used to switch off the pump and/or signal an alarm.

In larger systems or where redundancy is required, Plast-O-Matic has developed an external inductive limit switch to signal an unplanned manual valve closure. For example, an operator in a remote location may not be aware that a maintenance worker has inadvertently closed the wrong valve. The inductive limit switch may also be used with a timer relay to shut off a pump after a predetermined period.

On the other side of the pump, level switches are used in supply tanks to sound the alarm or signal corrective action before the tank is empty. Due to the complete isolation of all metal parts, the Plast-O-Matic level switch can be fully submerged in virtually any aggressive liquid compatible with either PVC or Noryl PPO. A unique pivot-pin motion enables the level switch to resist particle build-up, making it also suitable for liquids that are prone to crystallization.

www.plastomatic.com

Corrosion-resistant switches protect pumps in chemical piping systems

Show Preview

This year, the Chem Show — an event encompassing all sectors of the chemical process industries (CPI) — celebrates its 100th anniversary. The 2015 Chem Show, taking place November 17–19 at the Jacob Javits Convention Center in New York City, will include an exhibition and various seminars focused on all types of process technologies used in the CPI. The event will also include the announcement of the 2015 Kirkpatrick Chemical Engineering Achievement Award recipient, a biennial award bestowed by *Chemical Engineering* to honor the most noteworthy CPI technologies that have been recently commercialized. This show preview highlights some of the equipment and services that will be showcased at the 2015 Chem Show.

A screen filter with an automatic self-cleaning mechanism

The Model ORG automatic self-cleaning screen filter (photo) removes suspended solids from process water, cooling water, condensate or water for pump seals. The ORG has a large screen area and connection flange area for high filtering capacity. This filter model uses minimal water during the self-cleaning cycle. It traps organic and inorganic suspended solids and then cleans the debris off the screen element automatically with a very low pressure drop. Booth 619 — *Orival Inc., Englewood, N.J.*
www.orival.com

Use this vacuum dryer for heat- and shear-sensitive media

Rototherm D (photo) is a new continuous, indirect vacuum dryer for free-flowing solids, designed to handle materials that are sensitive to heat or shear. The dryer's shell and rotor are both heated for a high surface-area-to-volume ratio. Dynamic baffles create plug-flow continuous conveying through the unit. Continuous operation produces consistent results, and with indirect heating, the unit uses much less energy than direct dryers, such as fluidized-bed and convection dryers, according to the company. Booth 704 — *Artisan Industries, Inc., Stoughton, Mass.*
www.artisanind.com

A portable contamination-free mixer for plastic totes

This company's ITM Tote Mixer is a portable high-performance mixer for plastic totes, and is specifically engineered for portability, ease of use and power conservation. It has a powerful motor and rugged, collapsible impellers, and is quick-coupling and gear-reduced for high-torque mixing. The mixer completely encloses the tote and achieves product uniformity quickly. The device can be used easily by a single operator and eliminates product contamination, says the company. Booth 727 — *Dynamix Agitators, Inc., Richmond, B.C., Canada*
www.dynamixinc.com

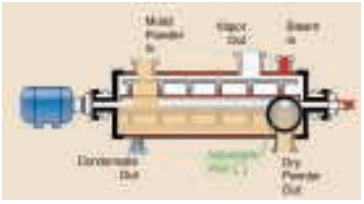
Monitor sensors, logic solvers and final elements

The DeltaV SIS process-safety system, which can be standalone or integrated with control systems, helps to reliably protect assets and improve process availability. The DeltaV SIS system continuously monitors the ability of sensors, logic solvers and final elements to perform on demand, diagnosing faults before they cause spurious trips. DeltaV SIS provides built-in functionality, eliminating complex custom programming, and enables a consistent approach throughout all safety applications. Designed to allow easy compliance with the IEC61511 international standard, DeltaV SIS can lower the upfront costs of engineering, installing and commissioning. Booth 305 — *Emerson Process Management, Austin, Tex.*
www.emersonprocess.com

Inverting-filter centrifuges with automated cleaning

This company's inverting-filter centrifuges (photo) are capable of separation and filtration of liquids, and feature pressure-assisted filtration and thin-cake technology. Fully contained, there is no residual heel and very low moisture levels. Certifiable cleaning of the inverting-filter centrifuge is effectively carried out in a closed-condition, fully automated clean-in-place (CIP) cleaning system. Product changeover is quickly and easily completed. The centrifuges are easy to install, says the company, requiring a simple

Orival


Artisan Industries


Heinkel Drying and Separation Group

Aalborg Instruments

Enardo

Bronkhorst USA

Fluke

Hawk Measurement Systems

"through-the-wall" procedure. Booth 104 — *Heinkel Drying and Separation Group – USA, Swedesboro, N.J.*
www.heinkelusa.com

This digital mass flowmeter is suitable for use with bioreactors

The ZFM digital mass flowmeter (photo) provides programmable flow measurements of gases, as well as instantaneous and elapsed-time data recordings for bioreactors and surface depositions. The device can monitor input-output of nitrogen, carbon dioxide and other gases in systems, and features a carbon dioxide reactor, chemical-microcell environmental monitoring, surface deposition monitoring and multi-gas and multi-range functionality. The ZFM also offers two programmable totalizers, Modbus network interface, automatic sensor zeroing, self-diagnostics and software for configuration and calibration. Primary calibrations of multiple gases are included with this meter. Booth 231 — *Aalborg Instruments, Orangeburg, N.Y.*
www.aalborg.com

Pressure-vaccum vents for inline or end-of-line installation

This company's family of high-performance, pressure-vacuum vents (photo) are used to control the pressure in low-pressure storage tanks, and are designed with special sealing technology that addresses regulatory codes that limit emissions. The product line includes an inline model (the ES-800) and an end-of-line model (the ES-900). S-800 inline vent valves maintain pressure in the storage tank. This valve is installed directly into the vent-line exhaust. The ES-900 vent valve, installed directly on the end of the vent-line exhaust, has both pressure- and vacuum-relief capability. Booth 709 — *Enardo, Tulsa, Okla.*
www.enardo.com

These process chillers have high-power cooling capacity

This company's process chiller is designed for reliability during continuous temperature control, and features onboard diagnostics that to help predict chiller health, touchscreen interface and communications via various protocols for remote chiller control. The chiller also has –80°C, high-power cooling capacity and high reliability for continuous heat removal. Booth 555 — *Thermonics Corp., Mansfield, Mass.*
www.thermonics-chillers.com

Versatile flow devices with a very large control range

Mini Cori-Flow devices, such as the ML120/M1x model (photo), are suitable for numerous applications within chemical processing, industrial and laboratory environments as an alternative to traditional filling and dosing methods. Features of Mini Cori-Flow instruments include: measure and control for almost every fluid without recalibration; mass flowmeter and controller range of 0.05 g/h to 600 kg/h; a low-flow Coriolis instrument (down to 0.05 g/h); accuracy as high as 0.2% of reading; and direct-control capabilities for pumps or valves. Booth 109 — *Bronkhorst USA, Inc., Bethlehem, Pa.*
www.bronkhorstusa.com

This infrared camera helps diagnose problems in equipment

The TiX560 infrared camera (photo) is used to detect temperature differences and unusual thermal patterns, which may indicate abnormalities in electrical and mechanical equipment. Inspecting hard-to-reach targets becomes simplified with the TiX560's full 180-deg rotating lens and the large 5.7-in. LCD touchscreen with on-camera analytics. Image-enhancement features include ultra-high resolution and continuous blending. Picture-in-picture functionality allows for the overlay of a thermal image onto the equipment itself. Booth 610 — *Fluke Corp., Everett, Wash.*
www.fluke.com

Level measurements for multiphase systems

CGR guided-wave radar devices (photo) are used to measure levels of liquids, gases and powders with emphasis on single-level and two- and three-phase measurement capabilities for liquids. The devices offer high-temperature measurements (up to 250°C), HART communications with additional single 4–20-mA output,

explosion-proof classifications and intrinsically safe two-wire operation. CGR models are designed to measure difficult applications with multiphase level requirements. Booth 812 — *Hawk Measurement Systems, Lawrence, Mass.*
www.hawkmeasure.com

A top-mount valve positioner compatible with any system

The Research Control SRD991 valve positioner (photo) mounts directly to the top of a control valve with a rugged linear potentiometer, avoiding hysteresis between the positioner and actuator. With integrated network communications, including HART, Profibus-PA and Foundation Fieldbus H1, the SRD991 valve positioner is compatible with any system's distributed control system (DCS) or process logic controller (PLC), according to the company. Booth 405 — *Badger Meter, Inc., Milwaukee, Wis.*
www.badgermeter.com

An ultrasonic homogenizer for many applications

The UIP2000hdT digital ultrasonic homogenizer features 2 kW of ultrasound power for batch and inline processing, and automatic data recording of power, amplitude, sonication time, temperature and pressure for many applications, including homogenization, mixing, dispersing, wet-milling, emulsification, lysis, cell disintegration, extraction and sonochemical applications (such as phase-transfer catalysis, emulsion chemistry, synthesis and nanochemistry). The homogenizer features continuous operation, an industrial-grade, colored touchscreen display and browser remote control, with no software installation required. Booth 628 — *Hielscher USA, Inc., Ringwood, N.J.*
www.hielscher.com

These graphite gasket sheets are reinforced with stainless steel

The new Graflit IQ graphite gasket sheet is constructed from a graphite-based material, and is suitable for high-temperature applications. Graflit IQ is a specially engineered, high-quality sheet made of expanded natural graphite foil and reinforced by an expanded stainless-steel (316L) insert with anti-stick functionality. This heavy-duty material has improved surface-load resistance (in particular for cycling operations) and blow-out resistance, according to the company. A variety of standard sheet dimensions are available, with customizations available on request. Booth 115 — *Donit Tesni, d.o.o., Medvode, Slovenia*
www.donit.eu

Generate ultra-high purity hydrogen with this modular system

The Hydroprime hydrogen generator (photo) is intended for use in numerous manufacturing and refining applications in a variety of industries. The modular, skid-mounted plant produces ultra-high purity (greater than 99.999%) hydrogen at 200 psig onsite utilizing a steam-methane reforming technology. The generator is fully automated with load-following controls to allow unattended operation. The new product line has a very high natural-gas conversion rate and is highly heat integrated, which translates into low operating costs, says the company. Booth 720 — *Linde Engineering North America, Inc., Blue Bell, Pa.*
www.lindeus-engineering.com

Tank linings that are approved for potable water use

Stonchem 444 lining for tanks and structures constructed of concrete and steel (photo) offers very high tensile strength at 3,400 psi. The lining is fast-curing, dense and waterproof, with extremely low levels of volatile organic compounds (VOCs). Additionally, it is very chemical resistant and is NSF 61-approved for potable water, as well as low outgassing. The lining can also be used in cleanrooms and biosafety level (BSL) 4 laboratories. Booth 319 — *The Stonhard Group, Maple Shade, N.J.*
www.stonhard.com

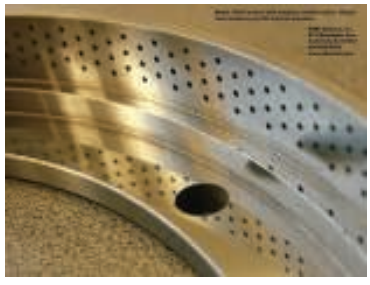
Inline shear mixers with high abrasion resistance

The Cavitron family of inline high-shear mixers (photo) provides dispersion of fine particles down to single-micrometer sizes and emulsification


Badger Meter


Linde Engineering


The Stonhard Group


ARDE Barinco

CV Technology

Wanner Engineering

Husky Corp.

Fike Corp.

of immiscible liquids to size distributions in the sub-micrometer range. The mixer has a 7,200-rpm impeller nested in four stators constructed of tungsten carbide, making it extremely resistant to fine, hard-particle abrasion even at high speeds. Booth 105 — *ARDE Barinco, Inc., Carlstadt, N.J.*
www.arde-barinco.com

A family of basket strainers with a wide capacity range

This company's multi-basket strainers and bag filters cover a wide range of flow capacities and contaminant-holding capabilities. The products contain anywhere from two to twenty-three baskets. To serve as a strainer, a unit can be ordered with perforated stainless-steel baskets. When ordered as a filter, the device is fitted with perforated stainless-steel baskets that are designed to hold disposable or cleanable filter bags. They accept industry-standard #1- and #2-size filter bags or 500-series pleated cartridges. Booth 504 — *Rosedale Products, Inc., Ann Arbor, Mich.*
www.rosedaleproducts.com

Prevent dust explosions with this flameless venting device

The Interceptor-QR quench tube (photo) is a flameless venting device that can be used on a variety of process equipment, including indoor equipment and equipment in occupied areas, to eliminate the release of a flame. The Interceptor-QR is ATEX-certified and compliant with NFPA 68 requirements. It provides an option for safe indoor venting of combustible dust explosions in pneumatic conveyors, bins, silos, cyclones, mills, dryers and more. Booth 726 — *CV Technology, Inc., Jupiter, Fla.*
www.cvtechnology.com

These seal-less pumps can handle a wide viscosity range

The Hydra-Cell Model P200 metering pump (photo) features capabilities for metering, injecting, blending, dosing, filling, adding and mixing virtually any low-to high-viscosity fluid to be pumped into a chemical-feed processing system. The pump is seal-less, has a multiple-diaphragm design, a replenishment valve in every piston, is spring-loaded and has horizontal-disk check valves. The pump also includes new gearbox reducers, variable-frequency and drive-electronic flow adjustment. Model P200 pumps offer accurate flow throughout the entire turndown range, with virtually pulse-free linear flow. Booth 612 — *Wanner Engineering, Inc., Minneapolis, Minn.*
www.wannerneg.com

Increase loading and unloading safety

The SGA loading arm (photo) is designed to carry fluid-handling hose lines between stationary systems and mobile units. Whether loading or unloading chemicals and fluids to or from tanker trucks and railcars with top, bottom, or side loading, the SGA elevates the hoses off the ground. The loading arms handle hoses with lengths up to 22 ft and are height adjustable ±4 ft. The SGA is a low-cost, easy-to-install solution to protect against operator injury by making chemical loading and unloading safer. Booth 221 — *Husky Corp., Pacific, Mo.*
www.husky.com

High-tolerance rupture discs for large-diameter applications

Large Atlas rupture discs (photo) deliver last-line-of-defense pressure relief for applications with relief sizes of 18 in. (DIN 450) and larger, with a burst pressure range of 3.25 to 90 psi. According to the manufacturer, the reverse-acting disc delivers 95% operating ratio, very high tolerances and high backpressure resistance. The Large Atlas delivers long service life and consistency in applications where safety relief valves are not a viable alternative and holders with knife blades are no longer desired. Booth 304 — *Fike Corp., Blue Springs, Mo.*
www.fike.com

Illuminate process vessels with this cool-operating luminaire

This company's compact LED sight-glass luminaire is said to be two times brighter than a typical sight-glass light, offering a clear, comprehensive view inside process vessels. Designed for cool operation and equipped with temperature shutdown, LEDs have

a long service life and are resistant to vibration and impact. With the use of these luminaires, no heat radiation is directed into the process vessel. Booth 431 — *L.J. Star Inc., Twinsburg, Ohio*
www.ljstar.com

Knead and blend high-viscosity materials

The Model DKL double-arm kneader (photo) has a forged stainless-steel bowl and high-pressure, high-temperature jackets that are used for kneading high-viscosity materials into a homogeneous blend. The novel forged-bowl technology provides improved mechanical integrity and durability, says the manufacturer. Standard capacities vary from 1.5 to 9 quarts, and custom sizes can be manufactured to fit any process. Booth 513 — *Orbis Machinery, LLC, Waukesha, Wis.*
www.orbismachinery.com

Dry vacuum pumps for chemicals and pharmaceuticals

The CXS chemical dry-vacuum pump offers high reliability and effluent-free pumping, even in the most difficult and harsh chemical and pharmaceutical processing applications. The pump is simple to install and integrate with an existing system. According to the manufacturer, the pump has a minimum 25-yr design service life, with 5-yr service intervals, and no routine maintenance is required. Due to their dry-run technology, these low-vibration, quiet-operating pumps do not generate any contaminated oil that must be disposed of. Booth 448 — *Edwards Vacuum, Crawley, U.K.*
www.edwardsvacuum.com

Quickly monitor flammable gases and vapors

PrevEx flammability analyzers (photo) monitor flammable gases and vapors in process ovens, dryers, kilns and oxidizers. The devices measure total flammability with a 1-s response time and reduced ventilation-air requirements. These heated, standalone analyzers have a low-maintenance, failsafe design. They provide consistent and reliable readings even when faced with multiple or changing solvent concentrations. The analyzers' lower energy consumption reduces fuel costs and improves production rates, while complying with necessary safety directives. Booth 807 — *Control Instruments Corp., Fairfield, N.J.*
www.controlinstruments.com

Simplify vessel opening with these screw clamps

This company's segmented pressure-vessel screw clamps (photo) are intended for use on high-pressure vessels, filter housings, manways and more. They eliminate the need for drilling bolt-holes in flanges and reduce opening and closing requirements for the covers and flanges on which they are mounted. The clamps also decrease the time to open and close the vessels, housings and manways. Booth 212 — *Walter G. Rathmann Segmentklammerschrauben GmbH & Co. KG, Koblenz, Germany*
www.wgr-rathmann.com

Built-in flow-based valve control with this meter

The Model 106-SPI-MV is a single-point-insertion electromagnetic flowmeter, installed and calibrated in conjunction with this company's control valves. This provides an accurate flowrate that can be utilized with the metering valve as a standalone option or built into a pilot system to provide complete flow-based valve control. A water application provides a ±2% flowrate accuracy. Also included are complete pressure control, tank level control and pump control with integral flow metering on valves ranging from 3 to 48-in. in size. Booth 708 — *Singer Valve LLC, Surrey, B.C., Canada*
www.singervalve.com

A dryer with integrated solvent recovery

The H-10 Turbo-Dryer (photo) dries water or solvent-based wet organic chemicals, metal compounds, food additives and ceramic products. The dryer operates continuously with a nitrogen recycle process to evaporate and recover solvents. It dries to levels as low as 0.01% without the need for a vacuum, and handles fragile crystals and preformed pellets with-

Orbis Machinery

Control Instruments

Walter G. Rathmann

Wyssmont Company

BKT United

Komax Systems

Beamex

Filtra Systems

out breakage. The low-maintenance Turbo-Dryer features high onstream time and has lower heat requirements than other dryers, according to the company. Booth 204 — *Wyssmont Company, Inc., Fort Lee, N.J.*
www.wyssmont.com

This filtration system has a built-in anti-fouling mechanism

The FMX anti-fouling membrane filtration system (photo) can be employed for liquid-solid separation and liquid filtration at any stage of the production process to efficiently concentrate or recover desired constituents. It has an anti-fouling mechanism, is specialized for high-solids loading and high-viscosity streams, and delivers high concentration and high recovery. The FMX also ensures higher purity in the end product, says the company. The system's anti-fouling mechanism allows it to filter high-solids and high-viscosity liquids beyond the capability of conventional membrane systems, while maximizing concentration and recovery. Booth 444 — *BKT United, Anaheim, Calif.*
www.bkt21.com

A tank heater that produces little noise and vibration

The Scepter tank heater (photo) is designed for the direct injection of steam into tanks for heating water-compatible products. Water and steam are divided and mixed in each mixing module, producing complete contact between steam and the product to be heated, with low noise and low vibration. The heater has a strong stirring action to help keep any solids or particulate matter in suspension, and produces a uniform temperature throughout the tank, allowing for accurate thermostatic control. Booth 811 — *Komax Systems, Inc., Huntington Beach, Calif.*
www.komax.com

A calibration instrument with five different operation modes

The MC6 (photo) is an advanced, high-accuracy field calibrator and communicator. It offers calibration capabilities for pressure, temperature and various electrical signals. It also contains a full Fieldbus communicator for Hart, Foundation Fieldbus and Profibus PA instruments. Designed for ease of use, the MC6 has a large 5.7-in. color touchscreen with a multilingual user interface. The robust IP65-rated dust- and waterproof casing, ergonomic and lightweight design make it suitable for field use. The MC6 features five different operational modes: meter, calibrator, documenting calibrator, data logger and Fieldbus communicator. In addition, the MC6 communicates with this company's calibration software, enabling fully automated calibration and documentation. Booth 710 — *Beamex Oy Ab, Pietarsaari, Finland*
www.beamex.com

A fully automated press for filtering and dewatering

The fully automated Verti-Press filter press (photo) can both filter and dewater products and wastewater streams. The Verti-Press has incorporated all of the features of the most robust tower press, with a cost that is an estimated 50% less than conventional filter presses, according to the manufacturer. In order to dewater slurry and form a filter cake, the filter utilizes vertically stacked chambers, each of which can be isolated for individual operation, providing flexibility. Available in various sizes, the Verti-Press can be installed as a replacement for conventional plate-and-frame filter technology. Booth 428 — *Filtra Systems, Farmington Hills, Mich.*
www.filtrasystems.com

Benchtop reaction systems made of resilient materials

This company's benchtop jacketed reactor systems are constructed of borosilicate glass that meets ASTM Specification E438 for chemical and heat resistance. The reactors also have an overhead stirrer motor, tool-free connections and optional manifold systems. The systems are fully customizable, and reaction vessels range from 100 mL to 100 L in size. The reaction systems can be used for chemical synthesis, process development, filtration, purification, evaporation, stirring, dissolving, mixing and extracting. Booth 454 — *Chemglass Life Sciences, Vineland, N.J.*
www.chemglass.com ■

Mary Page Bailey

Sealing Technology

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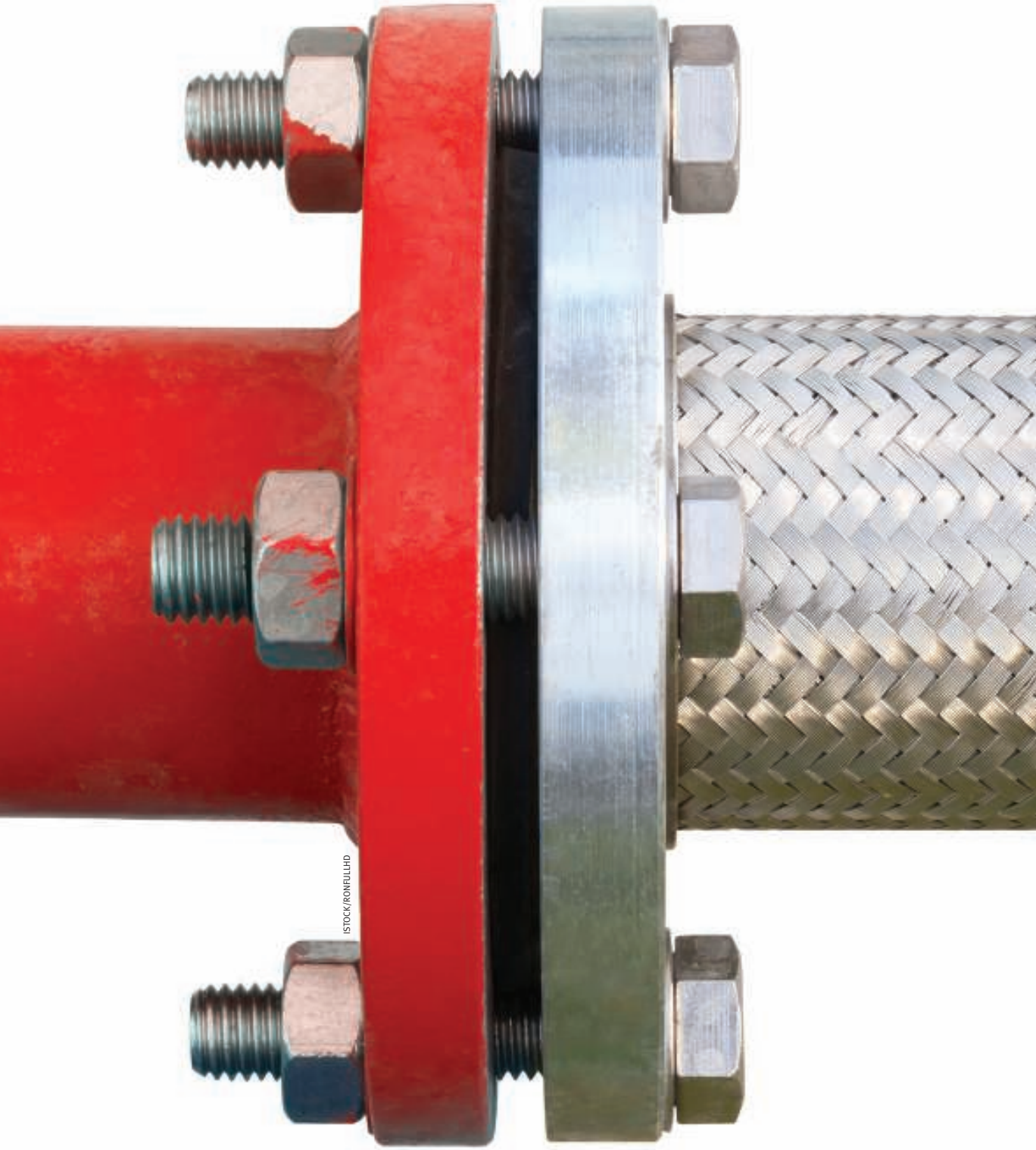


ISTOCK/RONFULLHD

FSA focuses on subject matter expertise

The Fluid Sealing Association is moving its foundation from standards to knowledge, explains Ian Baynes of A.W. Chesterton Co., FSA Marketing Committee Chair

For many years the **Fluid Sealing Association** (FSA) has been predominantly a standards-focused association. Moving forward, the leading association for technical information and standards in the fluid sealing market will push to further its recognition as the premier technical subject matter expert on environmental compliance and the role sealing devices play in energy conservation and reducing overall VOC emissions. The FSA will also drive more strongly to provide industry training programs supporting the primary focus of its technical divisions as well as its member companies in the future.

"We decided to take a deep breath, step back, and plan a path forward that would elevate the standing of the Association, promote its industry technical and subject matter expert leadership, and ultimately enable our collective voice to be heard," FSA President Mike Shorts said. "At the beginning of 2015 we structured a new strategic plan, focusing the Association on the key issue facing our customers: environmental compliance, which expands into energy conservation and methane emissions abatement."

The 2015 FSA Fall Meetings are scheduled for October 6–8 at Hotel Monteleone in New Orleans, La. Registration is now open.

Below are some highlights of the more recent FSA division accomplishments and initiatives.

Compression packings

A fully revised *Compression Packing Handbook* is scheduled for release at the end of 2015.

The Compression Packing Division members continue to liaise with and influence key industry standards groups, including API and ISO, to keep FSA current with regard to EPA regulatory measures, including fugitive emissions mandates. Standards include API 622, API 641, and ISO 15848.

Joint work with the European Sealing Association (ESA; Morzine, France; europeansealing.com) continues in the form of a behavior study that will allow the development of tools to optimize valve stem packing design so as to improve packing life and reduce fugitive emissions. This work is being carried out at the French research organization CETIM (www.cetim.fr). In addition, joint work with the ESA continues at CETIM on a study of friction in pump packing, with energy efficiency and power consumption as its primary output. This directly ties to efforts by the FSA Government Affairs Committee to influence trade and tariff legislation on environmental goods (see below).

The power industry has its own specific sealing needs

Refineries and petrochemical plants are key sources of environmental pollution in the form of fugitive emissions. Better knowledge of how to use sealing technology can help, says the FSA.

Results have directly influenced the revision of the power formula used to calculate life-cycle cost (LCC). A tutorial is scheduled to be presented at the 31st Pump Symposium in September 2015 (http://pumpturbo.tamu.edu/program/pump/pump-tutorials/icalrepeat.detail/2015/09/15/278/-/tutorial-p06-compression-packing-a-traditional-sealing-method-achieving-high-levels-of-performance-with-modern-technologyWebinar).

The division continues to work on its relationship with the Valve Manufacturers Association (VMA; www.vma.org) aimed at jointly furthering industry education. Division members continue to promote industry education through FSA's Sealing Sense articles, with most recent topics aimed at improvements to pump packing performance (http://www.fluidsealing.com/sealingsense/May15.pdf).

Expansion joints

The Expansion Joint – Piping Division is currently working on a full revision of *Piping Handbook 8.0*. In addition, it is also completing work on harmonization of definitions, and updating drawings in the *Piping Handbook* from "outdated stick figures to 3-D renderings".

The Division will also be adding five new expansion joint designs to the *Piping Handbook*, and recently published FSA-PSJ-702-15 – Rubber Flanged Non-metallic Expansion Joint Installation, Maintenance and Storage (http://www.fluidsealing.com/industry-standards/).

The Expansion Joint – Piping Division published three rubber expansion joint articles in *Pumps & Systems* magazine, updated its "Fitter's Flyer" pamphlet, and is reaching out to other associations and entities such as Cooling Technology Institute, EPRI, and Caesar.

The Expansion Joint – Ducting Division, meanwhile, is working to complete the harmonization of definitions from ESA, EJMA, NAHAD, and FSA Piping and Ducting publications, and writing specifications for ducting expansion joints in various applications.

Gaskets

The FSA's Gaskets Division is targeting a completely updated *Gasket Handbook* for release in October 2015.

A new standard on methane leakage performance criteria for spiral-wound gaskets is currently under development, and a training seminar is being created in conjunction with the VMA for presentation at their 2016 Technical Meeting in March 2016.

Water and wastewater treatment need seals, too

Mechanical seals

The FSA Mechanical Seals Division has significantly enhanced its Life Cycle Cost (LCC) tool. This now provides accurate assessments of energy consumption and operating costs associated with different seal configurations under various operating parameters, including metric conversions. A module covering compressor gas seals has also been added. The existing webinar training programs have also been expanded to include "Fundamentals of Mechanical Seals," "Advanced Mechanical Seals," and "Gas Seals for Pumps."

Government affairs

The FSA Government Affairs Committee leaders were in Geneva, Switzerland, during the last week of July to participate in the 8th round of negotiations with the World Trade Organization (WTO). Their job was to press for sealing devices to be added to the WTO's Environmental Goods Agreement (EGA).

Sealing Technology 2015

Mechanical seals, gaskets, packings, and expansion joints are key to the safe and profitable performance of every process facility. This Special Advertising Section on sealing technology highlights the recent activities of trade associations and vendors in this field.

Starting on p.96, our report from Ian Baynes of the U.S.-based Fluid Sealing Association (FSA) describes how this important trade body is continuing to turn itself from a setter of standards to a source of knowledge. A key point here is the importance of sealing technology to environmental protection by reducing atmospheric emissions of natural gas and volatile organic compounds (VOCs). The FSA has been aided in this work by its sister organization the European Sealing Association (ESA). Industry representatives hope the environmental significance of sealing technology will allow it to escape trade tariffs in future.

On this and the following pages we present a few of the commercial developments that make possible today's high standards of sealing performance. ■

FSA and ESA representatives met with trade negotiators from the U.S., Switzerland, China, Hong Kong, South Korea, Taiwan, Norway, the European Union, Japan, Singapore, New Zealand, Australia, Canada and Turkey to affirm why mechanical seals, gaskets, packings and expansion joints should be recognized as "environmental goods" and hence exempt from import and export tariffs.

Trade negotiators intend to complete their work by December 2015 and announce an agreement. ■ **www.fluidsealing.com**

Sealing success is based on advanced materials

Thermodyn uses Genuine Viton and other high-performance polymers to formulate a range of expansion joints, caulks, coatings, and adhesives for demanding conditions

Selling advanced polymers and manufacturing high-temperature, chemical resistant expansion joints and gasket materials since 1979, **Thermodyn Corp.** continues to lead the development, design and manufacture of innovative products for these markets.

The primary source for these resistant materials is Genuine Viton. Thermodyn has been a licensee to sell Genuine Viton materials for over 30 years and extends that tradition as DuPont transitions to Chemours. One of the oldest Viton licensees in the world, Thermodyn continues to brand its products accordingly.

Thermodyn's specialties include the production of expansion joints used by the power industry in modern scrubber systems designed to protect the environment. Thermodyn also produces Viton sheet material for all types of industrial, automotive, chemical and electrical production. Product lines include commercial-grade materials, plus specification grade A, B and F Vitons as well as Viton Extreme and FDA-approved materials. Thermodyn also manufactures custom-made diaphragms and extrusions using both Viton and Aflas.

Thermodyn also offers a unique line of caulks, coatings and adhesives. Mixed with a Viton-based polymer, these products are ideal for sealing flanges in high-temperature and/or corrosive environments. Fluorodyn Caulk contains 75% solids, making it an easy-to-apply, single-component caulk. Offering excellent chemical resistance in both an uncured and cured state, Viton Caulk offers increased resistance to virtually all chemicals, including nitric, sulfuric and hydrochloric acids, and comes highly recommended for harsh environments that require flexibility, leak-proof sealing, and high resistance to permeation. The coatings and adhesives have been compounded in liquid form, making them easy to use in bonding, splicing, and repairing expansion joints and gaskets.

Manufacturing sheet material at Thermodyn

Thermodyn's staff have many years of experience, and are trained to ensure that the products offered by Thermodyn Corp. will meet customers' needs at a fair and competitive price and are delivered in a timely manner. **www.thermodyn.com**

PTFE gaskets reinvented

Durlon 9000 from Triangle Fluid Controls uses PTFE and glass to its best advantage, to bridge the gap between cold flow and sealability

PTFE gaskets generally get a bad rap because of inherent cold-flow properties of the base material, notes gasket specialist **Triangle Fluid Controls**. Manufacturers have therefore come up with several ways of modifying PTFE in order to combat creep, ranging from adding various fillers to expanding the material in one or more directions.

Regardless of these efforts, PTFE gaskets continue to creep. But one physical property does not a gasket material make. Gasket material properties are holistic – much like system pressure, temperature, flow, and line size.

Since its inception more than 25 years ago, the company's Durlon 9000 has been engineered to deliver the best performance based on the interaction of all physical properties within any given application. Simply put, Durlon 9000 is designed to be the ultimate universal PTFE pipe gasket.

Expanded PTFE (ePTFE) resists creep, but its lack of recovery quickly becomes a safety liability. To eliminate creep, ePTFE must be compressed to nearly the thickness of a piece of paper, significantly reducing its ability to recover from system fluctuations. Durlon 9000, on the other hand, balances creep properties with recovery properties to maintain its original seal.

Gaskets made from Durlon 9000

Durlon 9000's engineered filler system incorporates a homogeneous dispersion of solid architectural glass which provides superior physical and sealing performance over hollow glass and other fillers. Solid architectural glass gives the gasket enhanced structural integrity and low uncompressed porosity, allowing Durlon 9000 to be used in aggressive chemicals and at both reasonably high and very low flange loads.

Silica-filled PTFEs, in contrast, are hard and require significant flange load to seal tightly. ePTFEs feel soft but still require relatively high flange loads to seal their internal porosity. Durlon 9000 bridges these concerns while providing long-term sealability and reliability.

Another advantage to Durlon 9000 is that unlike calendered and ePTFEs, which are only available in fixed sheet dimensions, Durlon 9000 is skived from a large billet and can be made longer than a regulation NFL football field. This continuous profile allows larger one-piece gaskets, improves yield for gasket cutters, and cuts prices to end users. Durlon 9000 is PTFE reinvented.

www.trianglefluid.com

Expansion joints with ASME B16.47 Series B flanges

Proco Products explains two ways to accommodate ASME B16.47 Series B flange drilling when specifying rubber expansion joints

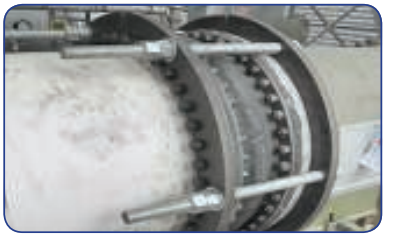
"Piping system designers: Have you ever come across the need to supply rubber expansion joints/control units in a piping system where the flanges have ASME B16.47 Series B drilling?" asks **Proco Products**. "If so, you will know that the conventional control rod setup can be challenging, since the attachment area for a traditional triangular control rod plate is greatly reduced." This is because with Series B drilling the bolt circle for the flange is closer to the O.D. of the pipe than it is for Series A drilling, Proco explains.

For example, say a designer has an application for a 30 in. I.D. X 24 in. OAL triple-arch rubber expansion joint, where one end has ASME B16.47 Series A drilling and the other end has ASME B16.47 Series B drilling. Control rods are used in this example as the piping system is unrestrained.

For ASME B16.47 Series B drilling, the best rubber expansion joint design is an "interior tie rod" type. This uses a thicker ring/rod plate to connect the expansion joint to the adjacent mating flange, while connecting rods control the thrust loads and movement of the expansion joint under pressure. This design eliminates the complication of a traditional control rod setup on the back side of the mating flange, where clearance of the I.D. of the control rod plate aligning with the mating flange holes becomes difficult (illustration, left).

(Left) Interior tie rod rubber expansion joint design for ASME B16.47 Series B flange connection

The only other option when dealing with ASME B16.47 is a control rod setup with thick fabricated split flange plates, so that the resultant thrust loads from the rubber expansion joints are evenly distributed to every bolt hole (photo, below). However, the "interior tie rod" configuration is preferred. **www.procoproducts.com**



Exterior control unit design

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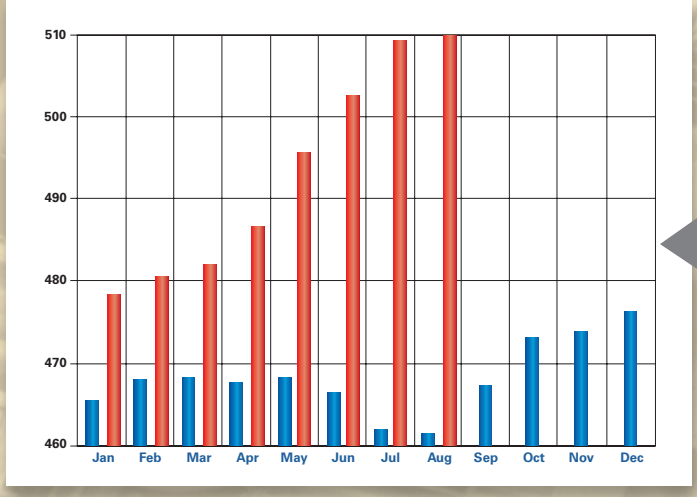
	Sep '06 Prelim.	Aug '06 Final	Sep '05 Final
CE Index	513.1	510.0	467.2
Equipment	606.5	602.3	541.2
Heat Exchanges and Tanks	565.1	560.9	509.2
Process Machinery	559.6	556.2	521.7
Pipe, valves and fittings	734.7	731.7	620.8
Process Instruments	441.4	437.2	379.5
Pumps and Compressions	788.9	788.3	756.3
Electrical equipment	418.9	414.2	374.6
Structural supports	643.7	637.7	579.3
Construction Labor	314.7	312.9	309.1
Buildings	476.9	475.2	444.7
Engineering Supervision	350.7	351.9	346.9



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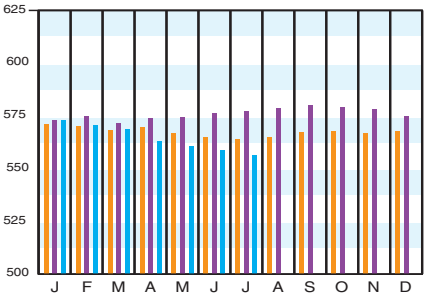
CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957-59 = 100)	Jul. '15 Prelim.	Jun. '15 Final	Jul. '14 Final
CE Index	556.3	558.3	576.9
Equipment	669.7	673.0	700.4
Heat exchangers & tanks	597.9	601.7	640.3
Process machinery	658.5	659.5	667.6
Pipe, valves & fittings	829.1	836.3	878.2
Process instruments	394.9	398.7	413.3
Pumps & compressors	956.5	957.8	938.8
Electrical equipment	512.5	512.9	516.1
Structural supports & misc	737.7	737.7	771.1
Construction labor	321.5	321.0	322.2
Buildings	541.9	541.4	544.5
Engineering & supervision	319.0	318.7	320.6

Starting with the April 2007 Final numbers, several of the data series for labor and compressors have been converted to accommodate series IDs that were discontinued by the U.S. Bureau of Labor Statistics

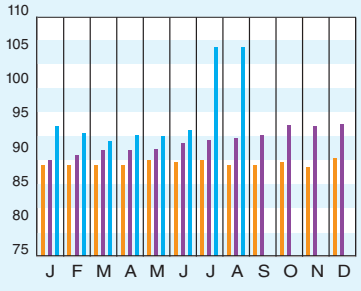
Annual Index:
2007 = 525.4
2008 = 575.4
2009 = 521.9
2010 = 550.8
2011 = 585.7
2012 = 584.6
2013 = 567.3
2014 = 576.1



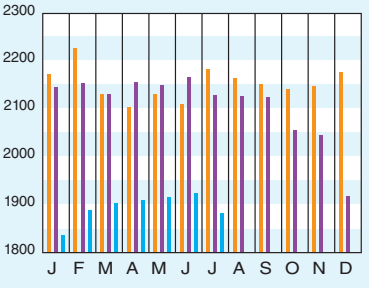
CURRENT BUSINESS INDICATORS

	LATEST	PREVIOUS	YEAR AGO
CPI output index (2012 = 100)	Aug.'15 = 105.5	Jul.'15 = 105.5	Jun.'15 = 105.1	Aug.'14 = 104.1
CPI value of output, $ billions	Jul.'15 = 1,882.9	Jun.'15 = 1,923.0	May'15 = 1,912.1	Jul.'14 = 2171.7
CPI operating rate, %	Aug.'15 = 76.2	Jul.'15 = 76.3	Jun.'15 = 76.1	Aug.'14 = 75.6
Producer prices, industrial chemicals (1982 = 100)	Aug.'15 = 249.1	Jul.'15 = 247.3	Jun.'15 = 241.4	Aug.'14 = 296.4
Industrial Production in Manufacturing (2012=100)*	Aug.'15 = 105.3	Jul.'15 = 105.8	Jun.'15 = 104.9	Aug.'14 = 103.9
Hourly earnings index, chemical & allied products (1992 = 100)	Aug.'15 = 158.4	Jul.'15 = 159.1	Jun.'15 = 157.6	Aug.'14 = 156.0
Productivity index, chemicals & allied products (1992 = 100)	Aug.'15 = 122.5	Jul.'15 = 122.4	Jun.'15 = 121.6	Aug.'14 = 121.3

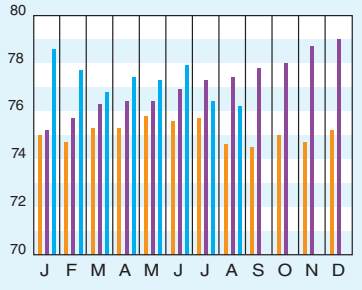
CPI OUTPUT INDEX (2000 = 100)†



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2000 to 2012
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

CURRENT TRENDS

The preliminary value for the July 2015 *CE* Plant Cost Index (CEPCI; top; the most recent available) fell compared to the previous month's value, driven by a decline in the Equipment subindex. The Construction Labor, Buildings and Engineering & Supervision subindices all rose slightly in the July numbers. The July CEPCI is 3.6% lower than the corresponding value from a year ago at the same time. Meanwhile, the latest Current Business Indicators (CBI; middle) numbers showed both increases and decreases. As a reminder, for the CBI numbers, the base year for determining the CPI output index and the industrial production in manufacturing were both changed to 2012 beginning with last month's chart.

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