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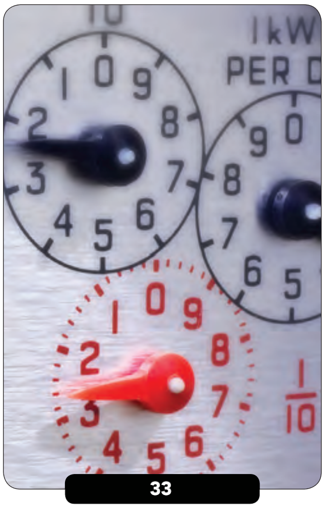

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# Call It Assault on Batteries

## Energy harvesting promises to address their limitations for wireless

**BATTERY-POWERED DEVICES** have altered our lives and workplaces in myriad ways. Of course, smartphones and laptop computers rank high on the list of key transformational developments. Meanwhile, wireless sensors and transmitters are assuming a bigger role in plant operations.

The roster of battery-powered equipment that we now rely upon seems almost endless, ranging from prosaic items like automobile key fobs to life-saving medical implants.

Going way back, I recall marveling over the first small transistor radios. The attraction of carrying a radio in your shirt pocket and then listening to AM stations whenever you wanted was stupendous. I still remember tuning into the "Good Guys" on WMCA – 570 kHz in New York City on my petite made-in-Indianapolis "Regency TR-4" radio!

Then being a teenager with a small allowance, that radio sensitized me to the finite life and fiscal impact of batteries.

Fortunately, battery technology has progressed dramatically since those days. Today, lithium ion batteries provide high power in a compact form factor undreamt of not that long ago — although with the risk of fire from overheating in some circumstances. Meanwhile, common inexpensive alkaline batteries now boast shelf lives of up to 10 years.

Nevertheless, despite these advances, concerns over batteries persist.

On a personal level, I still worry a bit about a battery's state of fitness when left for a long time in a device. That's why I keep on hand a small emergency radio (for listening to weather information as well as regular broadcasts) that gets power from turning a crank a number of times.

Battery life also remains a sticking point for some industrial applications of wireless technology. Sure, a wireless sensor/transmitter can make getting data from a remote or inaccessible location feasible. However, the need to limit the frequency of readings to ensure adequate battery life as well as the overall cost of battery replacement thwart use of wireless in some services.

Fortunately, developments in energy harvesting may alleviate these concerns by augmenting or even replacing batteries. We've long covered the idea of scavenging power by taking advantage of machinery vibrations or the temperature gradient between equipment and ambient conditions (see, e.g., "Energy Harvesting Widens Wireless' Appeal," http://bit.ly/2H0TlmP). Progress continues to occur. For instance, last month, we reported that researchers at MIT have developed a harvester that doesn't require two different temperatures at a given time. Instead, the device works off the natural swings in ambient temperature that occur between day and night ("Temperature Swings Power Sensor," http://bit.ly/2q8dSMp).

Meanwhile, commercially available harvesters continue to win over users. For example, this issue's article "Energy Harvester Stars for Steam Monitoring," pg 40, highlights how a thermoelectric device with protruding heat-sink bristles now is teamed with a wireless transmitter in an inhospitable location at a process plant. It powers the transmitter during routine operations — significantly extending the life of the battery, which only gets called upon during turndowns and other situations involving loss of process heat.

While advances in batteries have ushered in the wireless era at plants, energy harvesters may significantly enhance the feasibility of widespread adoption.

*I keep on hand a "crank up" radio for emergencies.*

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# Stop Struggling with Your Slurry

Convert a settling solids suspension into a non-settling one

Several techniques can make solids that settle stop behaving so badly.

**THE PROBLEM** with solids is that they don't want to move. This often results in solids settling out of slurries. The only thing preventing such settling is movement of the fluid, so we call slurries either settling or non-settling. The latter is defined by the saltation velocity or minimum suspension velocity. A 2006 *CP* article, "Avoid Trouble with Slurries," http://bit.ly/2HcQy7D, describes some primary correlations. However, these correlations don't address the issue of the pressure-drop/flowrate characteristics when working with solids that settle in pipelines or vessels. The flow of settling solids is a complicated affair.

Unfortunately, analytically based studies don't offer practical guidance. Researchers have pushed back the boundaries of the unknown only a relatively short distance. Their correlations rely on between 10 and 20 pseudo-physical properties. However, the coefficients and exponents in these correlations are based on quasi-uniform particles over a narrow range of the relevant variables.

So, we must rely upon direct scale-up methods that have proven successful for non-settling solids. Increasing the velocity beyond the settling point (saltation or choking) is an option; however, this raises pressure drop and pipe erosion/particle breakage. Converting a settling solids suspension into a non-settling suspension is a better alternative to ensure successful scale-up.

You can consider several approaches to make solids that settle stop behaving so badly:

• *Additives*. Introducing high-molecular-weight polymers, soaps or deflocculating agents (generally electrolytes) into a slurry can reduce pressure drop. The use of additives is common in the mineral industry (drilling mud, phosphate rock, limestone cement and coal) to cut the pressure drop while keeping the solids concentration unchanged. Small amounts of polymers (10–100 ppm) have proven to decrease pressure drop in the transport of large coal particles. Soaps provide an option that doesn't mechanically degrade as rapidly as high-molecular-weight polymers. Electrolytes reduce the zeta potential, which results in a lower head loss.

• *Vibration*. In certain situations, the oscillation of either the flow of slurry or the applied pressure can reduce head loss. Low frequency (5–10 Hz) tends to shift the peak velocity in a pipe from the center to nearer the wall, which aids in suspending the particles. This technique is most effective for non-Newtonian suspensions and decreases the terminal settling velocity. It has proven useful in inclined pipes where solids fold back on themselves. Vibration or oscillation of the pipe works but is much less effective than oscillation of the slurry.

• *Air injection*. For all Newtonian slurries in laminar or turbulent flow and for non-Newtonian slurries in turbulent flow, injecting gas into horizontal pipeline slurries will increase the pressure drop and shear on the slurry. However, this technique particularly suits shear-thinning fluids (i.e., pseudo-plastic non-Newtonian ones) because their viscosity decreases with increasing flow. The use of air injection on shear-thinning fluids can reduce the pressure drop or raise the capacity of a pipeline. Surprisingly, this technique hasn't gained wide application.

• *Fibers in suspension*. One very specialized option is using high-aspect-ratio (10:1) fibers to reduce drag. The current experimental information on this subject is contradictory but studies in the pulp and paper industry show that low concentration slurries flow as a plug with a lubricating water annulus adjacent to the pipe wall. In some cases, the pressure drop is lower than that with liquid alone.

• *Modified pipe geometry*. Many studies have indicated that a circular cross-section pipe isn't the most favorable for minimizing head losses in slurry flow. Among the alternatives evaluated are the use of segmented pipe of various geometries and the addition of helical ribs to the pipe. Some such configurations have reduced pressure drop by as much as a 20%. However, industrial acceptance has been poor, partially because these options increase both the weight of the pipe and installation costs. Also, there is fear that products may become contaminated or degraded.

If you have a troublesome settling slurry, there are many ways either to make it act like a non-settling slurry or at least increase the capacity of the pipeline. You can apply scale-up and design methods with confidence that the slurry pipeline will be trouble-free.

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# Combat Scope Creep

Items added to a project can undermine its success

**THE BUDGET** already was blown when I got the project. The money allocated was adequate for the original scope — replacement of a tank coupled with installation of a larger molasses centrifuge. Now, though, the project included improvements in the steam network and cleaning tank as well as some dumb experiments corporate requested. This is a perfect example of scope creep triumphing over common sense.

Fortunately, I was able to save this project — and my career — by taking several specific steps. I slowed down construction. I ignored corporate's ideas. I used non-union contract labor and pitched in myself. I personally did all the design and purchasing. Yet, even with all that, the project was on the verge of failure. So, I introduced several minor improvements and begged for more money based on them. We squeaked by.

Anyone responsible for a project should fight project scope creep.

First, let's consider tactics for avoiding such creep. The best defense is an explanation to corporate management about how an "adder," i.e., an item appended to the scope, will blow up the rate of return (ROR) on the project. Present your reasons as delicately as possible so you don't offend the individual promoting it. I suggest a phone call to ask permission after you've gotten a cost estimate. If you're uncomfortable doing an estimate, use "RS Mean's Facilities Construction Cost Data" and focus on the time needed to perform a construction activity, then apply local labor rates and current material costs. Depending upon the interest level, you may need a quotation rather than just an estimate.

Some adders are sensible and should be included in a scope. However, many aren't. Often, it's because they're not technically feasible — which gives you a strong defense.

A somewhat related defense applies when the technology itself is feasible but demands high-price-tag labor. For example, suppose the adder involves new instruments and controls requiring sophisticated support: bingo!

The next best defense is showing how an adder will delay implementation of the project. This actually can be the best defense if the holdup could push back product delivery. It's also powerful if you don't have time to spare because a leaking tank, failing pump, etc., demands immediate attention.

Lastly, consider a potent, if usually unspoken, deterrent to scope creep: inconvenience. If an adder comes along after the process hazard analysis or constructability review, you must restart the review process from scratch. Most companies don't want to go through that again. Other inconveniences include: retraining, additional tie-points, downtime, safety issues like relocating a sprinkler system, a capacity expansion requiring first a "permit to operate" and later a "permit to install."

Now, let's consider what you can do when scope creep is unavoidable. If you lose the fight, it may be less about completing the project and more about the aftermath. See: "Take the Right Approach to Projects," http://bit.ly/2Eo0OXv.

Your first problem is cash. If you were smart, you used the highest bids for your estimates ("Pad Your Cost Estimate," http://bit.ly/2q9dvR3). Now, go low bidder. Next, look for construction shortcuts to reduce costs. Get rid of any spares proposed for the job. Eliminate as-built drawings. However, first, you must create some space between project approval and kickoff. You'll need some time to squeeze every dime out of the project scope, schedule and budget — remember, they're all connected.

If even after doing all that you can't fully absorb the adders, look for ways they can help you improve the project's ROR. Most adders provide some value if you delve deeply enough.

Safety improvements get short shrift when it comes to projects. Yes, I know many plants display highly visible banners that proclaim "Safety First" — but you know what I mean. I don't want to sound cynical but there's real money in safety, as I've stressed before: "Worker Safety: Forget Political Correctness," http://bit.ly/2H1kMNo.

And, of course, maintenance improvements do provide savings, often significant ones. For example, one plant was suffering over $1 million/y in downtime because a key pump had to be taken offline for an hour at least four times a week; installing a simple strainer at the discharge of the previous pump eliminated the downtime. Roll that into your project and you're saved.

If none of this works, then you'd better prepare a good explanation for the failure for your next job interview.

**DIRK WILLARD**, Contributing Editor
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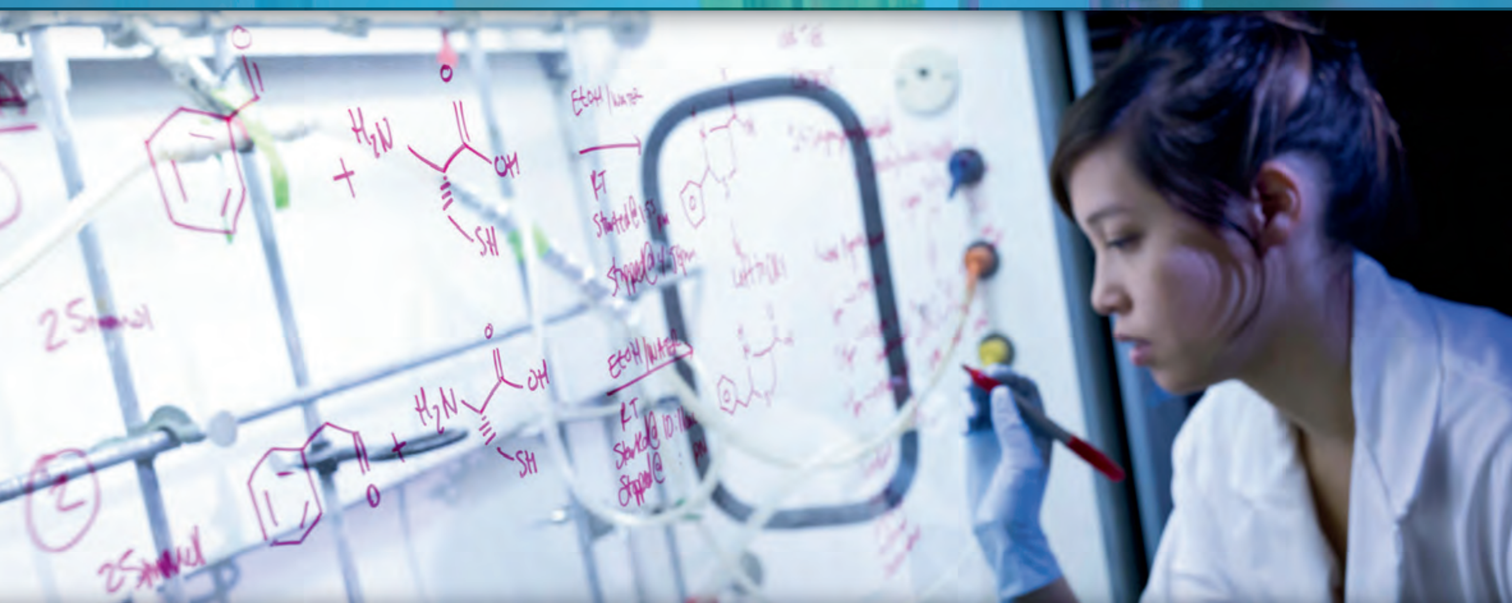
Consider if an adder could cause a delay in product delivery.

SUCCESS LIVES HERE

# WHERE INNOVATION GOES TO EXPAND ITS HORIZONS



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* 2003-2015 SOURCE: U.S. Census Bureau    ** 2016 SOURCE: TEConomy Partners

# Polyketide Process Opens Up Opportunities

Bio-engineered approach could underpin commercial production of plastics and drugs

**A NEW** sustainable method for making triacetic acid lactone (TAL) could turn it into a platform chemical for industrial-scale manufacture of a variety of products, say a team of researchers at The University of Texas at Austin (UT), Austin, Texas. Their synthesis approach provides output that far exceeds that of current bio-based routes to the polyketide, they note, enabling cost-effective production of TAL.

Polyketides are an important class of naturally derived molecules that already are used for making a variety of products such as specialty polymers, pigments and pharmaceuticals. For instance, pharmaceutical companies rely on polyketides now on the market to derive more than 20 drugs.

Technical challenges have constrained current synthetic production of polyketides, limiting practical applications for consumer- and industry-based needs. Most technologies suffer from limited product yields, resulting in difficult chemical synthesis and poor economics.

By rewiring metabolism in the yeast Y. lipolytica through synthetic biology and genetic engineering, the research team increased TAL production capacity tenfold, enabling mass production that can underpin a variety of industry applications.

Using the new approach, the researchers were able to purify TAL directly from a bioreactor to make a new plastic material that can be formed into a film; it exhibits an orange hue and relative transparency. An article in the *Proceedings of the National Academy of Sciences* contains more detail on their research.

"This work represents the development of a platform strain that can lead to new types of monomers. In reality, we have rewired this yeast cell to over-produce Type III polyketides generically. As a result, this same technology can be applied to a host of other known and novel molecules. Each of these molecules can have novel applications in the polymers, chemicals, and even fuels and pharmaceuticals space," says Hal Alper, a professor in the McKetta Department of Chemical Engineering who led the research.

UT's technology commercialization office has filed a U.S. patent application on the technology and aims to secure worldwide patents. It is looking to industry to help with the broader process development and pilot-scale production. "We have started talking with commercial partners who are interested in the technology and continue to explore commercial applications for both the TAL molecule and the broader cellular platform we have created," notes Alper.

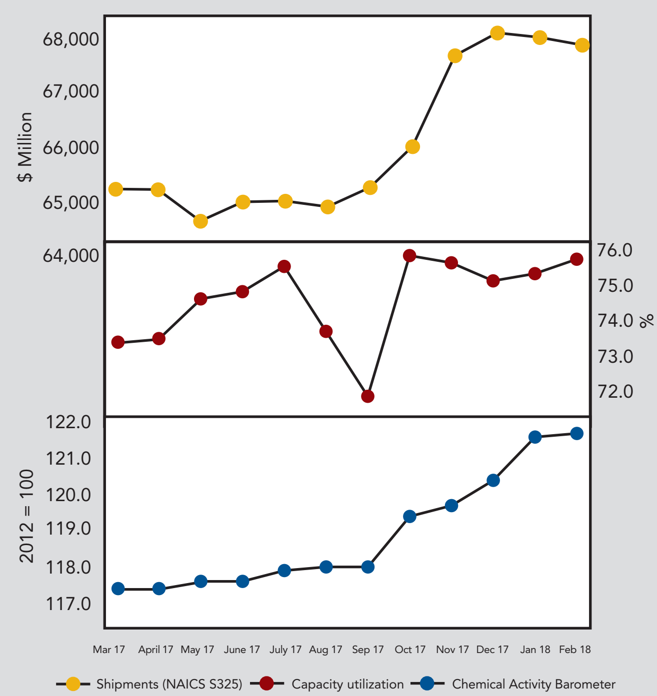
The team now is focused on enhancing the platform strain by identifying further genetic modifications that can increase the overall rate, titer, and yield of production. The researchers also are striving to diversify the type of monomers that can be produced.

"We continue to work on increasing overall efficiency in our system and in pushing the boundary to new types of monomers that can be produced using our system. In doing so, coupling the biochemistry with polymer science offers a unique opportunity and challenge. Our goal is to bring novel, valuable products to the market much faster using this pre-engineered organism," stresses Alper.

**SUSTAINABLE PLASTIC PRODUCTION**

Figure 1. UT engineers mold the new, sustainably produced plastic material into a Longhorn silhouette. *Source: Cockrell School of Engineering, University of Texas at Austin.*

**ECONOMIC SNAPSHOT**




Capacity utilization and the CAB rose but shipments slipped. *Source: American Chemistry Council.*

# Advance May Transform Gas Separation

**PORES IN** the molecular structure of metal organic frameworks (MOFs) enable impressive gas-separation performance. Indeed, researchers from Australia and Japan have shown that nano-scale membranes made from MOFs can yield orders-of-magnitude improvement over existing techniques. For example, one called ZIF-8 (zeolitic imidazolium frameworks-8) lets propylene diffuse through its pores 125 times more efficiently than propane at 30°C.

However, synthesis of the required highly intergrown ultrathin films without complex porous supports has proven challenging. In addition, a generic crystallization route capable of producing a wide range of MOF structures in the required thin-film morphology is necessary.

"The main challenge with this approach is to synthesize high-quality, ultrathin MOF films on commercial porous substrates without complicated substrate modifications," explains Kumar Varoon Agrawal, an assistant professor and chair of advanced separations at École Polytechnique Fédérale de Lausanne (EPFL), Sion, Switzerland.

"Such high-quality films have fewer defects and are necessary for obtaining the highest possible separation selectivity," he stresses.

A technique devised by Agrawal's team at the university just might provide the way to make such films.

Known as electrophoretic nuclei assembly for crys-

BETTER MEMBRANE

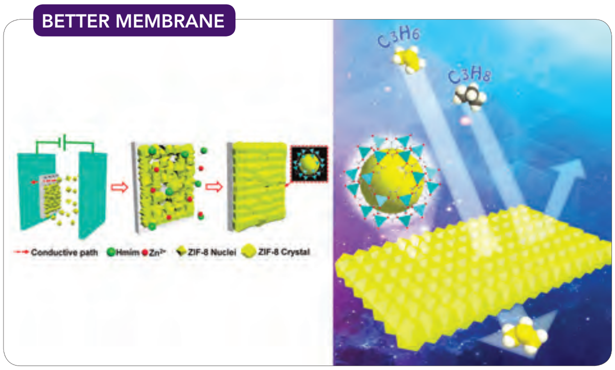



Figure 2. Electophoretic nuclear assembly transforms MOFs into highly efficient membranes for gas separation. *Source: K.V. Agrawal/EPFL.*

tallization of highly intergrown thin films (ENACT), their new method allows simple regulation of the heterogeneous nucleation on unmodified porous and nonporous substrates. This, in turn, facilitates the synthesis of ultrathin highly intergrown polycrystalline MOF films.

The team used the ENACT method to synthesize 500-nm-thick MOF membranes. When tested, these membranes provided one of the best performances in propylene/propane separation recorded to date. The ultrathin film also yielded large propylene permeance (flux normalized with pressure difference) that will help cut the membrane area needed for industrial applications.

"Scale-up of inorganic membranes is indeed one of the biggest challenges. This needs to be carried out on low-cost polymer support, and in a reproducible fashion. Our method allows for both," notes Agrawal.

"We are naturally interested in improving the process to make even better membranes. Currently, we are optimizing the process to improve the separation selectivity. On [the] scale-up front, we will develop a method to synthesize MOF membranes on a hollow-fiber support," he says.

The potential for the technology is enormous, Agrawal adds, with many industrially important separations possible — including hydrogen/carbon dioxide, carbon dioxide/methane, carbon dioxide/nitrogen and ethane/propane.

The work already has attracted the interest of a number of as-yet-undisclosed companies from industry, he mentions.

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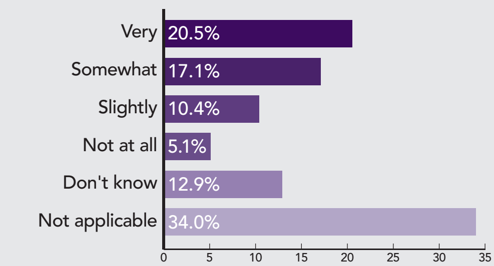
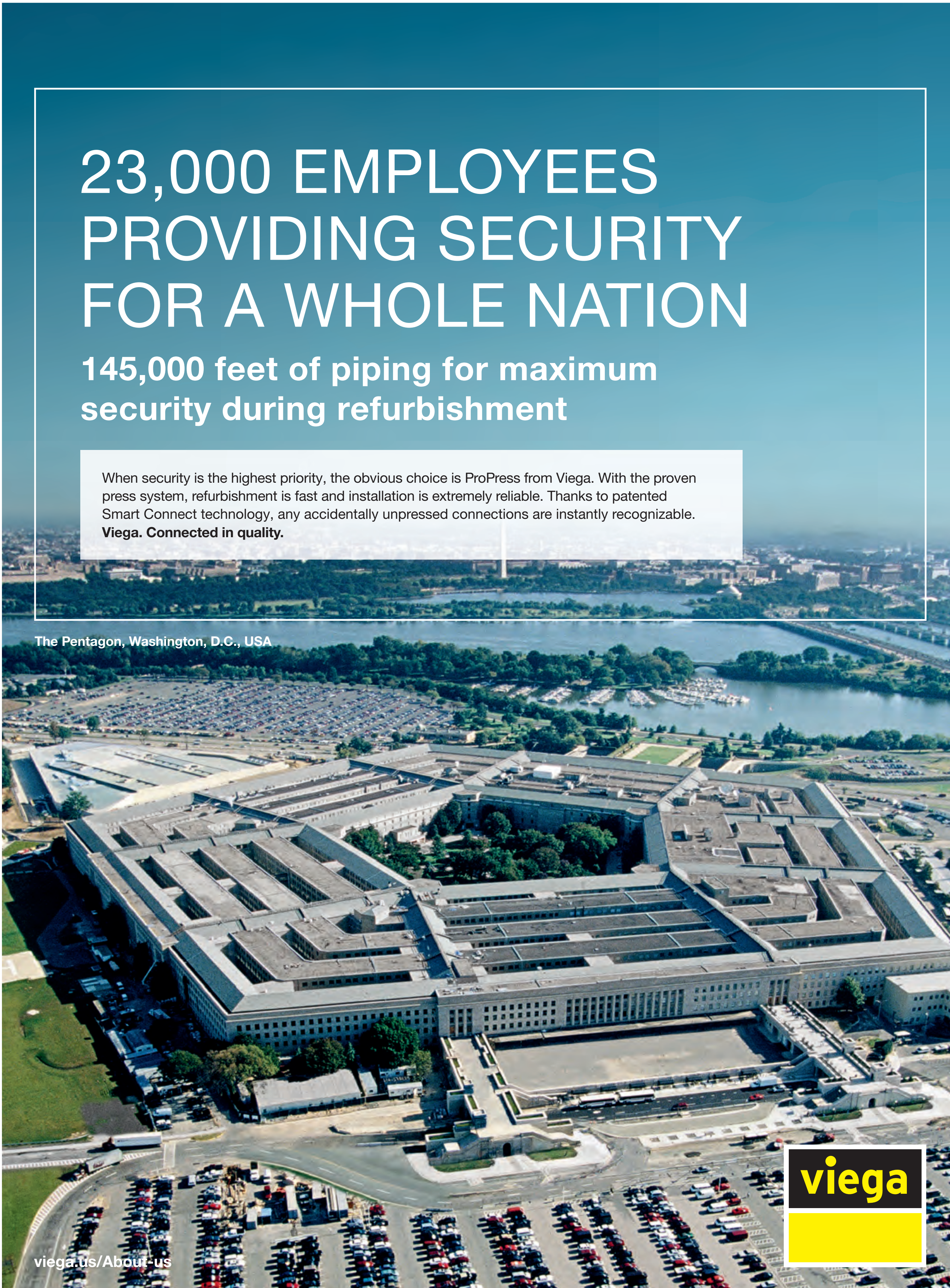
**How adequate do you consider the steam-trap monitoring and maintenance program at your site?**




Most respondents for whom the question was applicable felt the program was at least somewhat adequate.




The Pentagon, Washington, D.C., USA

# Don't Neglect Spring Cleaning Duties

A cooling tower's rapid performance decline stemmed from a surprising culprit

"Jake, the fouling is wiggling!"

**ROB AND** Jake started out their careers together. Rob was younger and attended night school while working as a designer with Jake during the day. Once he had his degree, Rob was transferred to one of the construction sites where he was the on-site project engineer. He and Jake maintained contact as they both moved from site to site and through a series of development assignments. Jake took an equipment specialist role and Rob moved into a field engineer role in Jake's group.

One day early in the spring, Rob called Jake, "I need your help. One of our chillers is losing performance quickly and we want to avoid taking it offline." Rob described the problem. They had just started this chiller. It ran fine for a few weeks, but recently performance started declining. The performance loss escalated rapidly. Jake told Rob to start troubleshooting the problem per the course he had just taken. Rob checked the condenser flowrate and pressure drop. They seemed a bit high. He also ran a test on the heat exchanger for fouling. It was inconclusive.

### GET MORE SAGE ADVICE

For additional tips on conducting thorough, successful energy assessments and implemeting energy-saving measures, check out past Energy Saver columns online at www.Chemical Processing. com/voices/energy-saver/.

Springtime usually was when "stuff" in the river water seemed to block condensers. So, Jake told Rob to take down the unit and open it up. It had lost so much capacity that it wasn't helping with the plant cooling load anyway. Rob broke the news to upper management, who agreed to the additional work involved. Once opened, Jake expected the team would find a lot of vegetation blocking the tube sheet. Cleaning this would be easy, bringing the unit back online quickly.

Jake got a call from Rob later in the week. "Jake, the tubes are completely packed. And the fouling is wiggling!" Jake was speechless; he had never seen or heard of this. "Rod out some of the tubes and see what it is," Jake advised. Rob called back later to say they discovered the identity of the fouling: eels, small ones from a spring hatch. Jake said, "Well that's a first for me — you had me stumped for an explanation, but I will put that down in the experience book. Do you know how they got in there?"

Rob and Jake continued their investigation at the river pump house. The maintenance group opened the pump strainers and found damaged strainer elements. After replacing these, the pumps returned to service. All condensers were opened and rodded out, and chillers put back online. The problem chiller turned out to be the first one on the river water line — so it had collected more of the eels, enough to nearly block off all the flow. Once the condensers were cleaned, Rob conducted performance tests and registered a new baseline. He also added new maintenance guidance to the annual schedule so the plant would check the strainers during the spring timeframe.

#### INSPECTION CONSIDERATIONS

So, have you checked out your cooling system this spring? Do you use river water? Springtime brings all sorts of "stuff" into the cooling water. Winter snow thaws and spring flooding picks up various plant material and dirt, some of which can get past even the best river water screens and strainers. Springtime also brings hatchings of marine animals, which also can end up in the river water intakes. Eels are not the only plant life affecting condensers. The spread of Asiatic clams has also resulted in springtime calamities in cooling systems. So, check and ensure your river water systems aren't hiding a potential disaster.

River water systems are not alone in this regard. If you have cooling towers, it's time to inspect and perhaps clean out the system. If the towers were offline, you could have algae growing in the fill and plugging the distribution basins and headers. Sometimes, wooden fill dries out, increasing mechanical failure as the dry rot can cause the fill to lose strength and fail when water passes over it. This, in turn, can result in blockage in the tower and condenser.

So, the time is now to do your checks. Happy energy savings hunting!

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# Deadline Looms for Prop 65

Mandate for new warning labels takes effect this summer in California

**IN JUST** a few short months, on August 30, 2018, the California Office of Environmental Health Hazard Assessment (OEHHA) revisions to its Proposition 65 (Prop 65) Article 6 "clear and reasonable warnings" regulations will come into force. By then, companies must be compliant with the revised regulations for consumer product, occupational and environmental exposures.

Key changes include adding a new warning symbol, consisting of a black exclamation point in a yellow equilateral triangle with a bold black outline. The symbol can be printed in black and white if the product's sign, label or shelf tag doesn't use yellow ink, even if other colors are used. Companies must change the warning language to state that the product "can expose you" to the Prop 65 chemical; reference OEHHA's new website, www.P65Warnings.ca.gov/product; and identify the name of one or more of the listed chemicals requiring the warning. When used to identify more than one endpoint (cancer and reproductive toxicity), the warning must include the name of one or more chemicals for each endpoint, unless the chemical is known to cause both and is identified as such in the warning.

The rules provide a short-form, on-product label as an acceptable alternative to the revised requirements for consumer product exposure warnings, previously referred to as "on-product" warning. This option requires the hazard symbol, the word "WARNING" in capital letters and bold print, and a reference to OEHHA's website, but importantly doesn't require a company to name a listed chemical within the text of the warning.

The short-form warning must contain one of the following: for consumer products that cause exposure to listed carcinogen(s), the words "Cancer — www.P65Warnings.ca.gov"; for consumer products that cause exposure to listed reproductive toxicant(s), the words "Reproductive Harm — www.P65Warnings.ca.gov"; or for consumer products that cause exposure to both a listed carcinogen and a reproductive toxicant, the words "Cancer and Reproductive Toxicant — www.P65Warnings.ca.gov."

The revised regulations clarify that the warning must be provided to the purchaser "prior to or during the purchase of the consumer product, without requiring the purchaser to seek out the warning." For Internet purchases, the warning must be provided prior to completing the purchase; this entails a warning separate from the one provided on the consumer product itself.

The amended regulations set forth new requirements if a business intends to comply with warning obligations by providing written notice to its retail seller. Retail sellers are generally responsible for placement and maintenance of warning materials, including warnings for products sold over the Internet, only when the manufacturer, producer, packager, importer, supplier or distributor of a product provides written notice that:

- states the product may result in an exposure to one or more listed chemicals;
- includes the exact name or description of the product or specific identifying information for the product such as a Universal Product Code or other identifying designation;
- contains all necessary warning materials such as labels, labeling, shelf signs or tags, and warning language for products sold on the Internet (i.e., no time-lag between receipt of the notice that a warning is required, and receipt of the warning materials themselves); and
- has been sent to the authorized agent for the retail seller, and the manufacturer, producer, packager, importer, supplier or distributor has obtained confirmation electronically or in writing of receipt of the notice.

New regulations exist providing tailored methods for transmitting warnings and warning language for several products, chemicals and area exposures: food (including dietary supplements); alcoholic beverages; food and non-alcoholic beverages in restaurants; prescription drugs; dental care and emergency medical care; raw wood; furniture; diesel engines; passenger or off-road vehicles; recreational vessels; parking garages; amusement parks; petroleum products; service stations and vehicle-repair facilities; and designated smoking areas. Any company that has warning obligations related to any of these scenarios must review and ensure compliance with the specific requirements.

Time is running out quickly. Companies are urged to review products, particularly consumer products, for which they provide warnings to determine how they will meet the new regulatory requirements. The review takes time. The consequences of non-compliance are high; you can bet private litigants will be watching closely.

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The consequences of non-compliance are high.

# EFFORTS PIN DOWN CORROSION

## Diverse research seeks insights for understanding and combating the pervasive problem

By Seán Ottewell, Editor at Large

**CORROSION EATS** up 3–4% of global gross domestic product each year, according to a 2016 study by NACE International. That translates to an annual cost of about $2.5 trillion, says the Houston-based organization that focuses on corrosion prevention and control. However, corrosion remains an elusive as well as an expensive problem to pin down.

"Chemically we understand what corrosion is — but unfortunately it doesn't occur uniformly at all. If it did, it would be easy enough to predict the rate of corrosion. What we need is well-controlled corrosion films to protect metals. It's understanding why corrosion accelerates suddenly and takes place in a particular location that is crucial here," explains Philip Withers, a professor of materials at the Royce Institute, University of Manchester, U.K.

"What is less well understood are specific features of corrosion. For example, corrosion at the atomistic level is a non-deterministic, stochastic process. So, the corrosion rate on a piece of equipment that is being used in exactly the same way from day to day will vary from day to day. Engineers don't understand this way of thinking," adds Stuart Lyon, AkzoNobel professor of corrosion control at the university.

In an effort to tackle this problem, last July BP, London, teamed up with the University of Manchester in a £5-million (≈$7-million) collaborative project. The funding is coming jointly from BP and the U.K.'s Engineering and Physical Sciences Research Council (EPSRC).

The project will bring together top researchers from the company, Imperial College London and the University of Cambridge — many of whom already work together on corrosion research through the six-year-old BP International Centre for Advanced Materials (BP-ICAM) at Manchester University — along with additional experts from the University of Leeds and University of Edinburgh.

This project stems from an earlier BP-ICAM effort which studied the fundamental processes that initiate corrosion.

"Manchester, Cambridge and Imperial have been working together for more than five years with BP looking at a range of advanced materials problems. But to solve these, we needed to bring in new skills. So, we recruited expertise from Leeds on tribocorrosion [material degradation due to the combined effect of wear and corrosion]

NEW CORROSION PROJECT

Figure 1. Effort brings together expertise from several U.K. universities as well as an oil company. *Source: University of Manchester.*


Figure 2. Advanced imaging techniques are helping researchers grasp what happens at the sub-micron level during corrosion. *Source: University of Manchester.*


Figure 3. On new builds, it is essential to confirm that protective coatings are applied properly and the underlying metal meets spec. *Source: AkzoNobel.*

and expertise from Edinburgh on how high pressure can affect the behavior of interfaces," says Withers, who serves as principal investigator on the new project.

By combining this expertise with different skills in modelling and imaging as well as performing experiments under real-life conditions, the team hopes to answer three fundamental questions: What happens at the start of corrosion? How does it then propagate? And what occurs in tribocorrosion? Some of the basic understanding gained should enable improving current materials; the team will focus particularly on developing better coatings and inhibitors as well as wear-side lubricants and additives that can be used with them to extend equipment life (Figure 1).

By applying synchrotron radiation, among other techniques, the researchers hope to understand the very early stages of oxidation. Such radiation penetrates the surface of corrosion films and helps to show the importance of material stresses and densities on how protective layers break up in localized areas.

"Imaging is very important and we are now able to cheat the fundamental limits of the accuracy to get amazing resolutions. Fifteen-to-twenty years ago, for example, 20–30 microns was high resolution with X-ray imaging. Today, we are [at] the 50-nm scale. The great thing about using X-rays is that you can look through materials, so you get to see pits and other features and understand them at the sub-micron scale," Withers explains.

Other imaging techniques used include atomic force microscopy, scanning electron microscopy and transmission electron microscopy (Figure 2).

Although the collaboration was announced in July, research really began in November. The team already has made progress: "What we have done is the basic modelling of the early stages of corrosion, looking at how structures change because, for example, the film gets thicker and this, in turn, affects diffusion and diffusion pathways. We have seen how corrosion films build up and this is very similar to the films that prevent wear. Further, when corrosion and wear occur together, the degradation accelerates and, so, we are looking at the interaction of the two. The interesting thing here is that one plus one can equal 1,000. This is because we can study the structure of corrosion and structure of wear individually — but acting together, their effect can be multiplied 1,000-fold."

The team also is starting to build some of the rigs needed to study in-situ corrosion, including special experimental cells that replicate corrosion conditions in the field.

Saline environments are getting a special focus because BP has many pipes and plant equipment that are either in or near salty water. "That'll lead us on to other studies, for example in the case of subsea pipelines, we can study the effects of different oxygen levels and different chlorine environments. On the tribocorrosion side, we are making up model lubricants and studying them, too," adds Withers.

In fact, the project has been set

up in a way to ensure that corrosion problems BP encounters in the field are fed directly to researchers via a team of company mentors who already work together in BP-ICAM. They have experience in many different specialities including upstream engineering, refining and lubricants.

"They help us to develop strategies about issues that are important to BP and also manage the flow of useful information between us and BP's businesses. These mentors are really important because they push us to look not just at simple corrosion situations but also more-complex industrial-type situations. We also have a project manager from BP with lots of goals for us to achieve, for example plotting the gradual move from in-situ investigations of simple species to more demanding situations," Withers notes.

This reflects the nature of the EPSRC funding, too, which came via the first round of a new initiative called prosperity partnerships. These are aimed specifically at bringing together industrial and academic expertise to solve industry-critical problems.

ONGOING INSPECTION

Figure 4. Coatings maker now offers a service to either manage corrosion protection for customers or advise when recoating is required. *Source: AkzoNobel.*

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## COATINGS CONCERNS

AkzoNobel, Amsterdam, has been collaborating with the University of Manchester for more than 30 years. Not part of the BP-ICAM initiative, the company focuses more on the interaction between corrosion and coatings, and broader materials sciences issues.

In 2009, the company decided that corrosion protection was such an important area both for itself and its customers that it set up a specialist community of practice (COP). "My job is to manage the knowledge in this area — to highlight what we know and what we don't know," says Simon Gibbon, AkzoNobel COP leader in the field of corrosion protection at the university.

One of the outcomes of this decision was the 2012 launch of a more-focused collaboration to look at how corrosion interacts with existing coatings and then to use this knowledge both to improve their function and to develop new, improved coatings.

In the intervening years, the team has nailed a couple of things — particularly some hypotheses that were based on gut feeling, according to Lyon. "We've proved some and disproved others."

For example, he says it's quite easy to imagine that coating adhesion is really important and controls corrosion processes. Yet, it's easy to find additives that increase adhesion but, in practice, actually reduce performance as well as some coating systems that show poor adhesion but provide superb performance, he cautions.

"So, this hypothesis is incorrect — sure the paint has to stick sufficiently to limit mechanical damage but beyond this there is no further benefit (and may be detriment) in corrosion protection by further increasing adhesion."

Another idea is that damage gradually builds up in coatings during service until flaws join to create an easy pathway from the environment to the substrate. Because the polymers used in most paint systems are crosslinked networks, it's been assumed that poorly crosslinked areas are most susceptible to water uptake and damage.

"However, for some coatings we have shown the opposite — more highly crosslinked parts of the polymer absorb more water. This counter-intuitive result was only obtained because, using our advanced analytical tools, we can probe the molecular composition of polymers at the nanoscale. So, this hypothesis may be correct but for the wrong reason. It's important because you cannot accurately and reliably design a paint system based on incorrect hypotheses."

One of the key chemical industry challenges Gibbon is tackling is corrosion under insulation (CUI). He notes: "This is particularly a problem caused by retrofits and if new builds aren't done to standard. But how do you detect it?"

The corrosion might occur at a location that's inaccessible or covered with a hard-to-safely-remove insulation layer. He knows of chemical companies that are fabricating entire buildings around very sensitive plant items to prevent exposure to water, drips from other pipes, joints, etc., that could lead to such corrosion. Another issue is humidity, particularly in cryogenic or other systems where condensation occurs, for example during plant downtime.

"So, it's a complex challenge. We are working with experts in sensing technologies at Manchester to identify clever ways to incorporate intelligence into coatings so that local damage can be narrowed down to a limited area on the plant."

"One way to prevent CUI, especially for new builds, is to ensure that the coatings are applied properly and the equipment they are used on is installed properly. It's also important that the underlying metal meets the design spec. We've had incidents of coating failures which occurred because the metal manufacturer changed its process slightly and this, in turn, created surface issues," adds Gibbon (Figure 3).

Lyon believes this message is getting through to the chemical industry, at least its more-enlightened companies: "The value added is definitely being appreciated and we are working together to create extra value for both Azko and the asset owners."

However, most operating companies have dispensed with in-house corrosion engineers and metallurgists, he points out, leading to a loss of knowledge that can prompt problems. For instance, he cites a company whose bronze shell-and-tube condenser failed after 22 years. A contractor suggested lining the tubes to plug the leaks. "However, what seemed like a good idea massively speeded up corrosion due to the increased flow rate such that the failure occurred again after just 18 months."

He mentions a corn syrup producer in the U.S. as another cautionary example. To save on the costs of potable water being used in manufacturing, it switched to its own well water. "It sounds like a very logical decision by the plant manager but the potable water contained 100 ppm of chloride ions while the well water contained 500 ppm. The plant suffered a $3–4-million failure because of the resulting localized (pitting) corrosion problems," he explains.

False economies also afflict painting. It's common for a plant to opt for the cheapest quote when paying perhaps 20% more for professional applicators could double a coating's life, stresses Lyon. This is one of the reasons that AkzoNobel has pioneered an industrial painting qualification with the Institute of Corrosion, Northampton, U.K.

The company also has launched a service for customers called Interplan in which AkzoNobel will either manage the corrosion protection of the assets involved or just provide advice as to when recoating is required (Figure 4).

"There are few corrosion issues on chemical plants that are not user-related," cautions Gibbon.

## INTERNAL RESOURCES

Unlike most chemical makers, BASF, Ludwigshafen, Germany, boasts an in-house materials engineering unit to support production processes. It covers all aspects of materials engineering connected with chemistry, including corrosion issues, and uses a range of non-destructive testing technologies.

However, the company goes outside when necessary. "In the case of exceptional and very specific problems, we cooperate with external partners such as universities and research facilities," notes a spokeswoman.

One such partner is the Materials Technology Institute, St. Louis, Mo., where BASF is working with other chemical companies including Air Products, Sabic, DuPont, Shell, Air Liquide and Chevron on a range of research initiatives. One focuses on using software for thermodynamic modeling of corrosion and training engineers so they can predict the performance of alloys in corrosive environments and to improve the design of corrosion experiments. Another focuses on developing non-invasive monitoring techniques that can identify corrosion issues that lead to the deterioration of refractory linings.

BASF also works with with the German Society for Corrosion Protection, Frankfurt, which acts as an interdisciplinary federation to bring together corrosion experts from industry and academia — with the aim of developing better tools to understand and deal with corrosion and its consequences.

"The benefit of these collaborations is that members affected with the same damage mechanisms work jointly together on mitigation approaches," says the spokeswoman. ●

# UNDERSTAND INDUSTRIAL WASTEWATER TREATMENT

A variety of techniques play roles in removing contamination | By Amin Almasi, mechanical consultant

**PROCESS PLANTS** generally try to minimize the amount of wastewater they generate. However, operations invariably result in production of some wastewater. Proper treatment of this wastewater is crucial for both environmental and economic reasons.

Industrial wastewaters usually contain organic and inorganic matter in varying degrees of concentration. They may include toxic and other harmful materials as well as components that are non-biodegradable or that can reduce the efficiency of many wastewater-treatment operations.

Thus, treatment of industrial wastewaters typically is a very difficult task — far more complicated than municipal wastewater treatment — that requires special methods and sophisticated technologies. These options fall into three categories: physical, chemical and biological. Physical treatment methods include sedimentation, flotation, filtering, stripping, ion exchange, adsorption and other processes that remove dissolved and non-dissolved substances without necessarily changing their chemical structures. Chemical methods include chemical precipitation, chemical oxidation or reduction, formation of an insoluble gas followed by stripping, and other chemical reactions that involve exchanging or sharing electrons between atoms. Biological methods rely upon living organisms using organic or, in some instances, inorganic substances for food.

Biological treatment is more widely used than any other option where reasonably complete treatment is required. It most often serves as the secondary treatment stage to remove major portions of contamination. Other processes handle primary and tertiary treatment to complete the removal of solids and other pollutants.

## THE CHALLENGE

Some industrial wastewaters are rich in organics and easily biodegradable while others are nutrient deficient, inhibiting or preventing biodegradability. Total dissolved solids and contamination may exceed by many times the levels found in domestic sewage. Industrial wastewaters often also have pHs well beyond the range of 6–9 and may contain high concentrations of dissolved metal salts. To further complicate matters, wastewater flows and characteristics within a plant also can vary with time because of campaign manufacturing or slug discharges on top of the usual discharges. In addition, spillages and dumping that occasionally may occur very adversely can impact the performance of the plant's wastewater treatment plant. Consequently, it's always prudent to carefully assess current wastewater and its treatment requirements rather than relying on the past situation. An understanding of the nature of the plant's operations is vital.

One key parameter for wastewater is its biochemical (or biological) oxygen demand (BOD). This is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given wastewater sample at a certain temperature over a specific time period. Therefore, BOD indicates indirectly the amount of organic compounds in wastewater. The BOD most commonly is expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20°C.

Another key parameter is chemical oxygen demand (COD), which indirectly specifies the amount of organic compounds in the wastewater. It indicates oxygen consumption and also is given in mg/L.

Both BOD and COD measure the amount of organic compounds in wastewater. However, COD is less specific because it measures everything that can be chemically oxidized rather than just levels of biodegradable organic matter. You can estimate the biodegradability of wastewater by considering its COD and corresponding BOD.

## PRIMARY TREATMENT

Removing large, suspended and floating solids is the focus of the first stage of wastewater treatment. However,



before such treatment takes place, the plant wastewaters usually first go to an equalization tank or system, which acts as a buffer and normalizes varying flow and contamination loads. It's always best to use a single large concrete tank to which an appropriate coating has been applied. This tank most often is sized based on the difference between expected peak and average flows, with a capacity of 4–8 hours' worth of difference common.

From the equalization tank, the raw wastewater goes for primary treatment. This usually includes screening to trap solid objects, sedimentation by gravity to remove suspended solids and some adjustments. Primary treatment sometimes is referred to as "mechanical treatment" because it relies on mechanical methods, although chemicals often are used to accelerate the sedimentation process. The design for a primary treatment facility most often includes neutralization (i.e., pH adjustment), coagulation, flocculation and dissolved air flotation (DAF).

The main purpose of primary treatment is to remove colloidal solids, emulsified oil and a small portion of BOD and COD. Primary treatment can reduce BOD of the incoming industrial wastewater by around 20–30 % and the total suspended solids by some 50–65%.

*Neutralization.* Usually, wastewater must have its pH adjusted so that sub-

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sequent operations such as downstream biological treatment can take place at optimum pH. Therefore, the wastewater passes to a neutralization system that corrects its pH. This system generally involves multiple neutralization tanks; common configurations are “3+1” (3 operating + 1 standby), “5+1” (5 operating + 1 standby) and “7+1” (7 operating + 1 standby). Injection of chemicals such as a caustic soda or sulfuric acid solution adjusts the pH to the desired level.

Sensors installed at the inlet and outlet of the neutralization tank (a minimum of one sensor in each location) measure the pH of the wastewater. A controller uses these readings to automatically adjust a dosing pump to achieve the desired final pH (typically, 6.7–8.3 with an optimum of 6.9–7.4).

The neutralization-chemical system consists of storage and mixing tanks and other equipment such as agitators necessary to reduce the concentration of the chemical and prepare it for injection. Dosing pumps are deployed in a “1+1” arrangement (1 operating + 1 standby) for each chemical. Often positive displacement pumps handle these services. However, these sometimes can pose maintenance and reliability issues. A variable-speed-drive centrifugal pump often offers an attractive alternative that provides reliability and high performance.

*Coagulation and flocculation.* Wastewater from the neutralization tank usually flows by gravity into coagulation tanks for removal of colloidal solids. Coagulation is a quick process, requiring a relatively low retention time of 2–5 min. There commonly are multiple rectangular coagulation tanks made of reinforced concrete with proper coating; each contains a few agitators that provide high-energy mixing. Large plants often use configurations such as “7+1” (7 operating + 1 standby) or “9+1” (9 operating + 1 standby) or similar. For instance, a treatment plant of 3,000-$m^3$/hr total capacity employed “7+1” tanks, each of 16 $m^3$ capacity, to achieve retention time of more than 2.2 minutes. Some large plants have used retention times as low as 1.5 min and certain radical designs propose times as low as 1 min. However, low retention times can pose risks. Generally, it’s wise to keep retention times above 2 min.

A coagulant solution (typically polymer based) usually is injected automatically by dosing pumps (“1+1” configura-

tion); most often stroke variation adjusts injection. Modern plants automatically control injection rate according to incoming flow rate based on a more or less fixed chemical concentration, preliminarily defined through site experimental tests and adjustable during normal plant operation. Coagulant aid can be added to the wastewater stream to facilitate separation of solids.

Wastewater from coagulation tanks most often flows by gravity into the flocculation system (tanks) where agglomeration of flocculent formed during coagulation process takes place. Anionic polymer usually serves as flocculent. Flocculation is a process of slow mixing with retention times of 12–40 min. Some designs for large plants have used lower retention times, say, 9–10 minutes, but typically times of 11, 12 or 15 min. are recommended. It is a process that requires less energy for agitation than coagulation.

*Dissolved air flotation.* Wastewater from flocculation passes by gravity into a DAF clarifier system. Its main purpose is to remove the suspended solids, emulsified oil, grease and some portions of BOD and COD from the wastewater. Elimination occurs through the action of micron-sized air bubbles. These are created by dissolving air in wastewater under pressure and then reverting to atmospheric pressure in DAF clarifiers. The millions of micron-size air bubbles released attach to the contaminants, decreasing their effective density and thus causing them to float on the surface to form a concentrated sludge blanket. A skimming device removes the floating sludge, which then go to sludge treatment units for processing. A common design uses a separate pressure vessel for compressed air introduction. DAF clarifiers operate effectively over a wide range of hydraulic and contamination loading.

## SECONDARY TREATMENT

Often considered the heart of the treatment plant, its major purpose is to remove biodegradable organics (expressed as BOD, COD, etc.) and ammonia. Secondary (or biological) treatment uses microbes to consume dissolved organic matter that escapes primary treatment, converting it to carbon dioxide, water and energy for microbe growth and reproduction. After this biological process, the stream goes to additional settling tanks ("secondary" clarifiers or sedimentation vessels) to eliminate more of the suspended solids. Well designed and

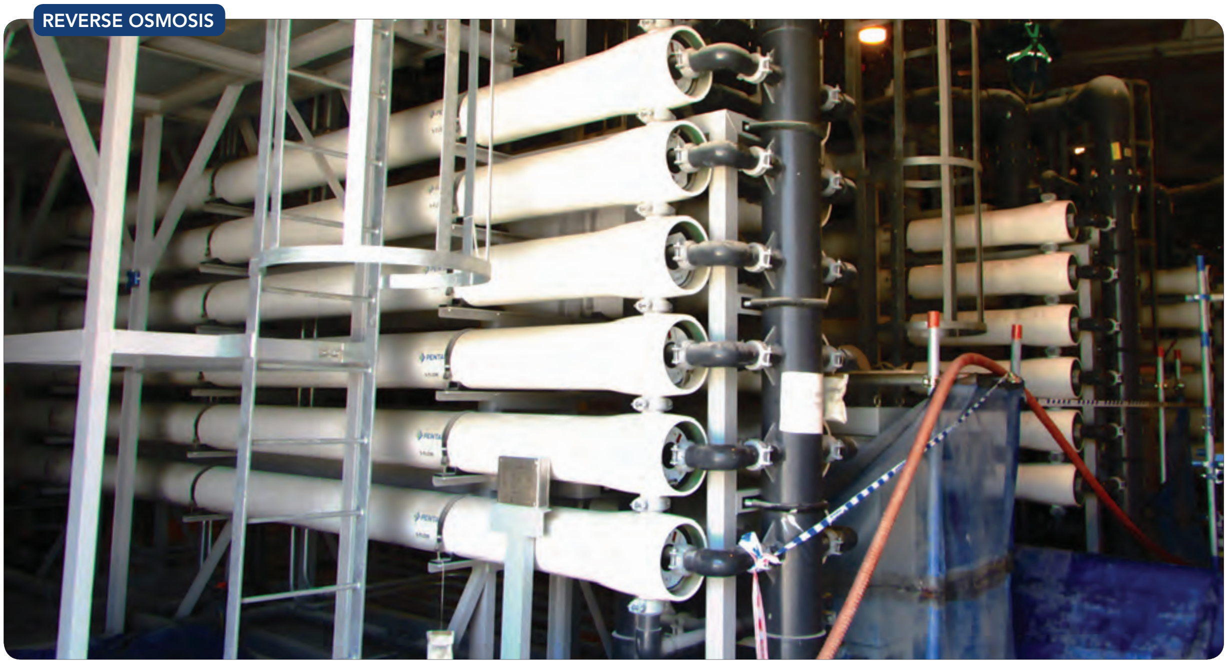


Figure 1. Use of such a unit for tertiary treatment of wastewater is becoming popular.



functioning secondary treatment can remove about 85–90% of the suspended solids and BOD. Technologies employed include the activated sludge process, which is the most commonly used method, as well as variants of pond and constructed wetland systems, trickling filters and other forms of treatment that rely on biological activity to break down organic matter.

An activated-sludge train usually is divided into an aeration section for BOD removal and nitrification, and an anoxic section for denitrification. In the aeration section, compressed air passes through the wastewater. Dissolved oxygen from the compressed air acts as a respiratory source for aerobic bacteria present in wastewater that decompose the organic load (expressed as BOD and COD) and ammonia to carbon dioxide and nitrates, respectively. In the anoxic section, bacteria use the oxygen in nitrates as a respiratory source, thus converting the nitrates to nitrogen gas.

In practice, denitrified wastewater from the anoxic tank flows downstream to the aeration (or BOD-removal) tank where aerobic bacteria decompose the organic load and ammonia present using dissolved oxygen supplied by air blower(s). The treated effluent from the aeration tank usually flows by gravity to a secondary clarifier, which most often is a gravity clarifier. Here, sludge is removed from the treated effluent, which then passes to tertiary treatment. A portion of the sludge gets recycled to the anoxic section to provide nitrates for denitrification. This recirculation keeps effluent nitrates' concentration below the required limits. The remaining portion of sludge goes to sludge treatment facilities.

Biological treatment usually consists of multiple streams, say, 4, 6 or 8 trains, with a proper safety factor (for instance,

1.5 or more) to ensure the biological treatment can handle the incoming design flow even if one train is taken out of operation. Selection of the hydraulic retention time for the anoxic zone requires great care. Considering different operational and process factors, as a rough indication, this time usually is 5–8 hr. Some designs for large plants have used 5.5 hr, 6 hr and 6.5 hr as optimum values. Hydraulic retention time for the aeration tank is longer, somewhere between 19 and 24 hr. Some large plants have found a retention time of 20 hr to be optimum.

### TERTIARY TREATMENT

This ensures removal of remaining contamination and solids in the wastewater. Such tertiary treatment usually involves filtration systems such as disc filters, reverse osmosis (RO) units (Figure 1), etc. You usually should direct filter reject from backwash or RO unit rejects to the flow distribution chamber upstream of the equalization system; most often, these rejects require a dedicated pumping system. To eliminate specific contaminations to meet regulatory requirements, many plants must resort to special treatment, e.g., the Fenton process to remove non-biodegradable COD. While other technology options are available, the Fenton process most often is selected because of its reliability, initial cost, operational cost and footprint.

The Fenton section usually consists of dosing systems for hydrogen peroxide and ferrous sulfate. After dosing with chemical in an oxidation tank, the wastewater goes to tube settlers to settle out the contaminants. During regular operation plants generally don't need to put wastewater through such treatment. However, having a Fenton section can ensure treatment adequacy when facing sustained peak COD in the wastewater.

Many units in tertiary treatment such as that for the Fenton process or fine filtration should consist of multiple parallel streams to provide flexibility during operation. Commonly used arrangements are "n+1" and "n+2" — for example, "2+2" "3+1" "4+2" and "5+1". ●

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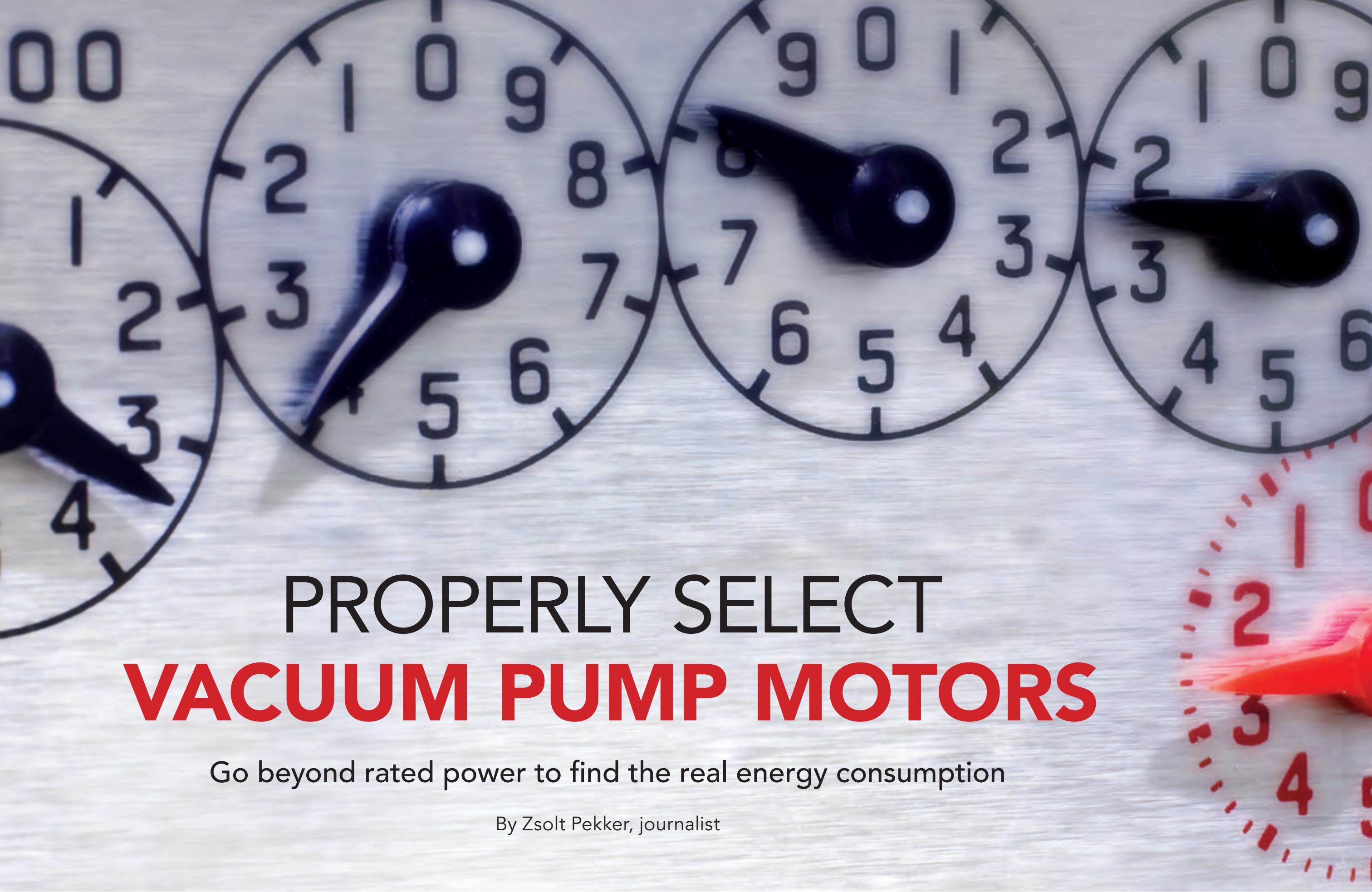

# PROPERLY SELECT VACUUM PUMP MOTORS

## Go beyond rated power to find the real energy consumption

By Zsolt Pekker, journalist

**PLANT DESIGNERS** frequently opt for the lowest possible rated power of drive motors, e.g., when selecting vacuum pumps. However, the kilowatt specification on the nameplate doesn't tell very much about the real energy consumption of the device in actual use. It tells even less when a service factor (SF) disguises the maximum rated power. Instead of focusing on rated power, you should perform a systemic analysis to find out how to achieve optimal energy efficiency in a vacuum system.

First, consider two key factors — ultimate pressure and pumping speed — when selecting a vacuum pump. They determine the actual vacuum performance, i.e., the vacuum level reached in a certain period and available in the application. Usually, vacuum pumps using completely different technologies can achieve the same required performance level. For example, a rotary vane vacuum pump (the most widely used technology today) operating at 1,000 rpm provides performance similar to that of an oil-lubricated screw vacuum pump running at up to 7,000 rpm.

Motor nameplates can reflect differences in operating principle. For instance, the nameplate on the screw vacuum pump might indicate a lower rated power than that shown on the rotary vane vacuum pump. However, power consumption in the actual process regularly departs significantly from the rated power. The motor with the smaller number in front of the kW specification doesn't necessarily use less power than the "larger" drive. Quite often, the exact opposite is the case, especially when the SF — a figure found on American nameplates — further obscures the real rated power.

You also should consider aspects other than nameplate figures to achieve optimal energy efficiency. To begin with, no linear relationship exists between power consumption and the provided performance (shaft power) in an electric motor. The device usually reaches optimal performance somewhere between 50% and 100% of its rated power. It's quite safe to assume that the motor works at highest efficiency in some range around 75% of the rated power. Below this range, the motor needs more power in relation to the actual

MOTOR NAMEPLATE

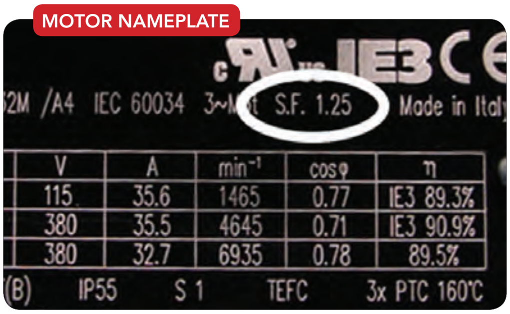


Figure 1. The service factor of 1.25 means the motor can temporarily exceed its rated power by up to 25%.

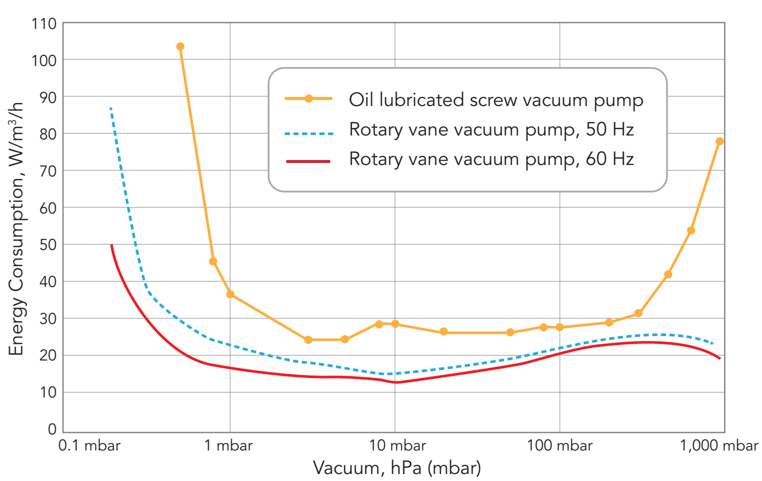


Figure 2. Lower-rated motor consumes far more energy than the "larger" one in actual service. *Source: Busch.*

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performance, thus increasing the relative power consumption.

### SERVICE FACTOR CONFUSION

The relative power consumption also is higher when the optimal range is exceeded. Permissible operation can extend beyond 100% of rated power if the SF is over 1.0. According to the U.S.'s National Electrical Manufacturers Association (NEMA) standard "Motors and Generators" (NEMA MG1-2016), the SF given on the nameplate specifies the degree to which a motor can be loaded beyond its rated power. The rated power multiplied by the SF value represents the degree of overloading allowed. For the nameplate shown in Figure 1, the SF of 1.25 means the real maximum rated power is 25% higher than indicated. So, in the case of this 15.0-kW-rated-power motor, the maximum permissible, thus real, rated power is 15.0 × 1.25 = 18.75 kW.

NEMA explicitly cautions that a motor should operate in the SF range only for short periods. However, strong oscillation routinely occurs in vacuum generation. Instantly starting the vacuum pump from standby mode or firing it up to high peak loads is recorded as "temporary" overloading, even if this happens regularly and in short cycles. In such cases, the relatively low rated power not adjusted for the SF suggests low power consumption although the actual pumping performance clearly exceeds the nominal figure. The motor also works significantly outside of its efficiency optimum for much of the time, periodically running in the SF range. Besides the extra energy consumption, such operation also negatively impacts the motor's maintenance costs and lifecycle, and can lead to earlier-than-expected replacement.

Realistic comparison of the actual energy efficiency of different vacuum pumps requires measuring power consumption and performance in practice.

A German vacuum pump manufacturer, Busch, ran such parallel tests using:

1. a speed-controlled oil-lubricated screw vacuum pump from another manufacturer with a specified rated power of 15 kW plus an SF of 1.25; and
2. a rotary vane vacuum pump from its own product line with a rated power of 18.5 kW on the nameplate.

Test results proved illuminating. In the main operational range around 10 mbar, the power consumption of the motor with the lower nameplate rating was nearly twice as high as that of the one with the higher rating (Figure 2). The rotary vane vacuum pump, running at much lower speed, worked substantially more efficiently despite its larger motor. The efficiency gap widened at both ends of the curve.

### MAKE A WISE CHOICE

You can't achieve the highest energy efficiency in a vacuum supply system without a comprehensive analysis. Don't merely compare nominal energy consumption. Apart from ultimate pressure and pumping speed, thoroughly evaluate the operating principle. Whether a pump is oil-lubricated or dry-compressing plays a crucial role as far as its compatibility with the process. Installation site, control technology, process cycles, the option of a vacuum buffer, and the connection between process and vacuum generation also can strongly influence the choice of technology. It's always a good idea to consult a qualified vacuum specialist. That person can help you find the right pump or system design by providing insights on actual energy consumption and the application's critical characteristics. ●

**ZSOLT PEKKER**, is a Heitersheim, Germany-based freelance journalist specializing in automation and production technology. Email him at pekker@pekker.de.


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# CONSIDER PROCESS COLORIMETRIC/PHOTOMETRIC ANALYZERS

## FIELD-BASED UNITS CAN PROVIDE LABORATORY-QUALITY RESULTS IN NEAR REAL TIME

By Steven Smith, Endress+Hauser

**MANY CHEMICAL** plants need colorimetric/photometric analysis of various compounds in their process and wastewater systems. Historically, processors relied upon lab-based benchtop systems to perform this type of analysis. Today however, improved designs and digital technologies in field-based process analyzers can produce lab-quality results automatically, more frequently and with much less required labor.

Colorimetric/photometric analysis determines the concentration of a chemical element or compound in a solution by combining a reagent with a sample. This results in a specific sample color; its intensity is proportional to the concentration of the compound of interest.

The color intensity is measured photometrically based on the Beer-Lambert law. This law states that a linear relationship exists between a sample's absorbance of light and the concentration of the absorbing species, in this case, color.

Lab-based systems rely upon hand-delivered and manually prepared samples for analysis. Field-based systems get samples via independent sample systems operating in concert with the analyzer.

Proper colorimetric/photometric analysis involves three elements: sample preparation and delivery; colorimetry (combining the sample and reagent to produce color); and photometry (measurement of the resulting color intensity). Improper or mediocre performance in any of these three areas will lead to measurement error. Therefore, it's important to thoroughly understand the potential limitations of any given system.

### WIDE APPLICABILITY

Colorimetric/photometric analyzers can handle a range of compounds and suit a diverse range of applications. For instance, analyses of ammonium, phosphorus, iron and nitrite are crucial for water and wastewater. Ammonium measurement is critical in wastewater for monitoring ammonia reduction. Orthophosphate measurement is used in process control of phosphate removal, either biologically or through flocculation.

Measurements of total phosphorus now are vital to ensure effluents meet discharge permit levels, which are becoming increasingly stringent as state environmental agencies and the U.S. Environmental Protection Agency (EPA) clamp down on nutrient levels in effluent.

Drinking water plants need iron analysis, which falls under the non-mandatory standards with secondary maximum contamination levels (SMCLs); the EPA secondary standard for iron is 0.3 ppm. In industrial processes, iron can build up in tanks, storage vessels, water heaters and pipelines. Iron deposits can decrease capacity, reduce pressure and increase maintenance. They also can cause self-closing valves to stick.

Plant steam and cooling-water systems require monitoring and control of hardness to improve the quality of the water. Hardness isn't a health hazard but the calcium, magnesium and other metals causing water hardness can lead to scaling in boilers, cooling towers and other equipment, reducing the efficiency of heat transfer. In steam systems, lower levels of impurities decrease corrosion rates in boilers and lower the frequency of blowdowns, which cuts fuel costs

### LABORATORY ANALYSIS

Benchtop spectrophotometers are a common tool for colorimetric/photometric analysis in industrial processes. These spectrometers use a small vial of sample, with colorimetric reagents added to achieve the desired color reaction. Because they operate over a range of light wavelengths, these devices can measure a range of colors — and thus can provide results for various compounds. It's not uncommon to measure more than 35 different parameters with one spectrometer by using a variety of reagents. Newer benchtop systems incorporate barcode readers and RFID [radio frequency identification] technology to auto-identify the appropriate method and calibration adjustments.

However, benchtop systems are relegated to the lab, with testing performed by lab technicians. This necessitates sampling at the process and transferring those samples to the lab for analysis. These systems can produce an accurate result — but one only indicative of the sample at the time of analysis, not when it was taken.

Moreover, sample collection and transfer can require very specific criteria to ensure sample integrity prior to analysis.



Samples may need filtering or treating and may demand analysis within a certain limited time. What may appear on the surface as a straightforward process — sample collection and preparation — can be time-consuming and prone to error.

For example, when analyzing for iron, dissolved iron requires a well-filtered sample while less filtering is necessary for total iron that includes undissolved iron. Turbidity, iron oxide, high iron content and other factors can interfere with the results and all must be taken into account.

In addition, the demand on lab technicians' time severely limits the frequency at which they can perform the analyses. As with any analysis, cost also must be considered. Benchtop systems can run more than $4,000. To this you must add the cost of reagents and sample preparation, as well as labor to collect and deliver the samples to the lab.

Because lab results don't represent what's happening in the process in real time, they at best enable manual adjustments to operations, with the impact of these adjustments not known until the next sample is analyzed.

### IN-SITU ANALYSIS

A field-based colorimetric/photometric analyzer (Figure 1) eliminates or greatly reduces the need for manual sampling and lab analysis for many compounds. Today, in many processes, lab analysis serves to spot check and verify in-situ analyzers making measurements directly at the process and in nearly real time.

Often referred to as "cabinet analyzers," these systems perform the same function as a benchtop spectrometer but generally use a photometer operating at a specific wavelength and so are limited to one parameter. This limitation rules these analyzers out for applications requiring simultaneous measurement of multiple compounds.

For many compounds, a straightforward reagent-based sample color reaction occurs that allows direct photometric measurement. However, total phosphorus analyzers need a digestion process ahead of the colorimetric analysis. There are a range of suppliers for these systems, with different approaches for how they perform the three basic functions of sampler preparation, chemical/sample management and photometry.

FIELD-BASED ANALYZER

Figure 1. Units such as this chromate analyzer can provide lab-quality accuracy in near real time.

A high-quality sample preparation system that ensures a proper sample is provided to the analyzer is key to the success of a photometric/colorimetric analyzer installation. Such a system (Figure 2) at a minimum must incorporate filter media. Removal of particulates is crucial to protect the internal workings of the analyzer, such as the tubing and photometer, from plugging or coating. Analyzers are designed to handle small sample sizes, reducing the amount of reagent required for each analysis, thus keeping operating costs to a minimum. As a result, tubing, pumps, valves and other fluid components have narrow flow paths that a poorly filtered sample could easily block.

Some sample preparation systems require an external pump or process pressure to deliver the sample to the analyzer while others include a pump for sample delivery.

Installation of the sample system demands care. You must position the sample system filter in the process to ensure extraction of a representative sample. In addition, you must choose a filter porosity appropriate for the application. The filter porosity should match that used for any comparative lab tests. The filter should be readily accessible and easy to clean on a routine basis.

Ideally, a system should offer automatic cleaning with air backwash or even chemical cleaning. Chemical cleaning can

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be critical in an influent installation where greases or oils can be present, along with high biological activity that can lead to filter or sample line plugging.

For freezing weather environments, install tracing or another appropriate heating option on the sample system tubing.

## OPERATIONAL IMPERATIVES

Achieving the most economic and effective ongoing performance of a field-based analyzer requires paying adequate attention to three key factors: consumables, components and control system integration.

*Consumables.* Operating costs of colorimetric analyzers rise and fall with reagent consumption. The more reagent required for each analysis, the higher the operating costs will be. The key to keeping costs low is long reagent life and small consumption with each analysis.

Look for reagents that are easy to prepare and have a long shelf life prior to preparation and after installation in the analyzer. A longer shelf life allows you to purchase the materials well in advance, so product is on hand when reagent replacement is necessary.

Higher consumption rates mean reagents will need changing out more often, increasing overall maintenance costs. Systems that track reagent usage and indicate when it's time to replace reagents assist in efficient analyzer maintenance. Some systems offer internal reagent cooling systems to help extend the life of reagents, reducing replacement frequency. Consider this approach to increase reagent lifetime.

Besides reagent consumption, each internal cleaning and calibration cycle consumes chemicals. In some analyzers, the rate of cleaner consumption will vary based on water hardness, which can add to the cost of operation.

*Components.* Any photometric/colorimetric analyzer will require routine maintenance that involves pump and tubing replacement, along with upkeep of valves and motors that may exist. Overall cost of ownership highly depends on the number of wear parts, their frequency of replacement, cost and impact on analyzer downtime. So, consider the inner workings of the analyzer and the wear components' lifetimes stated by the manufacturer. Some analyzer designs require extensive part replacements that rely on an array of tools. Newer designs significantly reduce the number of parts requiring service, virtually eliminating the need for tools and dramatically decreasing the time required to perform routine maintenance.

Historically, peristaltic pumps handled reagent and sample dosing. New analyzers now rely on dosing syringe pumps that are more precise, consume less liquid, need replacement less frequently and are easy to change out.

*Control system integration*. Today's photometric/colorimetric analyzers offer a range of output options from traditional 4-20-mA analog to fieldbus digital communications such as Profibus, Modbus or EtherNet/IP. Additionally,

SAMPLE PREPARATION SYSTEM

Figure 2. Such units must contain filter media and sometimes include a sample delivery pump.

some systems provide the ability to integrate other sensor measurements within the analyzer, expanding its functionality and reducing capital costs for additional measurement values.

### TAKE TO THE FIELD

Don't relegate colorimetric/photometric analysis to the laboratory. Getting accurate and reliable measurement of various parameters in situ has become a more attractive option. The advent of newer analyzer designs dramatically reduces reagent consumption and eases maintenance. These newer systems, working in conjunction with improved sample preparation systems, can provide laboratory-quality results at a much lower cost of ownership than a lab-based system.

However, perhaps the biggest advantage of field-based analyzers is their generation of nearly real time data. This allows for tighter control of a process thanks to a higher frequency of accurate actual process data. ●

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# ENERGY HARVESTER STARS FOR STEAM MONITORING

Device eases concerns about battery replacement for hard-to-access wireless transmitters

By John Rezabek, Ashland, and Andy Zaremba, Perpetua

**ASHLAND'S PLANT** in Lima, Ohio, converts low-value hydrocarbons into high-value organic chemical compounds via several processes. Other Ashland facilities use Lima's exceptionally pure end products to make numerous useful solvents and additives. Unforeseen interruptions to this supply chain put millions of dollars of product at risk. So, insights into the condition of key process equipment can play an essential role in effective planning of inventories and production as well as for optimal scheduling of preventative maintenance to maximize productivity while eliminating unnecessary and unplanned downtime.

The hydrocarbon conversion process is challenging and requires extensive technical expertise and sophisticated equipment. One important component is a fluidized bed reactor that handles a highly exothermic reaction. It relies on cooling provided by superheating saturated steam. Fouling in the reactor's steam coils can jeopardize the efficiency of the heat exchange. Even worse, fouling can cause leaks of superheated steam into the reactor that eventually damage the catalyst. Better monitoring of steam flow would enable determining the condition of the critical reactor coils and, thus, when appropriate scheduled maintenance was necessary. This, in turn, would allow the plant to operate the reactor with confidence.

Providing that confidence would require capturing information about the condition of the superheated steam coils, initially with no process connections or flanges. The instrumentation would need to accommodate pipe surface temperatures in excess of 500°F in an area reachable only by scaffolding. This initially led to the testing of acoustic and temperature transmitters.

It was thought that gradual fouling of the steam pipes would cause changes in the acoustic signature of the steam flow. While measurement changes did occur, the acoustic signals didn't show a strong correlation to variations in flow in the superheated steam coils.

The acoustic instruments did monitor surface temperature as well. When paired with the coil's outlet (surface) temperature, evidence of fouling could be surmised over time but the meaning of real-time measurements wasn't always clear. Because the differential temperature methods correctly identified fouled coils, the plant elected to install flanges to allow individual passes to be chemically cleaned.

The addition of flanges created the option for direct flow measurement — at a time the Rosemount unit of Emerson was looking for a beta tester for an experimental design that allowed top mounting of a differential pressure (DP) flow transmitter to a type-405C stainless-steel conditioning orifice plate in steam service. The Rosemount 3051 DP transmitter design avoided the need for heat-traced impulse lines. The wireless transmitter enabled getting flow measurements with minimal effort and installation cost.

The desired frequency of data readings from the flow meter raised an issue, though. A 4-sec update rate would require frequent battery maintenance in the extremely hot, hard-to-access location. With pipe temperatures greater than 500°F, the air temperatures around the transmitters easily could exceed 140°F. Given the high temperatures, the risk of burns and heat stroke are ever present. Even the toughest instrument technician was challenged during the initial equipment installations.

Looking for a way to tackle the battery replacement issue, the plant decided to explore the use of Power Puck thermoelectric energy harvesters. These small devices feature protruding heat-sink bristles and convert the heat flow from temperature differences directly into electricity. With heat sources ranging from "warm to the touch" to hot steam pipes, Power Pucks generate enough electricity to fully power the most-popular wireless transmitters for many years, eliminating the need for battery replacements. As long as a temperature difference is present, the thermoelectric energy harvester powers the transmitters; the battery is preserved for operation during turndowns and other occasions when a loss of process heat occurs. The devices are intrinsically safe and easy to install.

The plant installed a demonstration unit in November 2014 that harvests heat from the steam lines. That Power Puck was a success. It has prevented equipment failures and also improved worker safety by eliminating the need to service batteries in high temperature locations only accessible with scaffolding.

STEAM-COIL MONITORING

Figure 1. Teaming of wireless transmitter with energy harvester provided an ideal solution for gathering data.

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"Energy Harvesting Widens Wireless' Appeal," http://bit.ly/2H0TlmP

Plant staff feel teaming the Power Puck with the Rosemount 3051 transmitter (Figure 1) has been very beneficial. They are impressed with the resiliency and ruggedness of the wirelessHART 3051 and the Power Puck in this harsh service — one that provides accurate steam flow measurements while extending the period for battery changes by many years. Now, the transmitters and Power Pucks can be ordered together directly from Emerson.

For Ashland, the project met the original goals, which included a greatly improved understanding of the condition of the reactor superheated steam coils. With this information, the plant can reduce the risk of unplanned outages while improving the effectiveness of scheduled turnarounds. Most importantly, the measurements enhance the reliability and confidence of the supply chain for the product made in the reactor and, thus, for end products that depend upon it.

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# Deftly Diagnose a Dust Collector

Consider upstream operations as the potential cause of sudden problems

## THIS MONTH'S PUZZLER

At our plant, which manufactures a powder, we are suffering sudden problems with a pulsed-air cartridge dust collector. The unit, installed in 1978, is 20-ft tall and has an inside diameter of 6 ft and a 35° cone bottom. It has run flawlessly until the last month. The collector is downstream from a hammer mill in another unit. The mill is having a little trouble with wetting but otherwise runs like a Swiss watch. I've been asked to install an inspection platform in the collector and to resolve three reliability issues: 1) the external cartridge bags are wetted but only on one side; 2) like most dusts, ours is combustible, and collects up to 6-in. deep on some of the supports inside the collector; and 3) the wall thickness is only 10-gauge stainless steel.

What should I include in my inspection report?

**LOOK UPSTREAM**

For any piece of equipment that long has run well and then suddenly doesn't, I suggest starting your troubleshooting by asking what has changed upstream. You may not need to alter the downstream equipment if the change is temporary, seasonal, or its effects are minor.

I wouldn't assume just yet that all is well with the hammer mill. Hammer mills are fairly dynamic; when they do quit from build-up, it could be catastrophic. I would look at this upstream issue immediately.

As for the question of why the bags are wetting only on one side, you need to look at gas distribution. Something may have changed or gone unnoticed. There could be new blockages in the gas distribution plate, a reduction in the blower capacity restricting flow, or it could be the pulse jets.

Many years ago, I discovered choked flow in a plant's compressed air system. It first showed up in blinded cartridges in a dust collector. As I recall, the blinding was worse on the side farthest away from the air line header. Look at this carefully.

As for the inspection platform, this sounds like a lingering item on somebody's wish list. Ask maintenance how they grab the bags now. Chances are they don't need a platform.

If do you have to install the platform, the thin-gauge tank shell poses a challenge. In addition, you face risks from welding and cutting inside a tank that works with a combustible dust. I suggest welding a ring or donut outside of the tank and bolting together the structure of the platform inside the tank. If not, the platform structure will punch through the tank wall like a screw driver through a soda can. I suggest using about 25 lb/ft$^2$ with a 250-lb central load for a design basis. However, this is not a structural engineer's opinion; it may be possible to get away with only drilled holes and a completely bolted-in platform.

The platform will provide more surface for dust to collect. Go with polished round stock for supports; square tubing is a bad idea because it collects dust no matter how much it's polished. There may be specialized grating that could be used that won't collect dust. Instead, though, I would plan for sections that can be removed after the work is done inside the collector. Grating will collect a lot of dangerous dust; structure, especially round-stock tubing, won't collect much dust. Besides, it will be much easier to clean the outside of a tank for welding than to clean the inside.

If operations can't live without the grating, then make sure workers entering the dust collector wear electrostatic dissipating shoes, use non-sparking tools — usually bronze, and delicately remove as much collected dust as practical before entering the vessel. Also, if there's a way to humidify the air in the tank without making work difficult, do so. Ideally, you want avoid working on tanks during the winter when air is especially dry.

*Dirk Willard, consultant*
*Wooster, Ohio*

*Continued on p.44*

# Understand a Cold Fact about Ice

The common perception that it provides insulation on surfaces is wrong

The erroneous summary appeared in a reputable peer-reviewed journal.

**WALKING AROUND** plants can identify many small improvements that can enhance profitability. One example comes from a refrigerated process plant that called me in for troubleshooting. An improperly operating unit there required considerable field work. In walking between the control room and the problem equipment, I noticed a lot of ice in many spots on the piping. In a cryogenic plant, ice signals heat gain from the environment; this adds load on the refrigeration system.

My first response was to comment that the plant could save energy or increase capacity by fixing the heat gain problem. The response came back: "We don't worry about that — the ice insulates the piping." The idea that ice acts as insulation is a common, but false, perception. In another plant, I was told: "Ice must be a pretty good insulator — Eskimos use it to build igloos."

Today, many people turn to the Internet to quickly look up information. One engineer searching online for the insulation value of ice found a plethora of confusing data rather than clarity. That's not surprising because many factors — including the rate of freezing, airborne contaminants present, entrapped air or gases, measurement technique and measurement device accuracy — affect the measured thermal conductivity of ice.

Figure 1 presents a range of reported values from different sources for the thermal conductivity of ice. At -40°F, the highest and lowest cited values differ by about 23%!

This certainly is enough of a difference to worry about if you are looking at food processing or Arctic engineering work on pipelines to prevent permafrost melting. However, does it really matter when it comes to the issue of ice insulating pipes in a refrigerated or cryogenic process plant? Not really — because the variance pales compared to the difference between the thermal conductivity of ice versus that of insulation materials.

As Table 1 shows, ice has roughly 100 times the thermal conductivity of economic thermal insulation materials. Ice isn't a good insulator. In warm areas, ice comes from water condensed on a surface from the air around it. Condensation heat-transfer has enormously higher heat transfer coefficients than those of convection heat transfer. Ice on piping represents significant heat load for a refrigeration system.

Ice invariably indicates inadequacies in insulation practices at a plant. Insulation addition, replacement and repair always are worth the effort to prevent ice formation. Don't let uncertainty about precise values of data prevent informed decisions.

This example provides another, perhaps even more important, lesson.

I created Figure 1 by reviewing seven datasets. Each plot represents the original correlations developed for the particular dataset. These correlations date back to 1922. Often, engineers don't go back to the original work when verifying correlation data ranges but instead depend upon later summaries of the correlations.

Finding and verifying the data showed that one of the most recent summaries had two major flaws. First, the correlation given in the summary used the wrong temperature units; the authors had mixed up Kelvin with degrees Centigrade. Second, the summary transposed the inter-

ICE THERMAL CONDUCTIVITY

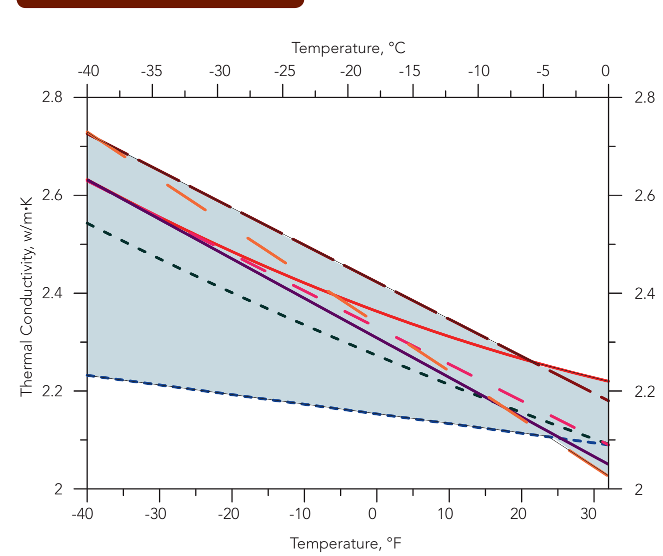


Figure 1. Broad variation in values reported in the literature can lead to confusion.

**THERMAL CONDUCTIVITIES**

| Material | Thermal Conductivity, w/m·K |
|---|---|
| Aluminum | 221 |
| Mild steel | 45.3 |
| Ice | 2.05–2.76 |
| Brick | 0.7 |
| Cellulose | 0.057 |
| Mineral fiber | 0.0519–0.115 |
| Calcium silicate | 0.0317–0.0851 |
| Fiberglass blanket | 0.0245–0.0866 |
| Polyurethane foam | 0.0159–0.0260 |
| Phenolic foam | 0.020 |
| Aerogels | ~0.014 |

Table 1. The thermal conductivity of ice is nowhere near that of common insulation materials.

cept and slope values of another correlation for a linear curve fit. This summary didn't appear in an Internet blog but in a reputable peer-reviewed journal.

The lesson here is that an engineer always should check the validity of calculation methods and data before using them. This might involve anything from a quick review of their reasonableness based on experience to a full statistical analysis of the data and correlations. The level of work will depend upon the criticality of the decision and the engineer's experience level with the subject. The more important the determination and the less familiar the topic, the greater the need becomes to verify. ●

**ANDREW SLOLEY**, Contributing Editor
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## PROCESS PUZZLER

*Continued from p.42*

# JULY'S PUZZLER

We migrated our distributed control system (DCS) last year as part of a major expansion. Our old system, purchased for $221,000 in 1995, handled about 148 analog points and about 272 discrete points. The new system runs about 201 analog points and 346 discrete points; we originally planned for 192 analog points and 320 discrete points — and allowed for 20% extra capacity. We used a rule-of-thumb of $500/point, which our consultant said was conservative. We spent $478,000; our budget was $256,000. Management isn't happy with the cost but they are thrilled with the performance of the DCS.

Accounting criticized the project team for eating the contingency for the expansion. Then, they asked us why the project was designed for 20% excess capacity and why we didn't plan better since we used 7% more capacity than expected. Lastly, corporate grumbled that we destroyed the rate of return for the expansion.

Meanwhile, production complained to corporate management that we constrained them on points. We replied that we couldn't fit more racks in the electrical room and this caused a lot of the extra cost because the old boxes couldn't be reused; we had to expedite getting replacements to complete the project. Our DCS is in the center of a hazardous area close to the operations.

What do you think we did wrong? Is there a better way to plan a DCS project?

Send us your comments, suggestions or solutions for this question by June 15, 2018. We'll include as many of them as possible in the July 2018 issue and all on ChemicalProcessing.com. Send visuals — a sketch is fine. E-mail us at ProcessPuzzler@putman.net or mail to Process Puzzler, Chemical Processing, 1501 E. Woodfield Rd., Suite 400N, Schaumburg, IL 60173. Fax: (630) 467-1120. Please include your name, title, location and company affiliation in the response.

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

## Coating Protects Flue Gas Desulfurization Systems

ARC S7 AR is a sprayable, erosion-resistant version of the company's ARC S7 coating. It is designed to protect surfaces exposed to condensing flue gas with erosive particulates in gas flow. The coating is comprised of silicon carbide particles and micronized glass flake reinforcements that are suspended in a high-performance Novolac vinyl ester resin. It can easily be applied by conventional airless spray at film thickness of up to 0.6 mm (25 mils) per coat. When cured, the coating forms a film, providing resistance to erosive particulate flow under elevated temperature condensing gas exposures seen in flue gas and desulfurization environments.


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## Fan Withstands Hazardous Environments

UL-approved for operation in Class II, Division 2 locations, the SA XD2 fan helps to prevent combustible dust buildup in overhead and hard-to-reach areas.


Along with reducing manual cleaning expenses, the fan also helps facilities maintain compliance with relevant NFPA and OSHA regulations to keep employees safe from combustible dust hazards.

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## Pressure Gauge Handles Harsh Environments


The Ashcroft 1209 pressure gauge reportedly provides maximum safety in harsh environments. A 316L stainless-steel solid front case and ring along with a pressure-relief back ensure that the process fluid will be directed away from the operator in the event of an internal failure. Optional liquid fill or the Plus Performance option dampens shock, vibration and pulsation. With a 4 ½-in. dial size and accuracy to ±0.50% of span, the pressure gauge meets the requirements of ASME B40.100, Grade 2A.

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## Module Optimizes Remote Monitoring

The Bedrock OSA Remote is a lower-cost and high-performance controller that combines PLC, RTU and edge control; intrinsic cyber security; and universal I/O into a compact standalone module that is ideal for remote monitoring and control applications, says the company. It is configured with standard Bedrock IEC 61131-3 engineering tools and a hardened metal enclosure. At 5.4 × 8.9 × 2.3 in. thick, the device takes up minimal cabinet space, which can help in remote areas where space is at a premium. The controllers operate at temperature ranges between -40° C and +80° C without fans or forced draft.


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www.bedrockautomation.com

## Scrubber Package Speeds Commissioning

Venturi scrubbers Series 7000/8000 are now available as an integrated pre-engineered package that includes recirculation pump, piping networks, instrumentation and automated controls. All components are factory assembled and tested to help lower engineering, installation and project costs while reducing lead times for quicker installation and on-time operation. Exterior units are available with freeze protection for operation in cold weather climates. These pre-engineered systems come with all necessary dimensional, weight and instructional information along with a system P&ID and process flow diagram giving all material balances. The scrubbers help meet PM 10 and PM 2.5 particulate emission standards and offer low maintenance operation.

**Bionomic Industries**
201-529-1094
www.bionomicind.com


## Flow Meter Easily Integrates into Automation Systems

The Picomag electromagnetic flow meter is an in-line transmitter for measuring temperature and flow of conductive liquids in pipe sizes ranging from ½ to 2 in. It measures flow up to 198 gal/min. with ±0.5% full scale accuracy and ±0.2% repeatability, and temperatures from 14 to 158°F (-10 to 70°C) with ±4.5°F accuracy. The flow meter combines a sensor and transmitter in the same housing, with a 1.4-in. TFT color display showing flow, totalizer and temperature readings, as well as warning and alarm messages. IO-Link connectivity provides flexible integration into automation systems. The Bluetooth wireless interface allows direct access to process and diagnostics data, and enables the user to configure the measuring device on the fly.

Endress+Hauser
888-363-7377
www.us.endress.com

## Augurs Expand Mixer Feed Range

Designed with circular flat-bottom feed chambers, the Model 170 dry solids volumetric feeder features a slowly

rotating horizontal agitator operating at a constant or variable speed. This ensures the feeder's two variable speed metering augers are completely filled with product conditioned to a consistent state, while simultaneously aiding the downward flow of material from the feeder's integral supply hopper into the feed chamber. Proper sizing of the two independently driven metering augers reportedly provides a wide feed range (over 130:1), with Model 170-1-2 capable of a maximum throughput of 84 $ft^3$/hr and 160 $ft^3$/hr for Model 170-2-2.

**Acrison, Inc.**
201-440-8300
www.acrison.com

## Valve Packages Save Space

These wafer-style V-port ball valve packages are designed for flow control in severe service applications. A choice of seven V-shaped ports offers control of viscous or corrosive fluids, gases and steam. Automated control valve packages are available in ANSI Classes 150 and 300 (½ in. to 6 in.), and 600 (½ in. to 4 in.) with carbon or stainless-steel bodies. Ball port choices include 15º, 30º, 60º or 90º V-balls plus variable tapered 15/30º, 30/60º or 60/90º V-balls for greater control. The space-saving wafer valves include a blow-out-proof stainless-steel stem with adjustable packing, stainless-steel ball and PTFE seats, packing and thrust washer.

**Bonomi North America**
704-412-9031
www.bonominorthamerica.com

## Visualization Technology Aids Batch Productivity

Experion Batch visualization technology combines batch automation processes with distributed control

capabilities. This approach provides operators with insights into upcoming events or potential delays, making it easier for them to conduct multiple tasks, take appropriate actions sooner and adjust next steps accordingly. It also makes operations less critically dependent on individual operator experience, which will help manufacturers overcome skill gaps at a time when more veteran operators are retiring, the company believes. In addition, the technology simplifies ongoing maintenance by eliminating the need for a centralized, dedicated batch server. Engineering and maintenance personnel can take a unit controller out of service without affecting other units.

**Honeywell Process Solutions**
800-822-7673
www.honeywellprocess.com

## Cone Mill Handles Sticky Materials

A 29.5-in. (750-mm) diameter cone mill, the Kason model CGM 750 gently grinds fatty, heat-sensitive, sticky, moist or fragile materials into uniform particle sizes with minimal fines at rates to 35 tons/h (32 m.t./hr). Vertical material flow and low-energy grinding action with short residence times yield close particle size distribution from 125 to 250 microns, without noise, dust, product build-up or heat generation. The sanitary unit is suitable for wet and dry milling, preconditioning and de-agglomerating of a range of bulk products. Constructed of stainless steel to sanitary or industrial standards, the mill is top-driven by a belt drive. Interlocked moving components include a time-delay function for operator safety.

**Kason Corporation**
973- 467-8140
www.kason.com

## Vacuum Pumps Offer Optimized Efficiency

Dolphin LM/LT liquid ring vacuum pumps come in two models with a total of 13 sizes available for a variety of process applications. The LM models are single-stage vacuum pumps for the rough vacuum range from atmospheric pressure to 100 Torr ultimate pressure. LT models are available in two-stage versions and cover the vacuum range from atmospheric pressure to 25 Torr. Both models have a modular design and integrated flow channels, making them compact. The optional motor pedestal eliminates the need for base frames because the NEMA premium efficiency motor is directly flange-mounted. Mechanical shaft seals, made of FKM or FFKM depending on the pumping medium, ensure a long lifecycle.

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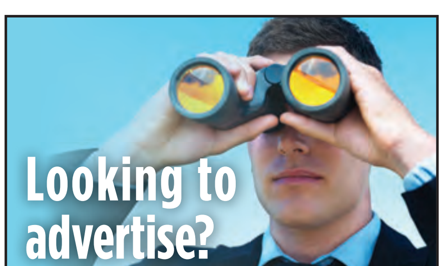

# Scientists Eye Cheaper Adsorbent

Algae-based material shows promise as a cost-effective replacement for activated carbon

The synthesis method is simple and easy to scale up.

**A TEAM** of researchers from the Chemistry for Technologies Laboratory and the Department of Mechanical and Industrial Engineering, University of Brescia, Brescia, Italy, has developed a new class of low-cost and sustainable materials that they believe could replace activated carbon in many wastewater and air pollution treatment applications.

Today wastewater treatment encompasses many different technologies, including membrane filtration, ion-exchange, coagulation, adsorption, flocculation, microbiological or enzymatic decomposition, and advanced oxidation. (For more on this topic, see, "Understand Industrial Wastewater Treatment," p. 26.)

Adsorption often is a favored technology because of its simplicity, ease of operation, ability to respond rapidly to changing conditions, insensitivity to toxicity, and high efficiency and convenience.

One of the most commonly used adsorbents is activated carbon, well-known for its high adsorption capacity for dyes, organic contaminants and heavy metals. However, it is expensive to produce and regenerate, and can pose disposal problems.

This was the starting point for the researchers. They considered various natural resources and industrial byproducts that could be used as cost-effective and more-environmentally-friendly replacements. The result is an easily synthesized, porous, low-cost hybrid material that can act as adsorbent and filter for organic compounds' removal, both from the air and wastewater.

The hybrid material is obtained by combining sodium alginate — a naturally occurring, highly abundant and inexpensive polysaccharide — with amorphous silica fume, a byproduct derived from ferrosilicon or silicon metal alloy processing.

Sodium alginate, readily extracted from algae and seaweed, has long been the focus of intensive research due to its gelling capacity, film forming, emulsion stabilizing, biocompatibility, and non-toxicity properties. However, its mechanical strength often is an issue; research to overcome the problem includes crosslinking, blending with hydrophilic materials and nanoreinforcement to produce nano-composites.

Also included in this research is alginate's ability to form organic/inorganic composites — particularly with silica. These composites offer many advantages in terms of chemical and mechanical stability. They already are being investigated for possible applications in the fields of biomedicine, biocatalysis, bioseparation and biosensing. However, manufacture of such composites can involve solvents and precipitating agents that impact both their environmental and economic benefits.

What the researchers have achieved is a simple synthesis of a new porous hybrid material using sodium alginate and silica fume that is easy to scale up. The material is consolidated by the gelling properties of alginate and by decomposition of sodium-bicarbonate controlled porosity at low temperatures (70–80°C). The structural, thermal, and morphological characterization shows that the material is a mesoporous (having pore diameters of 2–50-nm) organic/inorganic hybrid. An article in *Frontiers in Chemistry* describes the research.

"This paper shows the simple synthesis of a new porous hybrid material, obtained by using low cost and byproduct materials," says lead author, Elza Bontempi from the University of Brescia. "The material was designed on the basis of the European Commission's request to develop an affordable, sustainable and innovative design-driven material solution that can reduce the concentration of particulate matter in urban areas."

"The article reports preliminary results about the new material's capability to capture particulate matter. It can also be used for wastewater remediation. In particular, its ability to replace activated carbon is demonstrated," she adds.

Wastewater pollution was tested using methylene blue dye as a model pollutant. The hybrid material adsorbed and removed the dye, even at high concentrations, with 94% efficiency. Further, coating the material with a 100-nm thin film of titania imparts good photodegradation of pollutants (more than 20%).

Analyses showed that, compared with activated carbon, production of the hybrid material consumed less energy while leaving a much smaller carbon footprint. The material also demonstrated encouraging capabilities for trapping diesel-exhaust-fume particulate matter.

The hybrid material can be applied as a coating, used for spraying or brushing, or 3-D printed. This means it could be used to cover external building surfaces to remove particulate matter, as well as in the design of novel water filtration units. This versatility, says Bontempi, makes it an exciting addition to the toolkit for reducing air and water pollution. ●

**SEÁN OTTEWELL**, Editor at Large
sottewell@putman.net

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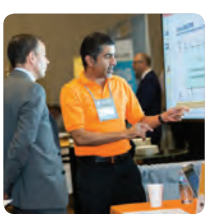

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