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ChE Apprenticeship Debuts

U.K. program combines on-the-job experience with part-time study

Such programs also could work in the United States.

STUDENTS EAGER to earn a chemical engineering degree but concerned about the cost or time commitment of attending university full-time now have a new option, at least in the U.K. An initiative just launched there provides an apprenticeship route to a bachelor's degree in chemical engineering from an accredited university. A candidate works directly for a company, gaining real-world experience while studying at the university part-time.

The Institution of Chemical Engineers (IChemE), Rugby, U.K., the University of Chester (UC), Chester, U.K., and employers worked together to set up the apprenticeship program. To take part, a candidate must apply directly to a participating company. If accepted, the person becomes a full-time employee of the company during the apprenticeship and pays no tuition fees.

"The new Science Industry Process/Plant Engineer degree apprenticeship has also been designed in consultation with major employers of chemical engineers in the North West. Unilever, the global consumer goods company, was the first employer in the U.K. to offer the apprenticeship," notes IChemE.

Bill Harper, immediate past vice president, qualifications, at IChemE, spent the last two years working with UC on its apprenticeship model.

Typically, the apprenticeship program will involve an average of 40 days of study per year over a five-year period, with the rest of the training occurring in the workplace, according to UC.

In late January, IChemE and UC announced the first person enrolled in the program: Michael Leary, who works for Unilever at Port Sunlight, near Liverpool.

"It's a superb opportunity for me. I'm busy but really happy to be learning in both the university and workplace environment. The principles I get from my university studies are reinforced with real-life experience at Unilever, where I work closely with process development engineers, R&D scientists and pilot plant technicians," he enthuses.

Tom Gibbins, a manager at the Unilever facility, adds: "We're delighted to have partnered with the University of Chester to offer the U.K.'s first chemical engineering degree apprenticeship and to be able to support Michael with the first step in his career. At Unilever we understand the huge benefit in supporting young future talent with their transition into work, and in the coming years we will be looking for more enthusiastic apprentices to join us in making a sustainable difference."

UC currently lists a similar apprenticeship opportunity at Cavendish-Nuclear in Warrington.

IChemE now is in early stage discussions with other U.K. universities about running similar apprenticeship programs. It sees its key role as accrediting programs so students have a clear route to professional development and registration.

Such programs also could work in the United States. Sure, apprenticeships represent a significant step up for employers of chemical engineers — in both commitment and financial support — from the short-term internships available here. However, enlightened companies should appreciate the potential value. For their part, American universities should see such programs as a way to extend their reach to capable people who can't engage in a full-time program for a chemical engineering degree. Moreover, the industrial insights the apprentices bring to their coursework might benefit other students — and even some professors.

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Properly Instrument Your Solids Process

Four types of measurements usually make sense

Advances have made suspended solids measurements more reliable.

THE DEARTH of instrumentation typically built into a process design involving particulate solids can lead to major challenges in effectively working with the materials. While cost certainly plays a role in limiting the amount of instrumentation, most often the primary factor is lack of understanding how solids behave differently than pure liquids or gases. For solids, measurement of physical properties and process conditions frequently is much more difficult and instrument placement more critical.

With suspended solids, restriction of the flow (orifice plates and cone meters) and attempts at measuring pressure drop are major problems. Also, suspended solids don't travel through piping at the same velocity as the fluid and have a tendency to settle. Even fine particles, which may move at close to the fluid velocity, can bunch up due to turbulence, making them behave like much larger particles. Fortunately, important advances have occurred in instrumentation for particulate solids, whether in slurries or suspended in gas.

Surprisingly, simplicity often is better when dealing with solids. When I was teaching graduate students, I asked a class at the start of a slurry pipeline experiment how we were going to calibrate our flow meter. After discussing several alternatives, one student sheepishly noted that in his home country the only option was to use a bucket, stopwatch and scale to establish flow rate. Advances have made suspended solids measurements more reliable, primarily due to non-intrusive or non-restrictive sensors and the durability of these devices.

EXPLORE ISSUES POSED BY SOLIDS

Check out previous Solid Advice columns online at www.ChemicalProcessing.com/voices/solid-advice/. Find out the questions others have had about solids processing — and the answers to them — and pose your own questions by visiting www.ChemicalProcessing.com/experts/solids-processing/.

Four key measurements usually are important when handling solids. So, let's look at them and some of the best devices for getting readings.

Volumetric flow rate. My favorite inexpensive device is still the old-fashioned Pitot tube. You must place it in the top of any pipe and purge it to prevent solids from accumulating and plugging the S-type probe. You may have to resort to occasional bursts of purging fluid to dislodge any deposits. A Pitot tube will give fluid velocities but works best at low solids concentrations, where settling is unlikely. Ultrasonic instruments can handle a wide range of concentrations: Doppler devices give the particle velocity, while transit-time devices provide an average flow rate but work best at low solids concentrations; both can be clamped on slurry pipelines. Electromagnetic flow meters suit applications with turbulent flow where turndown is limited and, when properly calibrated, are very accurate; some can be cleaned in-situ.

Mass flow rate. You can convert volumetric flow rate to mass flow rate with the appropriate physical properties; you may have to make do with estimates for these. Coriolis meters avoid this issue and often can be calibrated on a pure fluid such as water. Selection of the tube size is critical and you must consider vibration when placing the unit. Thermal flow meters are inexpensive and work best when the specific heat of the fluid and solids are the same; these devices can foul and mostly suit low solids concentrations. For bulk solids, you can use impact plates on discharge points. When feeding bulk solids, I suggest loss-in-weight designs.

Density. Vibrating tubes (which can be straight, a U-tube design or a probe) give bulk density that can be correlated to moisture content of a slurry when the particle density is well known. Particle size affects measurement very little but low flow rate gives slow response. Ultrasonic devices provide a rapid response to concentration. X-ray or γ-ray are best suited to concentrations above 5%. Because they are very expensive, electrochemical devices that give 3D concentrations via tomography seldom are used.

Level. Load cells are inexpensive and very accurate when calibrated for the density of the slurry system. They don't give the best indication of level for bulk solids due to the fluidity of the solids. Advances in the last few years in ultrasonic and radio-frequency echo systems have eliminated this issue. These devices are non-invasive and unaffected by deposits. For slurries, bubblers are inexpensive but gas can cause fouling. Restrict the use of capacitive instruments to upper limit alarms and conductive materials.

These four measurements usually suffice to control your solids processing systems. Leaving them out of a design likely will cause trouble for years to come. ●

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Give Prime Focus to Secondary Containment

This last line of defense can forestall major environmental events

DIKED AREAS keep fluids released by leaks, spills, overflows, etc., from wreaking major environmental damage. Yet, secondary containment measures sometimes don't get sufficient scrutiny. Consider what I found when called in as part of a team to repair and verify compliance for a solvent containment area at a paint manufacturer in southwestern Ohio in 1991 after the U.S. Occupational Safety and Health Administration had put that plant under its microscope. A few years earlier, a storage tank on the site blew up in a lightning storm for lack of a lightning rod; this led to a release into a nearby river. The plant also didn't provide an automatic shutoff for tanker trucks and a local alarm. Moreover, the site's procedure for emptying stormwater from the diked areas was simply to open a valve and drain the water into the river. Before you dismiss these lapses as ones that only occurred way back when, let me assure you that I've seen much worse, even recently.

Providing proper secondary containment is important. Getting it wrong can be expensive. Indeed, secondary containment is a last resort for preventing a potential turn-out-the-lights legal problem. If you release a flammable or toxic fluid into the environment, you've already committed a violation. Keeping it out of a creek avoids major liability for restitution.

First, know where to find the law: Title 40 of the Code of Federal Regulations (CFR) — Part 264.175 is for portable storage; Part 264.193 is for fixed storage of >1,320 gallons in aboveground storage tanks and 42,000 gallons in underground tanks.

Next, let's consider stormwater. In U.S. Environmental Protection Agency documents, this is covered under the Stormwater Pollution Prevention Plan. For large permanent tanks, secondary containment must hold 100% of the volume of the largest tank in the containment area as well as the stormwater runoff for a 25-year flood with a 24-hour rainfall intensity. (Perhaps with global warming, stormwater containment requirements may increase.) A diked area surrounding portable tanks must contain 10% of the sum of the tank volumes or 100% of the volume of the largest tank, whichever is greatest. Assume the same stormwater requirement for portable tanks as for large, fixed ones. It's safe to empty a diked area only if the pollutant stored is at less than the legal concentration for discharge. In New York, for instance, that's 1% by mass of the liquid in the diked area. A list of toxic chemicals appears in 40 CFR 401.15 of the Clean Water Act. Typically, regulations exclude ethanol, biodiesel and other biodegradable chemicals, if unblended with fuels — but check with your specific reporting authority.

There are ways to avoid problems with secondary containment: 1) build on a hill, avoid a flood zone; 2) put tanks under cover to reduce stormwater accumulation; 3) properly anchor tanks so they can't float away; 4) consider secondary power requirements to remove stormwater during a prolonged power failure; 5) use a double-walled tank in place of secondary containment; and 6) perform routine inspections of the concrete in the diked areas and the tanks — the American Petroleum Institute (API) generally recommends a 10-yr cycle that should include thickness testing and internal inspection.

Don't count on concrete alone; get the proper concrete coating and expansion joints for pads. Cracks developing in the concrete can cause significant problems. Remember, it's as important to keep groundwater out of the diked areas as chemicals in. Determine what happens to chemicals after exposure to water and air. If they produce an acid, you require an acid-proof coating. As a rough estimate, in 2019 dollars, a new concrete coating could cost $9–12/ft^2$ and demolition and repair of concrete could run $190/ft^2$.

Adequate control also is essential. API-RP-2350, "Overfill Protection for Storage Tanks in Petroleum Facilities," provides some guidance on instruments and controls. The National Fire Protection Association's NFPA-30, "Flammable and Combustible Liquids Code," also offers pointers. Both differentiate between attended and unattended (i.e., no one is present when liquids are transferred) facilities. According to API-2350, only unattended facilities must have automatic shutoff level control. (API recommends a high-high alarm/trip at 15 minutes after a steady-rate transfer reaches the normal, safe level in a tank.) However, regulators often insist upon automatic control for attended facilities, and also may set requirements for level instruments and controls.

For additional information, refer to: http://bit.ly/2t1WjyU; http://bit.ly/2t0VdU8; http://bit.ly/2CY44dD.

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It's as important to keep groundwater out as chemicals in.

Greener Ammonia Beckons

Approach could lead to smaller processing plants powered by alternative energy

A NEW hybrid route offers a more environmentally friendly way to make ammonia than the commonly used Haber-Bosch process, a highly energy-intensive method using nitrogen, hydrogen gas and an iron catalyst, say researchers at Case Western Reserve University (CWRU), Cleveland.

The approach, developed by professors Mohan Sankaran and Julie Renner, uses an electrolytic process with a plasma (Figure 1) to create ammonia from nitrogen and water at low temperature and pressure, and without using hydrogen or the solid metal catalyst necessary in traditional processes.

"In our system, the ammonia is formed at the interface of a gas plasma and liquid water surface and forms freely in solution," explains Sankaran.

The researchers took a cue from the Birkeland-Eyde process — which actually predates Haber-Bosch — where nitrogen and oxygen react to produce nitrates. The journal *Science Advances* contains more detail.

"Our approach is similar to electrolytic synthesis of ammonia, which has gained interest as an alternative to Haber-Bosch because it can be integrated with renewable energy," notes Sankaran. "However, like the Birkeland-Eyde process, we use a plasma, which is energy intensive. Electricity is still a barrier, but less so now, and with the increase in renewables, it may not be a barrier at all in the future.

"And perhaps most significantly, our process does not produce hydrogen gas," he stresses. "This has been the major bottleneck of other electrolytic approaches to forming ammonia from water (and nitrogen), the undesirable formation of hydrogen."

Eliminating the hydrogen and high pressure and temperature makes the process more scalable, adds Renner.

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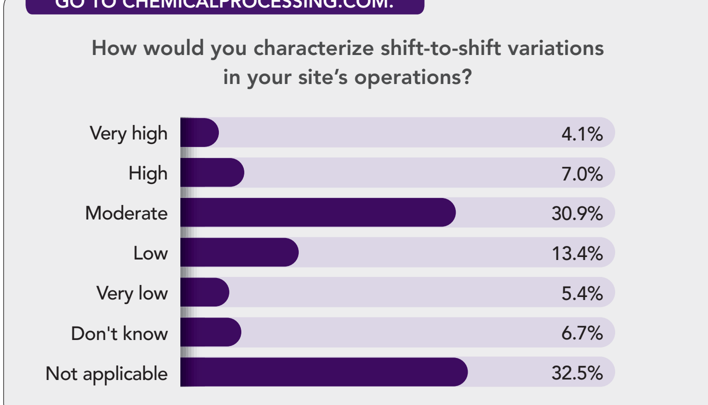


Far more respondents reported moderate or less impact than high or greater impact.

AMMONIA PROCESS

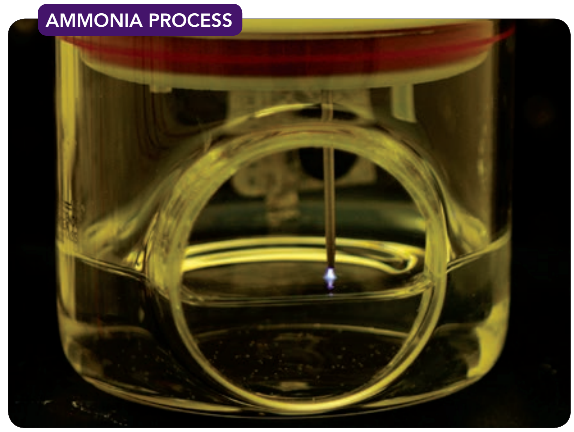


Figure 1. A plasma electrolytic system is used to synthesize ammonia from nitrogen and water. *Source: Joe Toth, Case Western Reserve University.*

The researchers see their process as the ideal kind of technology for a much smaller plant, one with high potential to be powered by renewable energy. "As the technology develops, larger plants could be envisioned," says Renner.

The team, which so far only has produced very small batches using their process at an energy efficiency less than that of Haber-Bosch, is optimistic. To achieve lower energy consumption, the Sankaran Lab currently is looking at different reactor designs. "We also aim to elucidate the reaction mechanisms in the coming years," notes Renner.

This will involve first gaining a deeper fundamental understanding of the process which likely will take 3–5 years, reckons Renner. "This knowledge will ultimately aid in reactor design in the future," she believes.

"While the potential exists to lower the energy consumption of the plasma-based process, ultimately the value of the process may not lie in the energy consumption. It may be attractive because it can directly use renewable energy and can be performed at small scales for distributed ammonia production," she adds.

The team currently doesn't have immediate plans to integrate the process with renewable energy, "but it is fun to imagine that one day we will have learned enough to be able to do a demonstration with the windmill located on the CWRU campus," notes Renner. "A nice first step could be to integrate the process with a battery, making it portable. The battery could be coupled or replaced by renewable energy in the future."

In addition, purification of the ammonia produced still needs attention. "Process engineering for the balance of [the] plant is a significant yet exciting undertaking," says Renner.

New Catalyst Takes Shape

A SHAPE-SHIFTING porous material that mimics the way proteins work looks promising as a catalyst, say researchers at the Department of Chemistry of the University of Liverpool, Liverpool, U.K. Proteins change their structures in response to their environment to carry out chemical processes. In contrast, the porous materials widely used in industry, both in catalysts for producing fuels and chemicals and in environmental remediation technologies such as adsorbers for removing harmful compounds from air and water, are rigid.

The Liverpool team has produced a flexible crystalline porous (pores <1 nm) material composed of metal ions and a small tri-peptide molecule that can change its structure in response to its environment to perform specific chemical processes.

Known as ZnGlyGlyHis (glycine, glycine and histidine – the tri-peptide), the material uses the same atomic-scale mechanisms as proteins to switch between structures.

"This offers exciting scientific possibilities, for example in catalysis, through the design of materials that can dynamically select the structure needed for a particular task," says research lead professor Matt Rosseinsky.

"ZnGlyGlyHis is a proof-of-concept material that demonstrates key aspects of enzyme-like response in a synthetic porous material. The identification of specific applications forms part of our future development of this class of materials, as in the long term we envisage them enabling new types of catalytic and separation processes inspired by biology," he adds.

Production involves simple solvothermal processing similar to that used in making synthetic zeolites — so, in principle, this class of material should be scalable. What will vary are the metal used and the synthesis cost and complexity of the organic molecule selected.

To understand the structural flexibility and activity of ZnGlyGlyHis, Rosseinsky's researchers now are refining the experimental and computational techniques they developed. This should allow them to develop the next generation of functional flexible porous materials that can alter their structure in response to changes in the surrounding chemistry.

In particular, the researchers are targeting materials with larger pores to allow them to handle a wider range of molecules and chemical processes, introducing chemical functionality into the material that enables specific catalytic and separation processes, and expanding the range of molecular linkers that permit the enzyme-like response (Figure 2).

ADAPTABLE MATERIAL

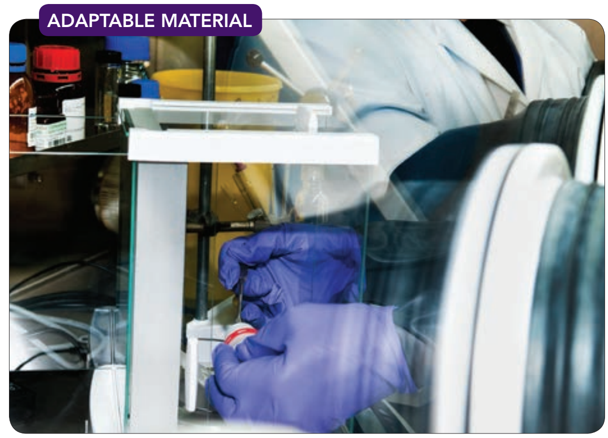
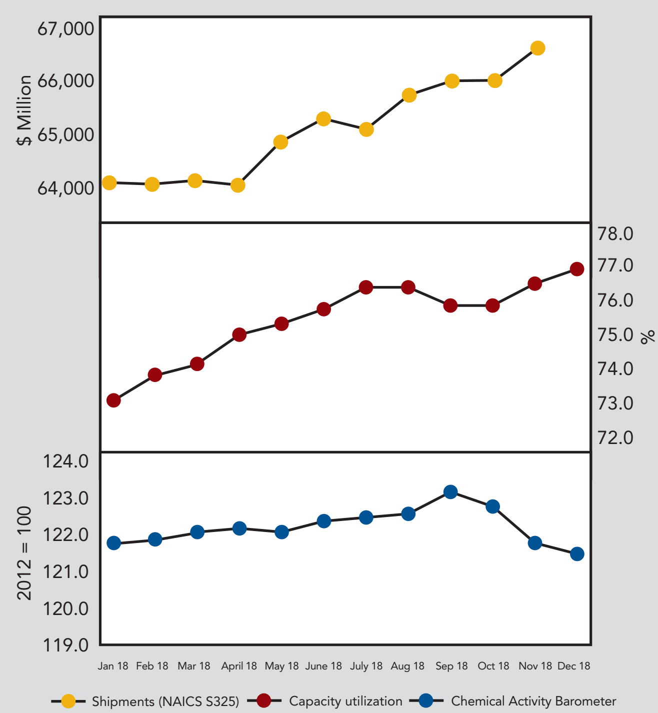


Figure 2. Planned introduction of chemical functionality will allow carrying out specific catalytic and separation processes. *Source: Department of Chemistry, the University of Liverpool.*

Although the researchers haven't developed the new material with an eye to particular industrial processes, they are in regular contact with a range of companies about the project's progress and have industrial scientists involved in their discussions about the future direction of the work.

ECONOMIC SNAPSHOT



Capacity utilization rose while the CAB slipped. *(The December shipments number was not available at presstime.) Source: American Chemistry Council.*

Incorporate Upgrades Right from the Start

Avoid opting for less-energy-efficient but cheaper equipment when building a new plant

"The greenfield advantage" can apply to revamps that combine energy efficiency with other objectives.

SUBSTANTIAL PRESSURE exists to design and build chemical plants and refineries as fast as possible, and with the lowest capital investment. It's often argued that enhancements, including those that improve energy efficiency, can wait until the plant is running and producing revenue. However, this logic has at least two weaknesses.

First, it's inevitably more difficult to install equipment after a plant has been commissioned, because you either have to carry out the installation in the midst of a busy, working facility — with all the inconvenience and added hazards that causes, or do it during a shutdown, which adds to the project costs, and also results in expensive lost production.

Second, quite apart from shutdown premiums, the economics of energy efficiency revamps are inherently less attractive than improvements incorporated in new designs because of what I call "the greenfield advantage."

Consider a plant that requires a motor-driven centrifugal pump with a shaft power of 500 kW. The designers consider two options — a "standard" motor/pump combination, and a "premium efficiency" motor/pump combination. The main equipment item cost for the standard option is $150,000 while the high-efficiency option is 10% higher, or $165,000. If we assume a Lang factor of 4, the total module costs are $600,000 and $660,000, respectively — a difference of $60,000 in total module costs.

The annual electric power costs for the two options are $500,000/yr and $450,000/yr, respectively — a difference of $50,000/yr in energy costs.

The simple payback on the upgrade to the high-efficiency combination is therefore 60,000/50,000, or 1.2 years — assuming the upgrade is made in the initial design.

Let's suppose the plant is built with the standard motor/pump combination, to minimize initial costs. The plant owners later consider a revamp project to replace it with the high-efficiency combination. The savings are the same as in the new plant analysis ($50,000/yr), because we are comparing the performance of the same two equipment options. However, the revamp project must bear the full cost of the new, high-efficiency motor/pump combination. If we assume that all of the existing infrastructure (foundations, piping, control, etc.) can be retained in the revamp, the total cost would be little more than the cost of the main equipment items, or $165,000. The simple payback is now 165,000/50,000, or 3.3 years. This is nearly three times longer than if the upgrade had been made in the original design.

This simplified example contains many assumptions that an astute reader might reasonably challenge. However, the overall conclusion is clear: When you replace an existing piece of equipment with an upgrade, you typically pay full price for the new item, while only gaining the incremental benefit between it and the old equipment. However, if you incorporate the upgrade in the initial design, you get the same benefit with much less incremental cost. Consequently, the overall economics of incorporating energy-efficient equipment into manufacturing facilities are generally much more favorable in new plant designs than they are in revamps. This conclusion applies not only to pumps and motors. It's equally applicable to a wide range of equipment types, including boilers, furnaces, heat exchangers and insulation.

This doesn't mean there are no attractive revamps that improve energy efficiency. On the contrary, there are many. Most of the best energy-efficiency revamp opportunities arise when equipment needs replacing or upgrading for other reasons. This might happen, for example, when a boiler or a pump reaches the end of its useful life. In these situations, the minimum cost option is usually a like-for-like replacement. However, it's generally possible to install high-efficiency equipment for a relatively small incremental cost — the economics can be very favorable, just as in the new plant (greenfield) case. Doing a like-for-like replacement is a wasted opportunity. You often can justify high-efficiency equipment or upgraded systems (e.g., heat integration) when new facilities are needed to debottleneck an existing plant. Another common situation involving replacements or upgrades is environmental compliance; this can create viable opportunities to install more-energy-efficient equipment. We can generalize this principle by saying "the greenfield advantage" applies not only to efficiency upgrades in new plant designs, but also to revamps that combine energy efficiency with other objectives.

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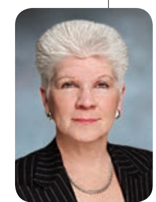
New York Disclosure Program Hits a Snag

Deadline to divulge information on ingredients in consumer cleaning products gets delayed



ON JANUARY 9, 2019, the New York Department of Environmental Conservation (NYDEC) announced it was delaying its enforcement of the New York Household Cleansing Product Information Disclosure Program (NYDP) to October 2, 2019. This article explains the significance of this development.

On June 6, 2018, NYDEC released its disclosure program setting forth extensive requirements for manufacturers of certain consumer cleaning products to divulge information regarding the ingredients in those products. Manufacturers are required to identify all ingredients and impurities in their products, including those that are chemicals of concern, as well as their content by weight in ranges, and post the information on their websites. Authority for the program derives from Article 35 of the Environmental Conservation Law.

The NYDP calls for grouping information into the following categories:

- All ingredients intentionally added to a covered product should be disclosed, including those present in trace quantities, unless they are withheld as confidential business information (CBI);
- All ingredients present only as an unintentional consequence of manufacturing and present above trace quantities should be disclosed where the manufacturer knows or should reasonably know of such ingredients, impurities or contaminants, unless they are withheld as CBI; and
- All ingredients present only as an unintentional consequence of manufacturing and present in trace quantities should be disclosed where the manufacturer knows or should reasonably know that such ingredients, impurities,or contaminants must meet certain criteria.

The NYDP significantly differs from California's Cleaning Product Right to Know Act of 2017 (S.B. 258), which was signed into law in October 2017 with partial implementation required in 2020. Despite New York's program following eight months after California's, NYDEC intended to implement the first phase six months earlier, or by July 1, 2019. California describes and requires the disclosure of intentionally added ingredients as: "a chemical that a manufacturer has intentionally added to a designated product and that has a functional or technical effect in the designated product, including, but not limited to, the components of intentionally added fragrance ingredients and colorants and intentional breakdown products of an added chemical that also have a functional or technical effect in the designated product." California also requires identification of nonfunctional constituents — certain substances that are incidental components of intentionally added ingredients, breakdown products of intentionally added ingredients, or byproducts of the manufacturing process that have no functional or technical effect on the designated product. California's requirements are much more clear-cut than New York's; manufacturers will be able to label their products with a high degree of accuracy. Under the NYDP, it's unclear what a manufacturer should reasonably know of impurities or contaminants present only as an unintended consequence of manufacturing.

Unlike California, New York's program wasn't extensively vetted among cleaning product manufacturers before its issuance. This, along with the lack of alignment between the New York and California programs, inspired two trade associations, the Household Cleaning Products Association and the American Cleaning Institute, to challenge judicially the NYDP. The suit alleges NYDEC violated important administrative procedures and that its refusal to work with industry has created an "unworkable" policy that should be retracted so a consistent national model for ingredient communication can be implemented instead. Some claim that NYDEC exceeded its regulatory power by issuing the program under the authority of the Environmental Conservation Law, a law enacted in the early 1970s.

While litigation progresses through the New York courts, NYDEC will delay enforcement, stating:

> [NYDEC] will not enforce the July 1, 2019 milestone requirement pursuant to ECL 35-0107 and 6 NYCRR 659.6, for a period running from July 1, 2019 to October 1, 2019. [NYDEC] will begin enforcing any violations of the above required disclosure as of October 2, 2019. Nothing set forth herein effect any other legally binding requirements for which manufacturers must comply; or [NYDEC's] right to enforce any other legal requirements.

NYDEC's decision to delay enforcement is a good development. To the extent the ongoing litigation may prompt greater alignment between the two divergent state programs, the enforcement stay may facilitate positive action in this regard. At the least, the delay allows impacted commercial entities and suppliers additional time to comply with the law's requirements.

NYDEC's decision to delay enforcement is a good development.

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INDUSTRY TACKLES

Developments aim to turn vast amounts of discarded material into feedstocks

By Seán Ottewell, Editor at Large

MID-JANUARY SAW what promises to be a significant move in the global push to tackle the problem of plastic waste. Thirty global companies involved in all aspects of the plastics value chain, from chemical and plastic manufacturers to consumer goods companies, retailers and waste management firms launched the Alliance to End Plastic Waste (AEPW), www.endplasticwaste.org. The AEPW counts companies such as BASF, Dow, LyondellBasell, Procter & Gamble, Sasol and Shell among its members. It plans to invest $1.5 billion over the next five years to develop and bring to scale technologies and strategies that will help minimize and manage plastic waste and promote a circular economy, i.e., using waste and end-of-life materials to lessen input of fresh feeds and energy.

Meanwhile, Pathway21, https://pathway21.com, launched in 2017, has developed a cloud-based materials marketplace concept to foster materials reuse around the world. Participants — more than 1,000 already take part in the organization's national and regional materials marketplaces — sign up and provide information about reusable materials and services they want to trade, sell or purchase. The marketplace actively analyzes materials desired and available, and sends participants curated matches. Joining materials marketplaces and listing and searching for material is free; a participant only pays a fee based on the value of a transaction once it's completed.

Regional initiatives also are underway, notably in the European Union (EU). Its "Strategy for Plastics in a Circular Economy," adopted in January 2018 (see: "Europe Eyes Plastic Recycling Efforts," http://bit.ly/2GeqiMH), sets ambitious objectives for recycling of plastics and reuse of plastic packaging that currently accounts for 27 million mt/yr of post-consumer plastic waste generated in member states. For example, the goal is to recycle 55% of plastic packaging by 2030.

The strategy provided a timely spur to technology developers keen to recycle this waste and reuse it as a raw material in chemical processes. The result has been a rash of announcements by companies including SABIC, BASF, OMV and Neste about investments in these technologies.

UPGRADING PROJECT

In December, SABIC, Sittard, the Netherlands, announced it had signed a memorandum of understanding with plastics recycling specialist Plastic Energy, London, to build a plant for the supply of feedstock to support SABIC's petrochemical operations in Europe. The facility — expected to begin commercial production in 2021 — will be the first commercial one in the Netherlands to refine and upgrade Plastic Energy's TACOIL feedstock.

The U.K. company has developed a thermal anaerobic conversion (TAC) process to produce TACOIL from raw,

PLASTICS PLAGUE

end-of-life or contaminated plastic waste. The feed material undergoes mechanical pre-treatment to remove unusable components such as metals and heavier plastics, leaving behind the usable portion — low density polyethylene (LDPE), high density polyethylene (HDPE), polystyrene (PS) and polypropylene (PP). The usable waste then is heated in the absence of oxygen until it melts and the polymer molecules break down to form a rich saturated vapor. After removal of non-condensable gases, the condensable gases produced during the process are converted to hydrocarbon products; atmospheric distillation columns split the hydrocarbon vapor into raw diesel, light oil and synthetic gas fractions. The non-condensable gases are burned to provide energy for the process.

While not revealing the scale of SABIC's investment in the upgrading plant, Frank Kuijpers, general manager corporate sustainability at SABIC, says the facility probably would supply about 15,000 mt/yr of upgraded pyrolysis oil suitable for use at the naphtha crackers at its Geleen site (Figure 1).

"The liquid resulting from the mixed plastic waste conversion process cannot be directly processed in SABIC's crackers and therefore must be upgraded in the new unit that will upgrade the pyrolysis oil, bringing it into the specification limits of our naphtha cracker," Kuijpers explains.

"The unit will process low-end, mixed plastic waste that is expected to come from the Netherlands and which would otherwise be incinerated," he adds.

The TACOIL process appealed because it already has been successfully commercialized and can handle a wide range of plastics that otherwise would be very hard to recycle by conventional processes, notes Kuijpers.

Once the facility starts up, SABIC's plan is to work on the engineering required for scaleup of the pre-treatment technology, develop a strong market demand for its own certified circular polymers and — if these efforts pan out — scale up production at the new plant.

Plastic Energy CEO Carlos Monreal says SABIC's interest in the technology stems from three factors: three years of experience of managing the TACOIL process through the full value chain; knowledge gained from two commercial plants already in operation in southern Spain — especially in terms of plant modularity and technology scalability; and the product quality.

DUTCH COMPLEX

Figure 1. A new pyrolysis oil upgrade plant at the Geleen site in the Netherlands will supply feedstock for naphtha crackers. *Source: SABIC.*

STEAM CRACKER

Figure 2. Unit at Ludwigshafen has successfully processed pyrolysis oil produced from waste plastic. *Source: BASF.*

"What we have been able to do [at our Almeria and Seville plants] is improve the quality of output from end-of-life plastic waste and adjust our technology in order to create the feedstock that chemical companies can process in their facilities to produce clean, recycled plastics. Each plant in Spain is operating 24/7, with stable and reliable yields," he stresses.

Plastic Energy now is working to find the optimal feedstock to improve the new plant's economics and energy efficiency.

"Although these are big challenges, the main challenge for us today is the policy environment because, despite higher recycling rates, chemical recycling is not properly recognized and incentivized," notes Monreal.

The company also is talking with other chemical manufacturers about using TACOIL. "We are investigating opportunities in various markets, including the U.S. Based on our three years' operational experience, we are ready to develop, build and operate multiple plants in different countries, with the goal to process over 200,000 tonnes [mt] of end-of-life plastic waste by the end of 2020," he says.

CUSTOMER TRIALS UNDERWAY

Also in December, BASF, Ludwigshafen, Germany, announced progress in plastic waste recycling via its ChemCycling program. In a pilot project at Ludwigshafen, the company manufactured its first trial products using pyrolysis oil made from chemically recycled plastic waste. The pyrolysis oil goes to a steam cracker (Figure 2).

The trial involves ten customers from different industries. Products manufactured so far include cheese packaging, refrigerator components and insulation panels. The customers currently are testing these to see how they compare with traditionally manufactured versions.

The pyrolysis oil itself was produced by Recenso, Remscheid, Germany. Its single-step catalytic tribochemical conversion (CTC) liquefaction technology combines catalytic and tribochemical mechanisms to crack the hydrocarbons in a variety of materials including agricultural waste biomass and mixed plastic waste. CTC doesn't require high temperatures, pressures, or the addition of hydrogen into the process.

"As a next step, BASF plans to make the first products from the ChemCycling project commercially available. [However] …we currently cannot offer a detailed timeline due to prevailing technological and regulatory challenges that still need to be addressed," notes a spokeswoman.

BASF currently is assessing various options and technologies, including which of two thermochemical processes — gasification or pyrolysis — is more suitable. "Neither is new, but they have not yet been used on a large scale to manufacture new chemicals. Availability and product specification of pyrolysis oil in the market need to be established. That is why we are currently investigating which process can best be scaled up to an industrial scale," she says.

Another issue is whether the use of pyrolysis oil or syngas from plastic waste can overcome some regulatory ambiguities. For example, current EU legislation doesn't oppose this approach — not least because chemical recycling barely plays a role in today's waste management landscape.

"Chemical recycling is not yet recognized as a process which contributes to fulfilling the plastic packaging waste recycling quotas, especially in Germany. We are optimistic that demonstrating technology, market demand and

LARGER PILOT PLANT

Figure 3. Unit started up in 2018 can produce 100 L/hr of synthetic crude. *Source: OMV.*

environmental benefits, we can provide good arguments why chemical recycling should be seen as a valuable addition to a circular economy, and should meet supportive legislative conditions," adds the spokeswoman.

BIGGER PILOT PLANT

Meanwhile, OMV, Vienna, is ramping up development efforts. The company has been exploring the potential of used plastics with its ReOil technology since 2011, and started up its first test facility, with a capacity of about 5 kg/hr of used plastic, at its Schwechat refinery in 2013. Last year, it began operating a test facility with a plastic processing capacity of up to 100 kg/hr that can produce 100 L/hr of synthetic crude (Figure 3).

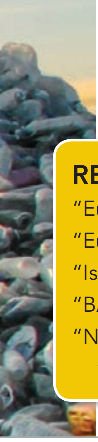
The ReOil processes involves feeding used plastics into a smelting facility and then adding a solvent (which is recovered after processing and reused). This creates a fluid viscous mass that enhances heat conductivity and eases breaking the plastic down via a thermal cracking process operating at over 300°C. The process yields a usable gas and a syncrude. The refinery can process both to make gasoline, diesel and a polymer material used in plastics manufacturing.

"Currently the focus of OMV is to learn from the ReOil pilot plant and to prepare the next scale-up step. We are still acquiring operating as well as maintenance experience with this plant. A key focus beside the technology scale-up development is to establish standard procedures, to verify them and to optimize them," notes Thomas Gangl, senior vice president refining & petrochemicals.

A future scale-up could handle more than a third of Austria's plastic waste, he believes, as long as it contains high levels of PE, PP and PS.

"The feedstock used in the ReOil process should contain only small amounts of polymers such as PVC [polyvinyl chloride] and PET [polyethylene terephthalate]. PET plastic contains oxygen molecules and is thereby only partially suitable (in very low proportions) for the ReOil process. The ideal feedstock contains common packaging materials PE, PP and PS, from household items such as yoghurt pots, shampoo bottles, plastic bags, plastic cups, lids from takeaway coffee, carton packaging, filling material, bubble wrap and confectionery packaging," Gangl explains.

OMV has invested approximately €10 million ($11.4 million) in the



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project so far, with the Austrian Research Promotion Agency subsidizing 10% of these costs.

CRUDE OIL REPLACEMENT

Last July, Neste, Espoo, Finland, announced plans to use liquefied waste plastic in a development project. The company is aiming for an industrial-scale trial this year and eventually to process more than 1 million mt/yr of plastic waste by 2030.

"To reach this target, development of processing technologies, supply chains, markets and regulation is still needed. Neste is actively working to accelerate development and make sure using waste plastic as a raw material becomes a viable alternative from technical, financial, sustainability as well as regulation standpoint," says Heikki Färkkilä, vice president, oil products development.

As part of this strategy, Neste is involved with Licella, Sydney, Australia, and ReNew ELP, Redcar, U.K. For over a decade, Licella has been developing a hydrothermal upgrading platform called the catalytic hydrothermal reactor (Cat-HTR). This can transform a wide range of products — including waste plastic — into a biocrude suitable for producing biofuels and chemicals. (See: "Is Supercritical Water The Green Future of Chemical Processing," http://bit.ly/2xEEpF4.) ReNew ELP, which has licensed the technology, currently is investing in a 120,000-t/yr plant at its Redcar site — the first commercial application of Cat-HTR technology.

However, Neste is more interested in the refinery processing of its liquefied waste plastic products than the liquefaction technology itself.

"Our intent here is to trial replacing crude oil — to an extent — as a refinery raw material while still producing high quality end products. We want to learn about the liquefied waste plastic oils' processability and behavior rather than the liquefaction processes required to create them," adds Färkkilä.

He also notes that Neste isn't limiting its activities in this area to just the one liquefaction technology. ●

SUCCEED AT SLURRY PUMPING

Consider a variety of factors to ensure satisfactory service

By Amin Almasi, mechanical consultant

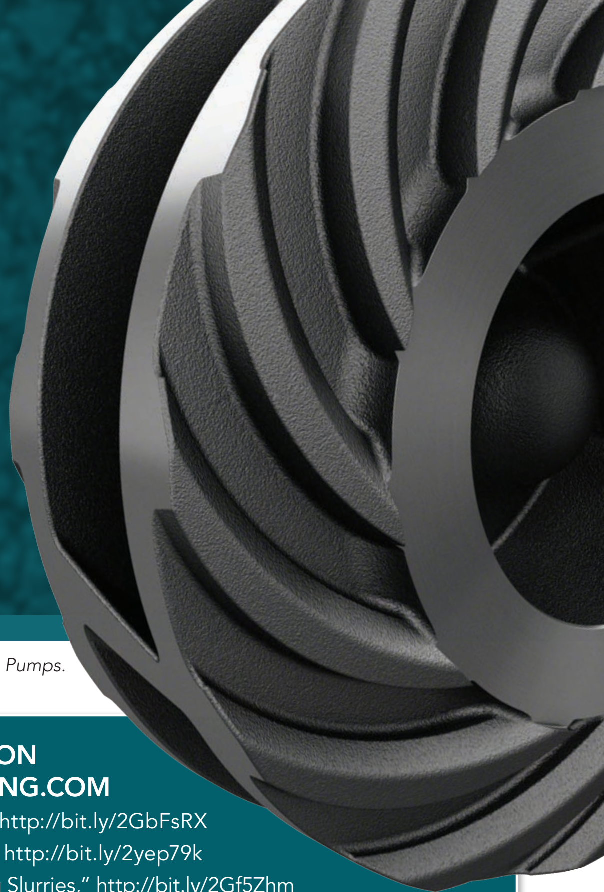

Photo: ITT Goulds Pumps.

PLANTS OFTEN must handle slurries in applications ranging from processing to wastewater treatment. Dealing with such mixtures of liquid and solids is challenging and difficult. Some key elements in slurry pumping are the size and nature of the solids in the liquid and the kind of the abrasive wear they cause. Another is the corrosiveness of the liquid or the mixture.

Sites frequently rely on centrifugal pumps for slurry services. These pumps (and their associated piping systems) need special provisions that call for a detailed knowledge of the solid and slurry properties to prevent wear, corrosion, erosion and other adverse effects such as settling of the solids. Specifying the optimum combination of speed, geometry and materials requires properly balancing often conflicting pump priorities; this demands consideration of stable operation, maximum wear life, operational flexibility and minimal energy consumption.

In this article, we'll cover practical guidelines and rules for centrifugal pumps for slurries. We'll also discuss key operational features, material selection and other considerations.

TAILORED PUMPS

Horizontal centrifugal pumps usually are used for slurry services, although vertical and other types of pumps are favored for some specific applications. Centrifugal pumps for handling slurries have features tailored to the particular service that reflect the corrosive or abrasive nature of the slurry

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and the solids concentration. These may include choice of materials, use of liners and even different driver sizing.

The first major requirement of a slurry pump is to provide adequate service life. Erosion and corrosion effects of slurries, such as the impingement of high velocity flow of liquid/solid mixtures, are really challenging. In many applications, some solids in the mixture are larger than usually specified particles; so, the pump should be able to pass them without any damage or operational problems.

As a result of such requirements, a slurry pump often is larger than its clear liquid counterpart. Moreover, it generally sacrifices efficiency, both maximum efficiency and efficiencies over the whole operating range, in exchange for the ability to achieve good operation in these challenging services.

Because wear is a function of velocity, a slurry pump's speed should be as low as possible; units usually operate at 1,200 rpm or slower. Often, direct coupling between the pump and a low-speed electric motor or other driver makes most sense. On the other hand, many other applications favor gearboxes to meet the desired speed and duty point. In services requiring variable flow, variable frequency drives are used to provide the necessary continual speed changes.

Although the emphasis on a slurry pump tends to be on the size and percentage of solids to be pumped, corrosion resistance is also an important factor for material selection in many applications. In such cases, the material chosen must provide an adequate combination of both erosion and corrosion resistance.

For slurry services, a pump operating on the left of the pump performance curve or at the best efficiency point (BEP) is usually preferred; as an indication, the rated point should lie somewhere between 85% and 100% of the BEP point.

The performance curves of many centrifugal pumps are based on handling water. So, to obtain the performance characteristics for these slurry centrifugal pumps, you must modify the results for the presence of solids. Many correlations and correction methods exist for predicting the performance of centrifugal pumps when handling slurries; these account for factors such as individual effects of particle size, particle size distribution, specific gravity and concentration of solids. They usually provide a head reduction factor and efficiency reduction factor for slurries compared to clear water. However, every pump has unique service-specific factors for a given application. You should verify these by experiments.

WEAR, EROSION AND CORROSION

Major factors that influence wear include the following:

- details of erosive particles (material, size, shape, etc.);
- concentration of solids;
- fluid velocity and particle velocity; and

- hydrodynamic properties of the flow (Reynolds number, etc.).

Turbulent flow analysis usually isn't applicable for slurry pumps because the presence of solid materials will directly influence the turbulence parameters. The mechanisms of turbulence become a complex problem particularly for dense slurries. This, combined with the nature of the flow inside a slurry pump, which is characterized by unsteadiness as well as deformed velocity distribution patterns, cause a very chaotic situation. However, some simple rules have been verified both in theory and experiments. For instance, the erosive wear rate is proportional to the flow velocity. It also depends on the solids concentration; as that concentration increases, so, too, does the wear rate. In addition, the sizing and specific gravity of solids in the slurry affect wear.

As a very rough indication, in medium and low concentrations, the mechanism of erosion resembles cavitation erosion. Here are some observations about a slurry pump that operated for a short period with low concentration slurry and then with a moderate concentration one. With the slurry at low concentration, the suction side of the blade showed very limited erosion at the leading edge while the rest of the surface was nearly unscathed. Most of the erosion of the back shroud was concentrated in the eye of the impeller and around the leading edge of the back-shroud corner. The maximum erosion appeared on the leading edge and towards the back shroud of the impeller. This pump, operated with a relatively higher concertation slurry, showed a similar erosion pattern — with the only notable difference being that the region close to the back shroud was more heavily eroded. Unfortunately, here and more generally, theoretical studies don't properly predict the level of erosion.

To cope with wear, pump designers generally rely on two options: use of thicker components or liners.

In the first approach, designers apply thickness allowances depending on estimates of erosion and corrosion of each part or component. Such pumps feature thick sections for all parts and components in contact with slurry including impeller and casing; those elements subject to high speed flow of slurry or solid impingements receive a greater thickness allowance.

In the second method, the designers provide wear liners on pump internals; many such pumps are fully lined internally. A lined pump, if properly done, can allow use of a wider variety of materials and also cost-effective application of exotic (expensive) materials. An unlined pump may offer lower initial capital cost. However, a properly lined pump usually affords a greater number of material choices, which may result in longer wear life and lower replacement spares cost. The lined pump also is inherently safer from a pressure containment standpoint because, in pumps relying on added thickness for components, corrosion and erosion over time might reduce the thickness to below the original value. Large clearances within the impeller and casing allow for the passage of large diameter solids, while also reducing internal velocities and corresponding wear. On the other hand, proper design and installation of liners can pose challenges — many pumps with liners have failed because of such inadequacies.

The materials used for wear components are hard metals, elastomers and, to a lesser extent, ceramics. Hard metals and ceramics combat erosion due to their high hardness values. Elastomers combat erosion by absorbing the energy of an impacting particle due to their resilience and tear resistance. Elastomers often can provide better erosion resistance in some applications. As a very rough indication, these are services where particle size is smaller than 250 microns, impeller tip speed is within the limits of the application of elastomers, and there's no risk of large particle damage. Elastomer-lined pumps have been successfully used in numerous slurry services.

Many metals have been used for slurry pumps. The ASTM A532 standard for abrasion-resistant cast irons covers the three basic types — "Martensitic White Irons" (Class I), "Chromium-Molybdenum White Irons" (Class II) and "High Chrome Irons" (Class III). These materials, which are made by melting processes, have been alloyed to achieve high resistance to abrasive wear. The bulk hardness of these alloys depends on many factors and parameters — for instance, not only upon the carbide and matrix type but also upon the volume of the carbides within the matrix. For slurry applications with small particles, microstructure, with smaller inter-carbide spacing, is particularly important to minimize erosion of the softer matrix. For slurry services with medium to large particles, the bulk (combined) material hardness is key. For applications with very large particles, fracture toughness of the matrix is important.

IMPELLERS

These tend to be larger than their clear liquid counterparts. Achieving a given head and providing more material for wear purposes requires a lower impeller speed. Minimizing speed and maximizing wear life of both the impeller and suction side depends upon a proper configuration.

High wear applications usually call for closed-type impellers. In applications with coarse particles, expelling vanes on the face of the front shroud make sense. These vanes prevent large particles from becoming trapped between the impeller and suction side liner and minimize recirculation. The benefit is reduced gouging and recirculation wear at the expense of a 2–3% drop in efficiency. In addition, expelling vanes often are used on the back shroud of the impeller in coarse particle applications to prevent the trapping of large particles between the impeller and back liner. In this location, they also serve to decrease the forward axial load by lowering the pressure acting on the back shroud and beneficially reducing the pressure at the hub. The decreased axial load improves bearing life. All these effects also cut the pressure differential at the shaft seal and reduce the tendency for slurry leakage from the pump. As with expelling vanes on the front shroud, back vanes usually absorb 2–3% of efficiency.

To combat wear and allow for passing large diameter solids, many slurry pump impellers feature fewer but thicker main pumping vanes. Both of these factors further contribute to reduced efficiency compared with clear liquid impellers. While a clear liquid impeller usually has five to nine vanes, most slurry pump impellers have two to five. Applications requiring large particle passing often employ pumps with two or three vanes. Slurry pumps use short blocky vanes in contrast to the thin long-length, long-wrap vanes found on high efficiency pumps for clear liquids.

SUMPS AND STORAGE TANKS

Slurry pumps usually require sumps or suction tanks to act as suction source or intermediate storage for slurries. However, lack of detailed knowledge about the slurry pump's behavior and sump hydraulics often leads to oversizing. The larger the sump or storage tank, the more likely it may become a settling tank for solids. For some services, the accumulation of solids leads to other problems, for instance, the build-up of harmful gases, and requires periodic desludging of the sump or tank, which increases operating costs and reduces overall safety and reliability. The optimal volume of suction storage, in this context, should prevent the settling of solids while avoiding problems for pump operation.

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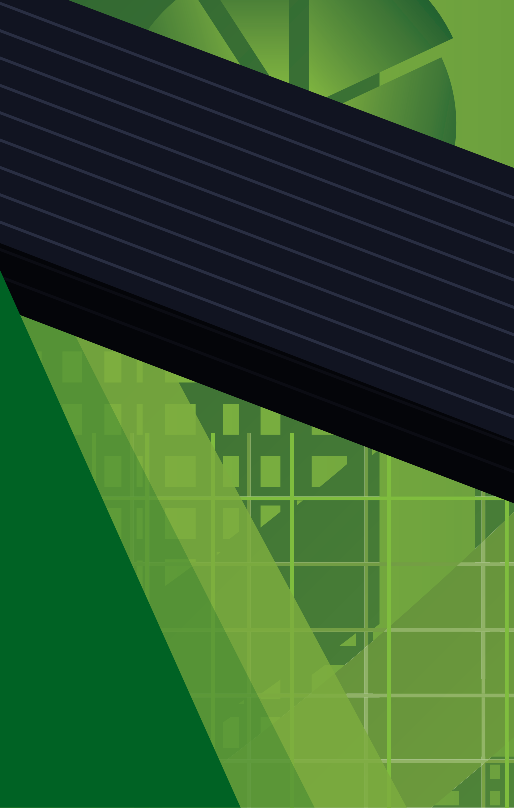
CONSIDER AN

ENERGY EFFICIENCY AGREEMENT



An operating company often can gain important benefits

By Chris Yurko, Motion Industries

CHEMICAL MANUFACTURERS in their ongoing quest to remain competitive are giving energy efficiency and sustainability projects a much higher priority. Such projects can reduce operating costs, cut greenhouse gas emissions, improve systems and hedge against future energy costs. However, upfront costs often pose a major barrier. Many companies don't have the capital available to pay for the equipment, installation and servicing of energy efficiency projects out-of-pocket. Even those with the capital may prefer instead to spend it on their core operations — what they know best.

When contemplating efficiency projects, operating companies typically have three general options: self-funding (cash); using traditional financing tools (e.g., a lease or loan); or opting for one of the "specialty" financing tools that have sprouted up for such projects. Here, we'll take a closer look at these specialty tools.

One of the most popular is efficiency-as-a-service. This is a pay-for-performance, off-balance-sheet, financing option that allows companies to implement their energy efficiency projects with no upfront capital expenditure. The energy services agreement (ESA) is the most common type of this arrangement. In it, the provider pays for the project's development, equipment and installation as well as ongoing maintenance and service costs. The vendor assesses the operation and determines achievable improvements in performance or energy savings to stipulate in the agreement (Figure 1). Once the project is operational, the operating company makes service payments based on these agreed-upon performance or energy efficiency values.

In other words, with an ESA, a chemical maker can redirect a portion of its current utility spend and utilize "savings" to pay for efficiency improvements. This works because ESA payments are based on realized energy and operational savings and are set below the current utility price.

COMPELLING ADVANTAGES

An operating company can reap a variety of benefits from opting for an ESA:

No upfront capital requirements. Self-funding and traditional financing require significant upfront capital. When paying cash, a company typically must pony up 50% of the project cost on the front end with the remainder due upon project completion. When financing through traditional tools, a firm often must pay 10% upfront or at least a minimum of a couple of months' payments and closing costs.

In contrast, in an ESA, payment to the provider isn't due until the project is operational and the savings have begun. This truly allows you to "redirect" payments that you would have been making to the utility and only send an agreed-upon portion of your realized savings to the provider.

Off the balance sheet. After five years of efforts, the Financial Accounting Standards Board issued an accounting standards update that greatly impacts the booking of leases. Those changes went into effect for U.S. public companies on December 15, 2018, and will apply to all other organizations on December 15, 2019. The result is that ESAs are one of the few remaining tools that offer the ability to book projects/efficiency programs off the balance sheet.

Immediate cut in operating expenses. By structuring an energy-reducing, cost-saving improvement in the form of an ESA, chemical makers immediately can see a decrease in expenses. For example, a company will see a monthly cash flow improvement of $5,200 if its electricity bill drops by $10,000/mo and its ESA requires payments of $4,800/mo.

No risk regarding performance. Typically, the efficiency and cost-reducing numbers evoke excitement at an operating company. However, executives often have an unspoken concern about the feasibility of the attractive return on investment (ROI) indicated.

With an ESA, an operating company needn't worry about whether the saving projections are real. The ESA provides protections for the firm by stating what the numbers must be and either setting payments as a percentage of the savings or, in some cases, guaranteeing via third-party insurance that the company gets the stipulated savings. The risk now resides with the vendor and insurer, not with the chemical maker. ESAs and other specialty service agreements offer this peace of mind.

Freedom from maintenance responsibilities. Many efficiency projects or programs require ongoing monitoring and maintenance. By utilizing an ESA, an operating company can ensure that the vendor handles these duties. The company can focus on its core business and not worry about placing extra demands on its maintenance team.

ESAs or specialty service agreements are increasing in popularity. They can apply to any operation where you can measure performance and savings, including:

- Compressed air systems;
- Steam systems;
- Equipment and process controls;
- Motors and pumps;
- Refrigeration systems;
- Boilers and furnaces;
- On-site cogeneration systems;
- Heating, ventilation and air conditioning systems;
- High-efficiency lighting; and
- Building automation systems.

UNDERSTANDING THE NUMBERS

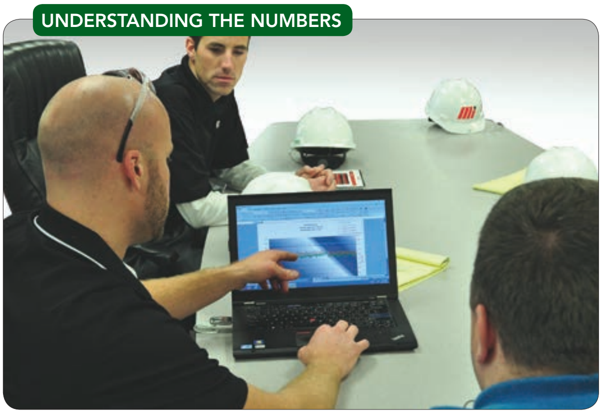


Figure 1. An energy service technician describes the results of an assessment and improvements possible via an ESA.

AVOIDING SURPRISES

Let's assume you're not only convinced of the value of entering into an ESA but also have found a contractor prepared to provide the equipment and improved efficiency that you need, handle installation, commit to ongoing maintenance and, through the use of an ESA, fund all of this with future savings. What could go wrong? Without the right partners and a properly worded and scoped ESA, you could wind up with some unpleasant surprises. You must pay attention to and thoroughly understand four areas prior to signing on the dotted line.

1. Is this the right partner and ESA for the long term?

Achieving enduring energy savings requires a long-term focus. With changing technologies and market conditions, contractors and vendors come and go. Before you enter into a 5-, 10- or even 20-yr contract, think about whether your prospective partners are going to be around for the long haul. Carefully look at their length of time in business, track record, financial strength and, where appropriate, licensing. Strategy is important. Execution is even more important.

2. **Do you have a detailed breakdown of all costs for equipment and installation?** Have you moved beyond estimated savings and drilled down to the real numbers? Do you have a detailed accounting for the equipment that will be installed? Does your agreement account for all labor? It's important to have final numbers before you commit to a long-term contract.
3. **Does the ESA properly cover ongoing maintenance?** When setting a long-term strategy, ongoing maintenance is a key component. Is there a plan or procedure for dealing with equipment failure either immediately or five and ten years into the contract? Does the ESA specify ongoing monitoring or periodic equipment checks? A strong contract will address ongoing maintenance and guarantees for both equipment and labor.
4. **Does your vendor and ESA provide for adequate ongoing measurement and verification?** A thorough grasp of how the numbers for savings have been generated and how numbers will be measured and quantified is also very important. Does your contractor adhere to and employ the International Performance Measurement and Verification Protocol (see: http://bit.ly/2TvZfPK) to determine actual energy savings? Does its billing comparison methodology consider the entire installation and interactive effects before and after installation? Understanding your vendor's methodology is key in understanding your long-term savings.

CRUCIAL MEASUREMENT

Figure 2. In-line hygrometer indicates the dewpoint of compressed air, which is part of assessing its operating condition.

UPGRADES TO COMPRESSED AIR SYSTEM

Project	Savings	Cost, including labor and equipment
Fix leaks	140 cfm	$20,200
Curtail inappropriate uses	1,140 cfm	$25,000
Replace automatic drains	400 cfm	$18,600
New supply-side equipment	$244,800	$526,300
Improve compressed air dryers	Better sustainability	$42,200
Total investment		**$632,200**

Table 1. Service agreement yielded a net positive cash flow of more than $300,000/yr.

REAL-WORLD EXAMPLES

To better illustrate when and where an ESA can work, let's look at two cases relevant to process plants that I have been involved in.

In the first, my energy services team was called in to "map" a plant's compressed air system and analyze its process from start to finish. (Compressed air is an expensive utility, see: "Upgrade Compressed Air Systems," http://bit.ly/2JzqabM.)

The team assessed both the supply and demand side of the system (Figure 2). We identified the demand-side waste and made recommendations for steps essential to reduce the overall system demand in the future (Table 1). As a result of these improvements, the plant would be able to meet the future demand by replacing the existing compressors with more-efficient ones equipped with an alternative type of control. This would yield an overall system savings of about $494,000 annually.

Under the 48-mo ESA, each month the operating company paid ≈$16,100 to realize a savings of ≈$41,200, resulting in a net positive cash flow of more than $25,000.

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In this case, the ESA was selected for multiple reasons. First, the plant would be able to realize immediate savings to its operating budget from the time of the install without having to put up the $632,200 of capital. Second, the ESA agreement guaranteed the expected savings of $41,000/mo. Finally, it provided 48 months of ongoing monitoring and any necessary maintenance.

Plants also often struggle with inefficiencies in another important and expensive utility — steam. So, now let's look at a case the team handled that addressed replacing steam traps and improving steam system efficiencies.

Our audit and analysis found that 13% of the steam traps were failing annually. We suggested a 10-yr ESA (divided into two 60-mo segments) that would cover replacing all 817 traps and their ongoing monitoring. It required no upfront capital from the operating company for the $859,000 cost (including all labor and equipment) for replacing the traps, and provided ten years of guarantees.

During the first 60-mo portion of the ESA, the operating company paid ≈$17,400 each month and saved ≈$29,900 in steam, resulting in a net positive cash flow of ≈$12,500/mo. On an annual basis, the steam savings exceeded $359,000 and the improvement in cash flow topped $150,000. During the second 60-mo period, the guaranteed steam savings rose even higher, resulting in a >$29,000/mo improvement in cash flow.

AN ATTRACTIVE OPTION

ESAs may be a good fit for your company. While they won't displace paying cash or using traditional financing options for all applications, they're worth evaluating if:

- You want to pursue retrofits across your portfolio without spending your own capital.
- You prefer off-balance-sheet treatment for the delivery of efficiency services.
- You like the idea of pay-for-performance where a third party takes on the performance risk and provides project management and maintenance. You pay for exactly what's delivered — nothing more, nothing less.
- You seek a strategy that provides operating budget relief immediately.
- You desire to procure energy-efficient technologies across your portfolio without the hassle of ownership.

In such situations, do three things. Interview and vet a properly qualified and trusted vendor or partner. Assess what areas in your processes might allow improved efficiencies while saving significant money. Finally, discuss whether gaining savings without accessing capital budgets would work for you.

For many companies, it's time to take a closer look at ESAs. ●

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SELECT THE RIGHT

Consider a number of factors to determine the most appropriate option | By Edward Naranjo,

FIRES AND explosions are common hazards in the chemical and refining industries. Unexpected releases of flammable liquids and gases can ignite, sometimes violently, when mixed with air, leading to injury and property damage. Energy-sensing flame detectors can enhance the safety of processes involving flammable materials by triggering an alarm when a fire erupts, thus providing early warning and helping ensure people's safety.

However, operating staff often debate about which type of device to select and where to place the sensors for best coverage. The confusion stems in part from the wide range of flammable materials that process plants may handle; a single process area may contain several different types. In addition, the development of new technologies like visual flame imaging and pattern recognition, while improving identification effectiveness, has created uncertainty around the choice of flame detectors. Fortunately, the particular application rather than detection technology determines the proper pick. In this article, we'll examine the criteria for selection and review the detector types commonly used to protect against industrial fires.

KEY CONSIDERATIONS

Flame detectors respond to the radiant emissions from a flame — so, the first and perhaps most important consideration when selecting detectors is that they accurately and reliably identify flames. Detection equipment must suit the particular hazard; the devices' spectral responses must match the spectral emissions of the flames to be detected [1]. Few plants fail to choose devices based on the process fluids present in the coverage area but many sites often don't consider other fire hazards. For example, flame detectors at a gas compressor building in Brazil failed to detect a small fire produced by ethylene glycol. The fluid had leaked from a heat exchanger onto a manifold in a compressor and ignited upon contact with the hot surface. Because ethylene glycol flames produce little infrared (IR) light, the IR flame detectors installed to detect natural gas flames didn't offer sufficient coverage to protect against alcohol fires. Luckily, personnel spotted the fire and quickly extinguished it.

Flame detectors vary in capabilities; each type presents advantages and limitations. You should consider several different types of performance variables when selecting the proper flame detector for a particular application:

• *Detector range and response time.* It's important to understand the maximum distance within which the device recognizes flames, based on fuel type, and the amount of time the instrument will take to collect, process and report feedback for the radiated energy detected. The response must be quick — within 30 seconds according to the EN 54-10 fire detection safety standard [2] — and accurate. To achieve best economics, look for wide area coverage per device, coupled with the shortest time to detect a flame. Place flame detectors high up and in the edges or corners of a room.

• *Immunity to unwanted alarms.* A flame detector must mitigate the possibility of false alarms from non-fire sources. A false alarm incident may cause system shutdowns and evacuations, as well as result in investigations by the company or local authority having jurisdiction. Restarting a process may take hours or months, particularly when considering quality, environmental and process safety regulatory requirements. Moreover, false alarms lead to wasted effort by emergency responders and worker downtime as operations sit idle. In addition, they incur costs for replacement of extinguishing agents from fire suppression systems and materials lost within the process. Placing the detectors in more appropriate locations, decreasing their sensitivity setting and increasing their delay setting may mitigate false alarms. You also may tilt the flame detector so it has a better orientation for false alarm rejection.

• *Field of view.* Most flame detectors have a 90° to 120° horizontal field of view. Wide fields of view usually are desirable to protect closed modules where obstructions may limit area coverage over long distances. Place the detectors high off the ground so they have good line of sight to the area of concern; you don't have to take ceiling height specifically into account.

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FLAME DETECTOR

Emerson Automation Solutions

• *Environmental factors.* Flame detectors at process plants must operate over a wide temperature range. You must consider high ambient temperature limits for devices installed inside compressor or turbine enclosures. In addition, flares and flare reflections may affect certain flame detector types like multispectral infrared and ultraviolet/IR (UV/IR) — particularly during blowdown to safely dispose of excess combustible gases or liquids in a flare.

• *Communication capabilities.* The role of flame detectors is to initiate suitable responses such as automatic control actions and alarms. This depends upon effective communication of outputs like 4–20-mA analog signals or relay contacts for remote alarm or fault indication. Bidirectional communication protocols like HART can make information pertaining to parameters, device configuration and device diagnostics available to central control or monitoring systems [3].

Besides considering performance variables, check that the flame detectors are listed or approved for use in hazardous or classified areas and for the specific environments in which they will operate. Certification under regulatory performance standards such as FM 3260 [4], EN 54-10 [2] and ULC/ORD-C386 [5] also attests to product fitness because these norms subject detection systems to a set of reproducible tests to certify their performance on deployment.

DETECTION TECHNOLOGIES

Let's now look at the different types of instruments available, their applicability and limitations, as well as factors to consider in making a choice.

• *IR flame detectors.* These devices find broad use in process plants. They are popular because the fixed emission wavelengths of flame in the IR spectrum can be separated from most non-flame sources and analyzed in various domains [6,7].

IR flame detectors can detect hydrocarbon or hydrogen flames. Hydrocarbon configurations suit facilities that process hydrocarbon gas or liquids — but are wholly unsuitable for detecting hydrogen flames or flames from other inorganic materials. Modulated radiation from hot surfaces, hot exhaust gases, sunlight, light from flares, and solar and flare reflections can affect certain IR flame detectors. The presence of these sources reduces flame response sensitivity and may cause false alarms. Don't use IR flame detectors if flare radiation can be seen, either directly or reflected.

Multispectral IR flame detectors are recommended for many uses, including crude oil tanks, diesel storage facilities and enclosed gas compressor buildings. They are the most versatile of the detector types available and have the longest detection range as well as strong false alarm immunity. These detectors can characterize flames more fully due to their large number of sensors. Instead of relying on a single spectral span, they use several to establish the presence of a flame. As a result, the instruments don't produce a false alarm when only one spectral span indicates a flame. Moreover, some sensors — called immunity sensors — monitor for the presence of false alarm sources.

• *UV flame detectors.* These devices suit facilities in which the only fuel sources are hydrogen and hydrocarbon gas. Because smoke scatters UV light to a far greater extent than it does IR, it's best to locate UV detectors well below roof level as smoke produced by paint, cables or oils may accumulate in ceilings or roofs. To prevent false alarms, inhibit UV detectors during welding, radiography and exposed flame hot work. Just as for IR devices, don't use UV detectors in areas where you can see direct or reflected flare radiation.

UV detectors are unsuitable for detecting hydrocarbon liquid fires or fires in highly congested spaces. Liquid fires produce little UV light and the dense smoke from these fires greatly reduces detection coverage. In addition, because UV light is most prevalent at the base of an open flame, the devices may not readily detect fires in congested spaces that block the line of sight to the base of the fire. Another consideration for UV detectors is the presence of oil or dust. Deposits of

UV/IR DETECTOR

Figure 1. This instrument must detect flames on both bands to trigger an alarm.

oil film or dust on detector windows can severely reduce flame response sensitivity; therefore don't use these devices to monitor environments that contain airborne oil droplets or are dusty. UV detectors do best when detecting clean flames (i.e., those from natural gas, pure ethane or butane).

• *UV/IR flame detectors.* These devices, such as the one shown in Figure 1, combine the characteristics of UV and IR to provide a detector for general hydrocarbon or hydrogen fuel applications. They generate an alarm signal only if a flame is detected on both bands. UV/IR detectors best suit clean flames because few light sources emit as strongly in both spectral regions as clean flames. Such flames afford a shorter detection range than that of a fire from a liquid fuel (ethanol, for example).

• *Closed-circuit-television (CCTV) flame detectors.* These devices process video images and resolve flame characteristics. They best suit highly hazardous areas and normally unattended ones, where manual intervention could take a long time, making loss prevention more difficult. Because CCTV detectors transmit a video signal to the control room, they can allow quick assessment of the overall situation in the event of a fire alarm and confirm the presence and magnitude of the fire. Certain CCTV flame detectors can mask parts of their field of view, a feature useful for monitoring areas exposed to direct light from flares or flare reflections, such as top deck process areas on offshore platforms.

Don't use CCTV detectors when you're concerned about invisible or nearly invisible flames like those produced by hydrogen and alcohol fires.

Table 1 provides an overview of the principal characteristics of these flame detector types.

Keep in mind that flame detection isn't always the best choice for identifying a fire. For instance, flame detectors may not be wholly effective in protecting zones due to high levels of congestion, interference from flare activities or environmental conditions. In such cases, other methods like heat and smoke detectors and pneumatic detection systems may do a better job.

Also, always remember that flame detectors don't negate the need to consider ways to prevent fires in the first place. Identify adequate safeguards using engineering standards and process hazards evaluation methods like event tree and layer of protection analysis [8].

MAKE THE RIGHT CHOICE

Successful performance of fire detection systems depends on the early and reliable identification of fire. Key to this is the careful choice of flame detectors in the process area. Base your device selection on an analysis of the characteristics of potential fires, their causes and the environment. UV detectors offer fast

FLAME DETECTOR OPTIONS

Detector	Advantages	Limitations	Typically Used for Monitoring
IR	• Strong false alarm rejection • Long detection range • Able to detect fire through dense smoke	• Susceptible to producing false alarms under certain combinations of heat, motion and gas emissions • Can't be used if flare radiation can be seen • Effective detection coverage reduced in presence of false alarm sources	Hydrocarbon gas or liquids (enclosed buildings and outdoor locations)
UV	• Fast response speed	• Unsuited for environments that are dusty or contain airborne oil droplets • Susceptible to interference from welding activities, x-rays used in non-destructive testing, lightning and direct and reflected sunlight	Clean burning fuels (e.g., natural gas) in closed or semi-enclosed modules
UV/IR	• Fast response to fires • UV/IR technology reduces possibility of false alarms • Wide field of view	• Unable to detect dense smoky fires • Affected by strong sources of UV radiation (e.g., arc welding) or certain combinations of UV and IR radiation	Clean burning fuels (e.g., natural gas) in closed or semi-enclosed modules
CCTV	• Enables operators to confirm presence of fire, assess hazard severity • Certain models may mask flare light, making them suitable for applications where other devices don't perform satisfactorily	• Not suitable for detecting invisible flames (i.e., hydrogen or alcohol flames)	Hydrocarbon gas or liquids in normally unattended installations

Table 1. Proper selection requires considering the nature of the flame as well as the operating environment.

response and good sensitivity while UV/IR and multispectral IR models provide increased false alarm immunity over UV models and operate at moderate response speeds. Multispectral IR detectors offer the largest area coverage per device of any detector type and boast versatility and strong false alarm rejection; so, plants prefer them for a whole host of uses. CCTV detectors, which can provide images of the area under scrutiny, may serve for event management in case of a fire. In practice, their singular advantage is discrimination of flames produced by process flares.

No flame detector technology is best in all situations; usually a combination of thermal, flame and smoke detectors or several flame detector types is necessary. Bear in mind that some operations such as raw material receiving, sorting and storing as well as reaction and product generation may involve a variety of fuels. In addition, regulatory bodies in certain jurisdictions (e.g., the Bureau of Safety and Environmental Enforcement in the Gulf of Mexico) mandate the installation of pneumatic fusible-loop heat detection systems as an additional and complementary layer of protection.

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REFINERY PIPE INSPECTIONS GET A LIFT

Device provides a safe and effective option for checking contact points

By Brad E. Cummins, special emphasis inspection lead

INSPECTING FOR external corrosion at piping contact points in refineries is challenging. As pipe coatings and insulation systems age, the potential for water ingress increases, making external corrosion of piping inevitable. Additional factors such as steam tracing leaks that can introduce the potential for moisture accumulation under insulation systems often compound the threat. These conditions can and do combine to result in external corrosion of refinery piping, especially at crevices like those found at contact points. Making matters worse, the importance of installing external corrosion prevention devices, such as rain rods, pipe shoes, etc., wasn't fully recognized in older piping installations. As a result, aging refineries diligently should check for corrosion at contact points.

The need for careful inspection certainly applies to the refinery where I work. It has been operating for 100 years and now has a capacity of 314,000 bbl of crude oil per day. Output consists primarily of fuels, including all grades of gasoline, diesel fuel, propane and butane. The refinery also produces benzene and asphalt. Although our site has had major projects and renovations, including many within the last ten years, it still has decades-old in-service piping that requires scrutiny to ensure safety.

We estimated contact points using refinery plot pipe rack drawings and came up with a staggering number — 400,000! Our program calls for general screening of all contact points (line-of-sight visual assessments), close (within touching distance) visual checks of all contact points deemed as "high or moderate" risk in general screenings, and finally, pipe-lifting, nondestructive evaluation (NDE) and remediation of all contact points identified with heavy external corrosion damage.

The API-570 Piping Inspection Code and the refinery owner's internal standards establish minimum inspection requirements and define inspection compliance timing. Our internal requirements go beyond the "standard" ones specified in relevant industry inspection codes.

Each refinery within the corporation must determine how to facilitate and execute the internal corporate requirements. The refineries differ in weather conditions, age, initial construction methods and piping arrangements, making it difficult to estimate costs and the magnitude of the work scope.

PIPE LIFTING

Figure 1. Portable device provides both efficiency and easy operation by one person.

TACKLING THE TASK

In 2017, I was given the responsibility to manage the various inspection programs defined in the corporate standard. I realized that the current inspection budget wouldn't suffice to execute the required work. While contact point inspections are just one key aspect of the corporate standard, they do represent one of the most challenging objectives. Conventional pipe-lifting methods wouldn't allow getting the job done in the allotted time. So, I needed to look for innovations that would help in achieving refinery inspection goals.

To construct a case for the necessary resources, I set out to build scope and cost estimating tools. Next, I defined a meaningful representation of the magnitude of the work scope by estimating the number of contact points from refinery plot maps. This led to development of a five-year comprehensive inspection and remediation program (that was subsequently approved) to address potential issues and concerns. The scope included: defining various levels of damage to aid in prioritizing future mitigation and follow-up inspections; canvasing the entire refinery to estimate the magnitude of the inspection work scope; determining how to track and manage field information; defining work and inspection efficiencies to help in optimizing progress while minimizing costs and ensuring field execution meets the highest level of safety and productivity during inspection and pipe-lifting activities.

The primary difficulty associated with inspecting contact points is accessibility. Most reside in pipe racks, where direct-line-of-sight visual inspection from available access points is impossible or at least limited. Many are insulated.

Because scaffolding and insulation work is expensive and time consuming, we rely on rope access technicians as much as possible to facilitate these pipe rack inspections. Building a self-sufficient ropes crew provided the foundation for developing a highly effective and productive inspection strategy that contained costs and ensured meeting the compliance timing deadline.

This is where the BobbyJack Pipe Lift came into the picture. We opted for this innovative portable device because it effectively addresses some of the more-challenging aspects of safely and efficiently performing pipe lifts in limited access locations.

CONTACT POINT INSPECTIONS

One of the most challenging activities involved in performing contact point inspections safely and effectively is lifting active pipes. Our refinery has used conventional pipe-lifting methods for many years. However, these techniques pose limitations and disadvantages, which the unprecedented scale of the contact point inspection program magnified.

Lifting piping with chain falls, straps, etc., requires rigging off other piping or structure above the subject pipe. This isn't a preferred option and demands even more evaluation and engineering. In addition, in some cases, no acceptable lifting point is available. Crane support requires the use of spotters, the cost of the crane and operator and, sometimes, working without direct eye contact between the rigger and the crane operator.

After some research, we discovered the BobbyJack and decided to use it to support such activities (Figure 1). Key features that make this option attractive include:

- *Safety.* The BobbyJack pipe-lifting device offers distinct advantages over conventional pipe-lifting options such as cranes/slings and chain falls because it's completely within the control of the person lifting the pipe; lifts are made gradually with the jack and you don't have to rig off other pipes.
- *Portability.* The unit can go almost anywhere it's needed with minimal clearance requirements. A small "lifting crew" can manage it with no additional manpower support.
- *Efficiency.* Because the person doing the lift manages the jacking system, other resources like cranes and additional craft support aren't needed.

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- *Ease of operation*. The system is easy to understand and operate. With only minimal training and experience, lifting crews can be qualified to make pipe lifts safely and effectively with it.

Using the BobbyJack pipe-lifting tool is a simple ten-step process:

1. Check the thickness of the top flange of the pipe support. (BobbyJacks are designed specifically to work with I beams or opposing C-channels). If the flange is less than ½-in. thick, install a box shim on the hook and secure in place with a shim-retaining pin (all parts included). If the beam is ½-in. thick or greater, don't use the shim.
2. On the pipe to be lifted, place one of the support arms of the BobbyJack across the top flange of the beam.
3. Pull the arm toward you to fully engage the support arm until it's fastened onto the opposite side of the beam.
4. Swing the pivoting brace until it's directed at the lower inside corner of the beam between the web and the lower flange of the beam.
5. Adjust the length of the screw as required to ensure the support arm lies flat across the top flange of the beam.
6. Repeat this process for the second support arm, positioning the two arms at least 12½ in. apart.
7. Position the lifting cradle/riser assembly into the vertical slots on the support arms.
8. Place the hydraulic jack into the lifting cradle and lift the riser about 2 in. to allow the rounded cap at the top of the jack to slot into the round socket of the riser.
9. Insert the jack retaining pin through the hole in the base of the jack and the matching hole in the base of the lifting cradle.
10. Put the appropriate lifting "vee" on the riser assembly and lift the pipe.

You can insert a locking mechanism into the assembly. This eliminates the possibility of the jack allowing the lifted pipe to fall back onto the support; it is a great safety feature.

Maintaining the safety and mechanical integrity of the piping during pipe-lifting activities requires a robust pipe lift policy. This should ensure that critical aspects of each lift have been considered and addressed. Key elements of such a policy include: an operations contingency plan, an engineered pipe-lift plan, inspection and NDE prior to lifting, and designation of a pipe-lift coordinator.

We have found the BobbyJack Pipe Lift to be a safe and effective way to lift piping for contact point inspections. It won't work at every location but certainly has its place among the multiple pipe-lifting methods needed to complete our refinery-wide program. ●

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Slurry Seals Pump's Fate

Inadequate attention to slurry particulars and seal plan impair performance

THIS MONTH'S PUZZLER

We use an axially split centrifugal pump to handle a catalyst slurry in naphtha. We were running with one pump on, one on standby, until the one in service tripped a high temperature alarm on the bearings. Flow fell drastically. We switched to the standby pump; it also developed low flow but the thermal sensors didn't trip. Both incidents resulted in a serious leak around the shaft seal of each pump.

Doing a post-mortem on the incident, we've run into an impasse. The maintenance manager suspects the seals were the culprit. He flushes the seals with a clean light oil. He never has been a fan of using an API Plan 62 with an oil quench. He would prefer a Plan 32 and has been working with the seal salesman for years to change the seal arrangement. However, production likes things just the way they are. Projects says they don't have the money. And the corporate environmental engineer wants to reduce emissions by installing a double seal plan plantwide.

Do you think the maintenance engineer is right? Did the seals cause the failure? Is this a problem we should be worrying about, given the money crunch? What do you think?

COME AT IT FROM BOTH ENDS

Pumping of slurries is a challenge regardless of the type of pump. There are two types of slurries: non-settling (particles with equivalent diameters less than 75 microns); and settling (particles with equivalent diameters greater than 75 microns). The situation can get complicated if these particles are trying to dissolve or are friable. Non-settling slurries tend to be highly non-Newtonian, perhaps shear-thickening or shear-thinning; in my experience, centrifugal pumps usually aren't used with these fluids. Settling slurries tend to behave — provided the particles' settling velocity is stable and the liquid in the piping doesn't slow down, which can cause quite a mess. Always perform sampling before selecting a pump; ideally, sample the fluid at different places and times in the process. It's worth a trip to the lab and the maintenance shop to do a change analysis of the pumps and process.

Usually something like a bearing failure occurs because someone took some shortcuts in pump selection. Because both pumps were affected, that person must have missed something in the fluid being pumped. So, there's more to solving the problem than the choice of the API seal plan.

API seal plans all have their flaws: high cost; a lot of instrumentation; inadequate seal protection to save cost; and over-reliance on a "clean" fluid. If one plan has worked well for many of the pumps, you may face resistance in changing, even if the maintenance manager and seal salesman can see a clear benefit in this case. Your best bet is to find comparable sites that have used a particular plan successfully.

API Plan 62, which is called a quench single seal, has a significant cost advantage over Plan 32. Plan 62 uses a clean, cooled liquid to prevent particulates from getting into the seal and scratching the pump shaft. However, if the liquid is dirty, hot, contaminated or a two-phase liquid mixture, or if it contains a gas or vapor, this seal choice could be a disaster.

CHECK OUT PAST PUZZLERS

Readers have suggested ways to grapple with a wide variety of problems over the years. More than a decade's worth of Puzzlers appear online at www.chemicalprocessing.com/voices/process-puzzler/.

API Plan 32 is an improvement on Plan 62 because of added instrumentation: a flow indicator, temperature gauge or transmitter, and a pressure gauge or transmitter.

Filtration, cooling and perhaps an additional instrument — a colorimeter — can improve both plans. A colorimeter can detect particulates and mixed liquid streams. At the very least, a sight gauge with a background light could bolster either plan and allow operators to inspect the flowing quench stream to the seal.

As for the thermal switches that didn't trip, check the commissioning. It should have included a trip check but that might have been overlooked. In addition, it's possible that the switches melted or malfunctioned from overheating.

Dirk Willard, consultant
Wooster, Ohio

MAY'S PUZZLER

At one of our gas/oil separation stations, we have an old reciprocating compressor that operates with a knockout drum at the inlet. This past winter, it started giving us problems, which is strange because it has outlasted the centrifugal compressors at our other stations. The temperature gauges on the inner-stage coolers are showing a high temperature. The after-cooler for the product gas at the station also is running way too hot. We must ensure smooth operation before the high-demand winter season arrives.

Walking around the old compressor, I notice a lot of corrosion. I can't read any of the equipment nameplates. Our data files are incomplete, compounding the problem if I must order a new compressor. I also see that one of the foundation anchor bolts is loose.

What do you think caused the problems with this old reliable unit? Do they relate to a seasonal factor or a capacity issue? Is it worth rebuilding the compressor or should we replace it — if so, how should I approach the replacement?

Send us your comments, suggestions or solutions for this question by April 12, 2019. We'll include as many of them as possible in the May 2019 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.

Find Opportunities Hidden in Plain Sight

Some problems get accepted as the status quo and fly under the radar

Look for situations now so routine that no one questions them.

AT LAST, the day arrives that you get to work and no problem awaits you. The plant is running smoothly. It's a day to catch up on filing, talk with colleagues and relax a bit. However, there's a better use for the time: go look for problems. That may seem odd — why seek out problems when normally they find you quickly enough — but it may allow you to identify difficulties masquerading as normal operations.

Normalization of deviance is a concept most fully developed in safety analysis. It's the idea that what starts as a lower standard eventually gets accepted as normal. The standard can be a safety margin, capacity, reliability (run length), product quality, energy efficiency or something else. To put the concept simply, expectations adjust to experience.

So, on this rare day when urgent problems aren't overwhelming you, it makes good sense to spend some time trying to spot important but unrecognized difficulties.

To find these, ask yourself some questions. A number should focus on how things always have worked. Others should probe the ways in which your plant differs from similar sites. In addition, you should query what represents ideal operation. The idea is to look for deviances hidden in plain sight — that is, situations now so routine that no one questions them.

First, review previous fixes. Check their documentation. For each one, did the described action do what it was supposed to? If not, follow up with several questions. Why was the original problem important? Does the plant still have the same issue? Why was the particular fix proposed? Why didn't it work? Should we try again? Have we just accepted that things can't be improved? Any of these questions can start you thinking about potential improvements.

For previous fixes, pay special attention to any situations where the plant felt compelled to summon outside troubleshooters. These deserve emphasis because someone thought the issues were serious enough that the necessity to fix them trumped the reluctance to admit defeat and bring in outsiders. Were they really fixed? If not, does the plant now just accept them as a given or are they worth a second look?

Second, go to the operations department. Talk to the operators. Use many of the same questions that safety professionals have developed to identify areas for improvement. One key warning sign to look for is when different shifts or specific operators strongly disagree on how to run a unit. These are areas where problems and opportunities hide. To uncover these, focus your attention on several telltales: problems that operators shrug off as no big deal; cases where they ignore instrumentation; and instances of tribal knowledge, e.g., where only particular people can make something work properly.

Third, talk to the maintenance staff. Find out what specific equipment items always seem to require repair. Which pumps cause the most problems? Which exchangers need cleaning all the time? Which towers regularly suffer from blown out trays? What parts of the plant commonly host contract crews for cleaning up messes? In these cases, you must get a baseline of what level of performance is normal. For instance, what are the industry standards for pump mean-time-between-failures? What is a usual heat exchanger cleaning schedule? Industry organizations and professional societies have extensive resources on such matters. Is your plant using them?

Fourth, go back to the operators. This time, focus on the more experienced ones. Were things always done a specific way? What about the current situation — is it better or worse than it used to be? For any things that now are worse, is there a good reason or is it simply normalization of deviance?

It's easy to see problems that are on top of everyone's mind. It's much more difficult to spot issues that now go under the radar because they have become accepted as the status quo. This is what makes normalization of deviance so pernicious. A site doesn't view improvements as necessary because normalization has made the current situation the accepted practice.

Your job is to question what's normal and to look for ways to improve it. The day urgent problems aren't overwhelming you is the day you get to look for what's an important but unappreciated problem. Use the day wisely and make the plant better; you'll feel a real sense of accomplishment.

ANDREW SLOLEY, Contributing Editor
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System Speeds Screen Changes

The operator-friendly Electro-Lift separator screen changing system is ergonomically designed and electrically powered to assist in making separator screen changes easier, faster and safer. Engineered with a 120-V sealed gear-driven system, operation is as simple as plugging into any convenient outlet and pressing a switch. The system is adaptable to fit a variety of different frame deck configurations. It eliminates the need for two people to remove each frame. Because it is mounted independently to the frame, there is no need for the screen to be locked out for users to work in and around the unit.

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The ICO semi-open-impeller i-FRAME pump series is designed for improved solids handling. It is also ideal for air and gas handling applications, says the company. The pump is fully compliant with both ISO 2858 and ISO 5199. Available in 34 sizes, the pump includes the company's Cyclone seal chamber, i-FRAME power end for improved service life, and the i-ALERT2 equipment health monitoring sensor as standard. The pump handles flows up to 450 m^3/hr (1,980 gpm), heads up to 160 m (514 ft), temperatures from -40°C to 280°C (-40°F to 530°F) and pressures up to 25 Bar (360 psi).

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Study Reveals PFAS Hazards

Perfluoroalkyl substances can pass from mother to fetus during pregnancy

More research is needed on the health effects of different chemicals.

THOUSANDS OF chemicals make up the PFAS (perfluoroalkyl substances) group and, thanks to their water- and grease-resistant properties, PFAS are used in everything from frying pans and food packaging to clothes, cleaning agents and firefighting foams.

However, they have long been considered harmful to health and to the environment.

The website of the U.S. Environmental Protection Agency (EPA) points out that the best known — perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) — can cause reproductive and developmental, liver and kidney, and immunological effects in laboratory animals. It adds that the most consistent findings are increased cholesterol levels among exposed populations, with more limited findings related to low infant birth weights, effects on the immune system, cancer (for PFOA), and thyroid hormone disruption (for PFOS).

Most PFAS manufacturing has been phased out in the U.S. under a number of EPA regulatory regimes, including its PFOA Stewardship Program. The European Union banned PFOS in 2008, and in January 2019, the European Food Safety Authority sharpened its appraisal of PFOS and PFOA, lowering the tolerable daily intake a thousand-fold.

Now, a new study by researchers at the Karolinska Institute, Solna, Sweden, shows how PFAS passes through the placenta throughout pregnancy to accumulate in fetal tissue.

The researchers focused on six PFAS substances, including PFOS and PFOA, and found that all appear to the same extent in fetal tissue as in the placenta. "So, when the baby is born, it already has a build-up of these chemicals in the lungs, liver, brain, and elsewhere in the body," explains Richelle Duque Björvang, doctoral student at the department of clinical science, intervention and technology.

PFAS levels were highest in lung and liver tissue, in some cases as high as in adults, and lowest in the brain.

"This shows how important it is for more research to be done on the health effects of different chemicals, especially in the longer term," says Pauliina Damdimopoulou, senior researcher in the same department. "Today's threshold values are based on an adult population rather than fetuses, which are much more susceptible."

The accumulation of PFAS substances also was higher in male fetuses than female, prompting Damdimopoulou to note that understanding this will be an important area of further research.

"The main source of PFAS substances today is food, in the form of fish, milk, meat and eggs, or in the drinking water, if you happen to live in a polluted area. We ingest them as a cocktail of substances that can also interact with each other. It would be in line with the precautionary principle in the restriction of chemical substances to make sure that all PFAS substances disappear from our society," she adds.

In their conclusion, the authors note the values they present may allow extrapolation for fetal exposure of other similar compounds through computer modeling.

Meanwhile, an earlier study found that PFAS compounds also may have a role in weight gain and obesity development.

Published last year in *PLOS Medicine*, the "Perfluoroalkyl substances and changes in body weight and resting metabolic rate in response to weight-loss diets" study followed the two-year, diet-induced weight-loss trial (the POUNDS Lost trial) carried out in Boston and Baton Rouge.

Here, the researchers measured plasma concentrations of PFAS at baseline in 621 overweight and obese men and women and collected information on changes in body weight, resting metabolic rate (RMR), and other metabolic parameters during weight loss and weight regain over the two years the participants were on the study diet.

Higher baseline levels of PFASs were significantly associated with a greater weight regain, primarily in women. On average, women in the highest tertile of PFAS concentrations regained 1.7–2.2 kg more body weight than women in the lowest tertile.

Higher baseline plasma concentrations of PFASs, especially PFOS and perfluorononanoic acid (PFNA), were significantly associated with greater decline in RMR during the first six months and less increase in RMR during the period when participants on average regained weight (6–24 months).

Overall the study found that higher baseline PFAS concentrations were associated with a greater weight regain, especially in women, possibly explained by a slower return of RMR levels.

"These data provide initial evidence suggesting that PFASs may interfere with human body weight regulation and counteract efforts to maintain weight loss in adults," noted the authors.

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