CHEMICAL ENGINEERING

October 2010

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Improving Control Valve Performance

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Thermal Insulation:

FACTORS FOR MATERIAL SELECTION

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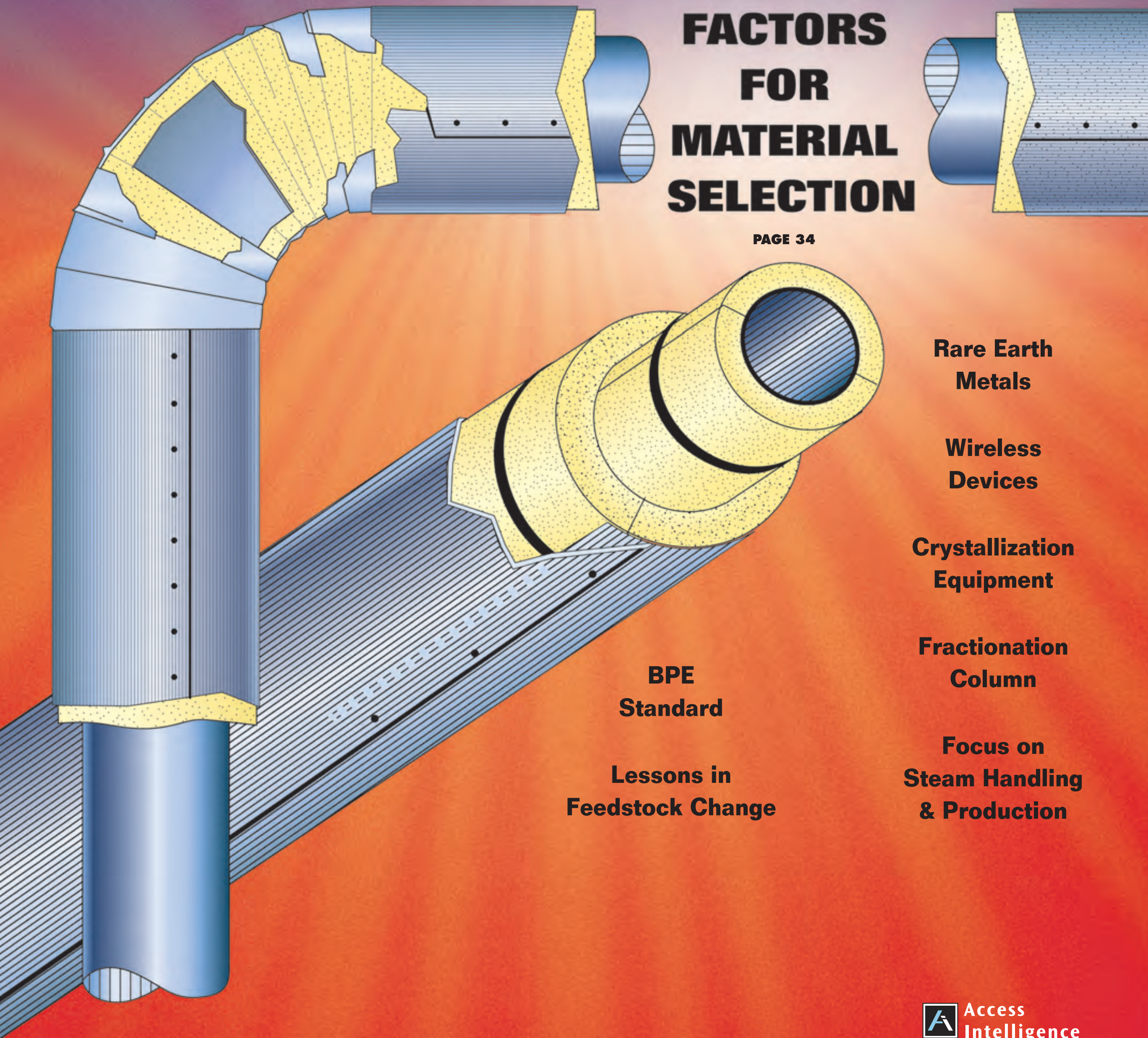

Rare Earth Metals

Wireless Devices

Crystallization Equipment

Fractionation Column

BPE Standard

Lessons in Feedstock Change

Focus on Steam Handling & Production

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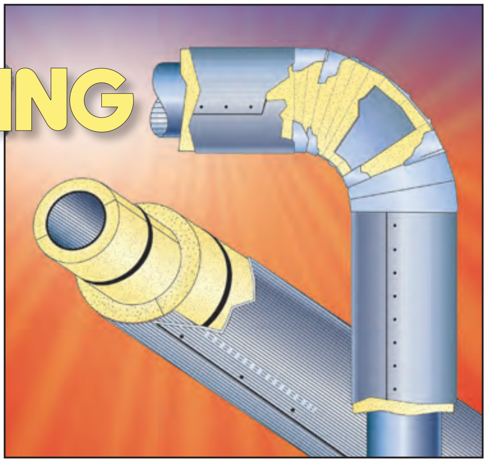

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32I-1 K Show Preview (International Edition) Mercury-free pressure sensors for polymer melts; Automatic cleaning of filter screens in recycling processes; A handheld photometer for the control of plastics' color; Targeted design of tribological surface properties; and more

32I-6 New Products (International Edition) This decanter uses less energy for sludge dewatering; Perform x-ray analysis at your desk; Extending predictive diagnostics to remote applications; A next-generation valve-diagnostic tool; A high-flow version of a filter regulator; and more

57 Focus on Steam handling & production Boiler-tube expanders with precise torque control; Angle-seat globe valves with flanged connections; Reduce NOx emissions from boilers, regardless of fuel type; Steam-system engineering and best practices; Customized condensers and heat exchangers; and more

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Cover: David Whitcher

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Editor's Page

Join *CE* at ChemInnovations

When it comes to a geographical concentration of chemical engineers and chemical process facilities, few cities in the world rival that of Houston, Texas. Given that, it might be surprising that this month will essentially mark the first time in more than a decade that the chemical process industries (CPI) will converge on that metropolis for an integrated conference and exhibition. The inaugural event is ChemInnovations (Reliant Center, Hall E; October 19–21; www.cpievent.com), and is being brought to the CPI by *CE* and its parent organization, the TradeFair Group.

As the conference chairperson for ChemInnovations, I am proud to have served on the advisory board, alongside the entire *CE* editorial staff and an esteemed group of CPI veterans, in planning a conference lineup that is truly designed by practicing chemical engineers *for* practicing chemical engineers. The relevance of each session is as broad as the readership of *CE*, encompassing industries wherever chemical change takes place: chemical & petrochemical, petroleum refining, plastics & resins, nonferrous metals, pulp & paper, food & beverages, glass & ceramics, pharmaceuticals and more. From its inception, ChemInnovations has been centered on delivering groundbreaking technologies and engineering approaches that are proven to uncover new levels of performance. The result is a conference program without vague theoretical treatises or research papers and an exhibition that offers much more than just an opportunity to "kick the tires".

The event provides solutions to the CPI's most pressing challenges today and provides insight for meeting those of tomorrow. For instance, a central theme of the conference is energy efficiency and the practical implementation of alternative energy sources in CPI applications. With a dedicated one-and-a-half day track on the topic and numerous other presentations in related sessions, attendees can find talks on generating electricity from low-pressure steam and streams cooler than 300°F; near-zero flaring; using solar energy to power cooling applications; use of wind power in CPI facilities; integrating biomass into your fuel mix; a new approach to improving the efficiency of fired heaters and more.

Other themes in the conference include, but are not limited to, process intensification; diversifying raw-material sourcing; immediate and long-term potential for biotechnology in the CPI; increasing production — design and revamps; new materials of construction; wireless plant communications and other innovations in process-automation, safety and security; strategies for clean air and climate change legislation; ensuring safer process plants; water treatment, supply and reuse; business insight for engineers; cost estimation and project justification; ethics and more.

The exhibition will feature an emerging technology pavilion and a host of other innovative solutions (see p. 32D-1–8 for more). One of the unique features planned for the exhibit floor is the Chementator Lightning Round. Like its namesake, the acclaimed and popular editorial department that has been a fixture in these pages for many years (see pp. 11–16), these live interviews — hosted by *CE* editors — will identify the unique benefits of newly proven technologies or approaches that can achieve breakthroughs in CPI applications. Each presenter will have approximately ten minutes to answer questions such as the following: How does the new process or technology work? How does it differ from traditional methods? What is the key characteristic that makes it unique and innovative? How do the economics or other benefits compare quantitatively? How far it has been proven commercially?

This description is only the tip of the iceberg, so I encourage you to join us in Houston and learn more. ■

Rebekkah Marshall

Letters

Comments on PAT article

September, Counting On Process Analytical Technology (PAT), pp. 47–50: The authors have shared and highlighted some of the shortcomings they have experienced in pharmaceutical manufacturing and how they can be improved upon to have sustainable and productive processes. Some of the information may still be considered sacrosanct.

A careful reading clearly presents some of the opportunities and alludes to others. If applied individually and collectively they can simplify pharmaceutical manufacturing processes. Each application would be customized as it should be and would improve productivity and yield. If done right, quality will be engineered into the products rather than analyzed into products as is done today.

The goal of process simplification is necessary and has been recognized for some time. It has been put on the front burner since about 2001. There has been and is significant ongoing discussion of acronyms like PAT, QbA (quality by analysis) and QbD (quality by design), which I believe are fancier ways of describing fundamentals of chemistry and chemical engineering.

Regulatory bodies have promulgated rules to ensure repeatable product quality. These rules have become the roadblock for process innovation. In the shadow of meeting profitability objectives, the pursuit of process innovation and simplification has become a distant second choice.

We need processes that produce quality product rather than processes that cannot convert good raw materials in to good quality products. If we can achieve repeatable quality, it is possible that regulatory requirements might ease, the cost of drugs might come down and profitability might improve.

I am pleased with this article as what has been taboo and where the problems and solutions exist are being discussed openly. It is healthy, as it would lead to innovation. The majority of articles on pharmaceutical manufacturing discuss formulation only. General coverage of API (active pharmaceutical ingredients) is good in this article.

Reading the article I was reminded of an advertisement "We need tuna that tastes good rather than tuna that has good taste."

Girish Malhotra, PE
President, EPCOT International

The perfect safety storm

What you wrote for the June 2010 issue (Safety, ethics on the Horizon, p. 5) struck like a laser beam at the heart of probably 80% of all industry-related incidents. You brought together the perfect storm of cause and effect in which the impetus for having to operate equipment and ancillary systems at their limit in trying to meet demand is the same impetus that gives cause for management to turn a blind eye to tell-tale signs of an impending upset. In such cases, protocol gets ignored in lieu of maintaining production demands. Well done — again.

Bill Huitt
W.M. Huitt Co., St. Louis, Mo. ■

Calendar

NORTH AMERICA

ChemInnovations. *Chemical Engingeering* (New York) and Access Intelligence (Rockville, Md.). Phone: 713-343-1880; Web: cpievent.com
Houston **Oct. 19–21**

Using WirelessHART Communication in the Process Industries. HART Communication Foundation (Austin, Tex.). Phone: 512-794-0369; Email: hartcomm.org
Houston **Oct. 21**
Huntington Beach, Calif. **Oct. 26**
Bakersfield, Calif. **Oct. 28**

Coating and Drying Technology Seminar. Edgar Gutoff, consulting engineer (Brookline, Mass.). Phone: 617-734-7081; Email: ebgutof@coe.neu.edu
Waltham, Mass. **Oct. 25–28**

2010 NAI Coating Show. NACE International (Houston) and The Powder Coating Institute (The Woodlands, Tex.). Phone: 832-585-0770; Web: thenaicoatingshow.com
Indianapolis, Ind. **Oct. 27–30**

44th ACS Midwest Regional Meeting. American Chemical Soc. (Washington, D.C.). Phone: 620-341-5515; Web: acs.org.
Wichita, Kan. **Oct. 27–29**

Valve Basics Seminar & Exhibition. Valve Manufacturers Assn. (Fredericksburg, Va.). Phone: 540-785-8901; Web: vma.org
Baton Rouge, La. **Oct. 28**

2010 Gasification Technologies Conference. Gasification Technologies Council (Arlington, Va.). Phone: 703-276-0110; Web: wef.org
Washington, D.C. **Oct. 31–Nov. 3**

5th International Process Analytical Technologies in Organic Process R&D. Scientific Update (Tonbridge, U.K.). Phone: +44 14 3587 3062; Web: scientificupdate.co.uk
Clearwater, Fla. **Nov. 1–2**

Polymorphism & Crystallization. Scientific Update (Tonbridge, U.K.). Phone: +44 14 3587 3062; Web: scientificupdate.co.uk
Clearwater, Fla. **Nov. 3–4**

2010 Automation Fair. Rockwell Automation (Milwaukee, Wisc.). Phone: 612-455-1722; Web: automationfair.com.
Orlando, Fla. **Nov. 2–4**

Solids Handling: Large-Scale Modeling Tour and Lecture. Jenike & Johanson (Tyngsboro, Mass.). Phone: 978-649-3300; Web: jenike.com
San Luis Obispo, Calif. **Nov. 4**

AIChE 2010 Annual Meeting. AIChE (New York). Phone: 800-242-4363; Web: aiche.org.
Salt Lake City, Utah **Nov. 7–12**

2010 IEEE International Conference on Homeland Security. IEEE (Waltham, Mass.). Phone: 800-678-4333; Web: ieee-hst.org
Waltham, Mass. **Nov. 8–10**

2010 AISES National Conference. American Indian Science & Engineering Soc. (Albuquerque, N.M.). Phone: 565-765-1052; Web: aises.org
Albuquerque; N.M. **Nov. 11–13**

EUROPE

5th International Gas Turbine Conference. European Turbine Network (Brussels, Belgium). Phone: +32 2 646 1577; Web: www.etn-gasturbine.eu
Brussels, Belgium **Oct. 27–28**

K 2010: International Trade Fair for Plastics and Rubber. Messe Düsseldorf (Düsseldorf, Germany). Phone: +49 211 45 60 0; Web: k-online.de
Düsseldorf, Germany **Oct. 27–Nov. 3**

Eurocoat 2010. Group E.T.A. (Antony, France). Phone: ++33 1 7792 9668; Web: eurocoat-expo.com
Genoa, Italy **Nov. 9–11**

Valve World Expo 2010, 7th Bienniel Valve World Conference & Exhibition. Messe Düsseldorf North America (Chicago, Ill.). Phone: +312-781-5180; Web: mdna.com
Düsseldorf, Germany **Nov. 30–Dec. 2**

SPAR Europe 2010 and Plant-Tech 2010. Diversified Business Communications (Portland, Maine). Phone: +31 6 2049 1242; Web: spar-eu.com
Amsterdam **Dec. 7–8**

Interplastica 2010. Messe Düsseldorf North America (Chicago, Ill.). Phone: 312-781-5180; Web: mdna.com
Moscow **Jan. 25–28, 2011**

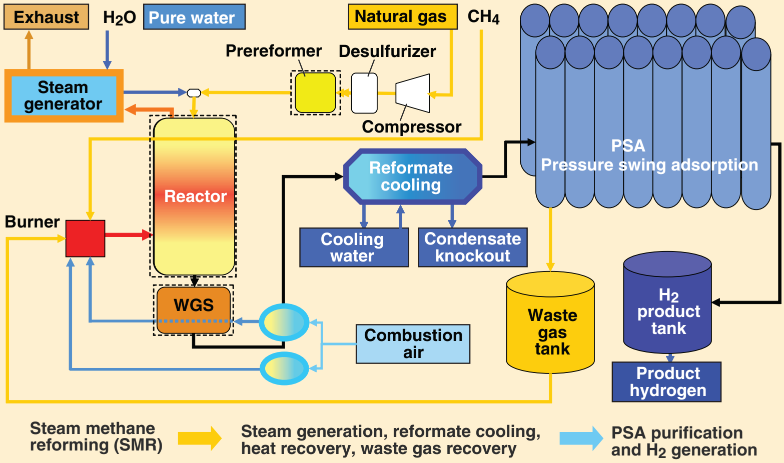
ASIA & ELSEWHERE

In-Cosmetics Asia 2010. Reed Ehibitions (Surrey, U.K.); Phone: +44 2089 10 7847; Web: in-cosmeticsasia.com
Bangkok, Thailand **Nov. 2–4**

Chemspec Middle East. Quartz Business Media Ltd. (Surrey, U.K.); Phone: +44 1737 855 000; Web: chemspecmiddleeast.com
Dubai, UAE **Nov. 29–30** ■

Suzanne Shelley

A modular SMR unit provides onsite hydrogen production



Source: Air Liquide

Standardized steam-methane-reforming (SMR) reactor units recently commercialized by Air Liquide (Paris, France; www.airliquide.com) allow direct hydrogen production at customer sites at costs much lower than those associated with alternative H_2 supply modes, including electrolysis and transporting compressed or liquefied H_2.

Because of the technology's specific applicability to facilities that produce silicon photovoltaic (PV) cells, the SMR unit, known as HYOS-R-10k, was given the 2010 Solar Industry Award for PV-materials enabling by *Solar*, an industry trade publication. Air Liquide says that onsite hydrogen-generation technologies previously available had not generally met the H_2 needs for typical PV cell producers.

The compact HYOS-R-10k modular hydrogen-production unit is constructed on a unique skid that contains all system components. To generate hydrogen, natural gas is mixed with steam and fed into high-alloy reformer catalyst tubes, where synthesis gas is produced (diagram). This process stream enters a shift converter, where additional H_2 is produced via a water-gas shift (WGS) reaction and CO is converted to CO_2. The gas stream is then cooled and fed into a unique pressure-swing adsorption (PSA) purification system, where carbon dioxide and water are removed, leaving H_2 gas with less than 10 ppm impurities (that is, an H_2 purity of 99.999%).

"Our proprietary catalyst allows the reformer reaction to be carried out at much lower temperatures than conventional SMR technologies," says Air Liquide. "This results in less NOx production and lower thermal stress on the catalyst tubes." The standardized skidded HYOS-R-10k allows lower capital and installation costs, and the unit's efficiency and flexibility can mean reduced operating expenses, explains the company.

The system is capable of generating 268 m^3/h of H_2 gas per unit at standard temperature and pressure. The modular nature of the technology allows installation of several units to match requirements for H_2 generation.

Nanowires that spring into action

A group of Singapore researchers have reported a new approach to induce the coiling of prefabricated gold nanowires (AuNWs) inside polymer shells, leading to structures resembling torsion springs. In contrast to gas-phase methods that require high temperatures and are limited to nonmetallic nanomaterials, the transformation of straight wires into circular rings takes place in a colloidal solution by modulating the contraction of encapsulating shells made of polystyrene-block-poly(acrylic acid) (PSPAA).

Professor Bengang Xing and his colleagues at Singapore's Nanyang Technological University (www.ntu.edu.sg) encapsulate the gold nanowires in a polymer container called a micelle. The solvent around the micelle is then changed causing it to shrink. Each micelle containes a single coil of 5 to 10 loops. The induced coiling in the stressed AuNWs stores elastic energy, which is released when the nanosprings spontaneously uncoil upon removal or swelling of the polymer shells.

Xing says the ultrafine AuNWs could serve as molecular-scale interconnections for the construction of nanoelectronic devices for use in sensors, piezoelectronics, or memory chips. The AuNWs could also serve as a platform to catalyze some organic reactions. By controlling their length and diameter, the AuNWs may find applications as a transporter to achieve target drug delivery and realtime biological imaging of cellular functions, or in pollution control for the detection of mercury in water.

Improved C_5 use

Some 106,000 ton/yr of so-called spent C_5 fraction is generated at Mitsui Chemicals Inc.'s (Mitsui; Tokyo, Japan; www.mitsuichem.com) naphtha cracker at its Chiba Factory. Presently, the company is selling about half of the C_5 fraction (50,000 ton/yr) — after partial hydrogenation — to Idemitsu Kosan Co. (Tokyo) for gasoline production, and the remainder is burned as fuel.

In order to better utilize these C_5s, the company is investing ¥1.3 billion ($13 million) for the construction of a new hydrogenation facility. When the unit starts up in July, 2012, it will be used to hydrogenate the C_5 fraction using H_2 from its naphtha cracker. Isoprene will then be extracted, which will be used by JSR Corp. (Tokyo) for making synthetic rubber, and the remaining materials used to enhance ethylene production at Mitsui's naphtha cracker. In so doing, Mitsui expects to achieve savings in naphtha consumption of several percent.

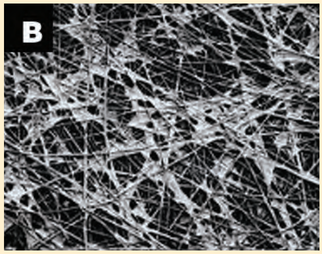
Efficient screw pumps

Allweiler AG (Radolfzell, Germany; www.allweiler.de) has developed a new system for regulating the speed of its

(*Continues on p. 12*)

Note: For more information, circle the 3-digit number on p. 66, or use the website designation.

Photos: Teijin Group



Fabric of carbon fibers set to improve fuel-cell performance

Toho Tenax Co. (Tokyo; www.tohotenax.com), the main company of the Teijin Group's carbon fibers business, has commercialized a gas-diffusion layer (GDL) made of carbon fiber fabric for use as an electrode component for fuel cells. GDLs are a key component of the electrode in fuel cells, supplying hydrogen and oxygen while collecting electrons generated and discharging water produced at the membrane. GDLs must be able to conduct electricity and be permeable to water.

The fabric-type GDL (photo A) exhibits better flexibility and strength than commonly used paper-type GDLs, which are carbon fiber sheets impregnated with resin or other materials (photo B). With the new fabric structure, roll-to-roll processing can be performed at high speeds, enabling a reduction in user costs. Because resin or other materials are not needed, water permeability can be further improved, thereby enabling higher output of fuel cells, says the company.

By creating a uniform textile surface using technologies refined by Toho Tenax, such as spinning, weaving and carbonizing, the carbon-fiber-fabric GDL has a lower contact resistance than conventional fabric-type GDLs. With low contact resistance, further improvements in fuel-cell performance can be expected, says the firm.

The new GDL is available in two thicknesses — 260 and 320 µm — and the development of ultrathin fabrics (200 µm and less) is underway.

Micro-plasma reactor makes methanol from methane

A plasma-based process has achieved a 30% yield of methanol from methane in a microreactor system developed by a research team led by Tomohiro Nozaki, associate professor at Tokyo Institute of Technology (TiTech; Tokyo, www.mech.titech.ac.jp). The yield is nearly the same as that obtained in conventional methanol-synthesis reactors (in single pass), which catalytically convert synthesis gas (from methane steam reformers) into methanol at temperatures of about 800°C. The direct, plasma-based route thus has the potential to slash energy consumption by one to two orders of magnitude, says Nozaki.

The Nozaki group constructed a microreactor that incorporates nano-pulsed plasma technology used in air-purification systems. A mixture of air and methane passes through a 1.5-mm dia., 5-cm long water-cooled quartz tube. When the nano-pulsed plasma is applied, methanol (as well as formaldehyde and formic acid) are produced with reaction times of 100–500 ms. The products are condensed on the walls of the tube and removed by a pulsed injection of water, which minimizes decomposition and further reactions. Selectivities of 40–50% for methanol formaldehyde and formic acid are achieved at 10°C operation. The researchers believe the technology has potential applications in utilizing stranded natural gas, as well as for small-scale fuel cells operating on biogas.

(*Continued from p. 11*)

screw pumps that can lead to energy savings as high as 75%. Dubbed Allspeed, the new control system features a proprietary algorithm that adaptively controls a frequency converter in realtime so the pump can adjust to changing conditions in less than 500 ms. With the system, speed jumps of up to 5,000/min and pressure differentials of up to 120 bar are handled.

Allspeed augments the company's Emtec Series, which is designed specifically for pumping coolants in tool machines. The control system enables operators to use low-pulsation screw pumps instead of the more common centrifugal pumps (up to 25 bar).

A new multiphase contactor promises to cut costs for carbon capture and more

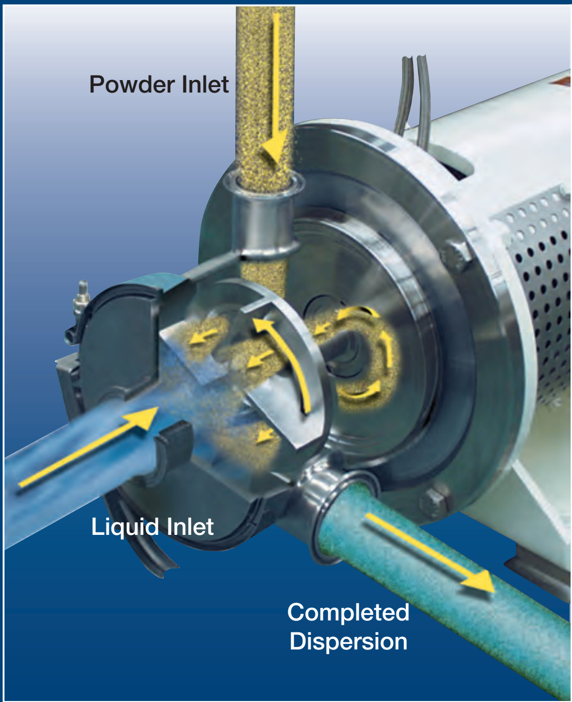
Westec Environmental Solutions, LLC (WES; Chicago, Ill.; www.wes-worldwide.com) has developed a gas-liquid absorption technology that can dramatically enhance mass transfer in gas-liquid absorption, extraction and scrubbing systems. The patented WES Absorber operates co-currently and creates a micro-froth matrix that intensifies mass transfer. Co-current operation allows the column to operate at gas velocities "far in excess" to those tolerated by conventional counter-current gas-liquid absorbers, without significant solvent losses through entrainment and flooding, says the firm.

In laboratory trials, the WES Absorber has achieved 10 theoretical mass-transfer stages in a single, 0.5-m high stage. The absorber requires less than one-fifth the mass-transfer height than conventional absorbtion columns with proprietary structured packing, for the same level of CO_2 absorption. Consequently, in fluegas applications, the WES Absorber will reduce total absorber height by approximately 50% compared to conventional or packed or tray absorbers, says the firm.

Last month, WES finalized a joint-development agreement with Process Group Pty Ltd. (Melbourne, Australia; www.processgroup.com.au) to further develop the technology. The first pilot field-demonstration of the WES Absorber will be the QER (Brisbane, Australia; www.qer.com) shale-to-liquids project in Yarwun, Australia. Process Group is contracted for the design of the CO_2-capture plant. The trial is said to offer a fast-track for commercialization of the technology.

The WES Absorber offers the potential to reduce the cost of carbon capture by up to 30% through reductions in absorber size and by facilitating higher solvent CO_2 loadings, says the firm. The technology can be applied to all solvent-based carbon capture and storage (CCS) processes, as well as other gas-liquid absorption processes that are deployed in natural gas processing, petroleum refineries, petrochemicals and other industries.

The ultimate in high speed powder dispersion.



An intense vacuum draws powders including silica, thickeners and pigments into the mix chamber of the SLIM Solids/Liquid Injection Manifold. They are injected through a ported rotor directly into the high shear zone and dispersed instantly.

SLIM eliminates the clogging and poor dispersion quality associated with eductor-based systems. It also eliminates the need for an auxiliary pump in most applications. Operation is simple – and the portable inline SLIM easily serves multiple process lines.

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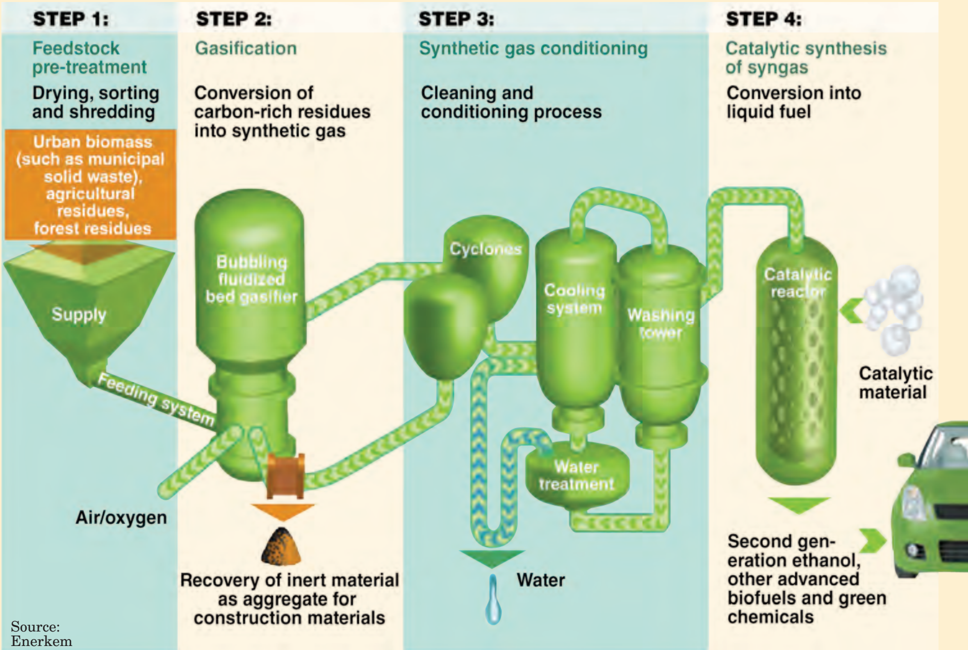
Circle 38 on p. 66 or go to adlinks.che.com/29255-38

'World's first' commercial plant to produce biofuel from municipal waste

Enerkem Inc. (Montreal, Can-ada; www.enerkem.com) has broken ground in Edmonton, Alberta, on what is said to be the world's first industrial-scale plant to produce liquid fuel from municipal solid waste. When the plant starts up at the end of 2011, it will convert 100,000 metric tons per year (m.t./yr) of garbage into 10-million gal/yr of methanol, followed by ethanol, under a 25-year supply contract with the City of Edmonton. The garbage represents 40% of the city's waste that is currently landfilled because it cannot be recycled or composted.



Source: Enerkem

In Enerkem's process, garbage is shredded and gasified in a bubbling fluidized bed at "low severity" (750–800°C and atmospheric pressure). The severity is increased in stages to produce a synthesis gas that is mainly carbon monoxide and hydrogen. Particulate matter is removed by cyclones, then the gas is water-scrubbed, compressed and converted sequentially, by proprietary catalytic processes, to methanol, acetate, and finally to ethanol. Early next year Enerkem will start construction on a similar plant in Pontotoc, Miss., supported by $50 million in funding from the U.S. Dept. of Energy (DOE; Washington, D.C.; www.energy.gov).

Modifier improves the heat tolerance of bioplastic

Plastic derived from corn, used mostly for bottles and cups, costs about 20% more than petroleum-based plastics, but has two desirable qualities: it comes from a renewable resource and is biodegradable. However, the use of the plastic — polylactic acid (PLA) — is restricted because PLA has a heat-deflection temperature of only about 60–70°C, well below the 100°C filling temperature required for many food products.

An additive, or modifier, that promises to resolve that problem is being developed at the U.S. Dept. of Agriculture's (USDA) Western Regional Research Center (Albany, Calif.; www.ars.usda.gov) in collaboration with Lapol, LLC (Santa Barbara, Calif.; lapol.net). In laboratory tests the modifier has already pushed the deflection temperature above 100°C, says researcher Allison Flynn, a Lapol chemist. Lapol, a startup company, specializes in additives for plastics and has already developed a plasticizer that makes PLA more flexible.

USDA chemist William Orts explains that PLA is made by using bacteria to ferment corn sugar to lactic acid. The acid is dehydrated to lactide, which is polymerized to obtain beads of PLA. The modifier is blended with the PLA to make it more heat-tolerant. Flynn says the modifier is a PLA-based copolymer that has a shorter chain length than PLA. About 10–20% modifier is mixed with the PLA for compounding. Flynn declines to give further details on the copolymer or the production process, pending patent applications.

FAs to chemicals

The first microbial platform for producing fuels and chemicals from fatty acids (FAs) has been reported by Glycos Biotechnologies, Inc. (Houston; glycosbio.com). Researchers from the company have metabolically engineered native and heterogeneous fermentive pathways to function in *E. Coli* under aerobic conditions. The team has successfully synthesized ethanol, butanol, acetate, acetone, isopropanol, succinate and propionate.

New membranes

The ion-exchange-resins business unit of Lanxess AG (Leverkusen, Germany; www.lanxess.com) plans to add membrane technology to its water-treatment portfolio. The company has invested €30 million in a new facility in Bitterfeld, Germany. The new plant will start up at the end of this year for producing ion exchange resins and for the pilot-and-development

(*Continues on p. 16*)

Graphene produced by CVD launched commercially

Graphene Laboratories Inc. (Reading, Mass.; www.graphenelab.com) and CVD Equipment Corp. (Ronkonkoma, N.Y.; www.cvdequipment.com) recently announced the commercial launch of single-layer graphene films, marketed as CVDGraphene, grown by a chemical vapor deposition (CVD) process.

Using slightly modified CVD equipment that has been used to produce carbon nanotubes, the CVDGraphene films are made by decomposing diluted methane on transition-metal surfaces at elevated temperatures. Thickness of the sheets can be verified using Raman scattering spectroscopy.

The graphene films are deposited on either copper foils or on copper-coated silicon wafers, and are offered in 2-in. by 4-in. squares or custom-designed for specific applications. A single CVD furnace can generate a graphene sheet in about 45 min, says Graphene Laboratories CEO Dr. Elena Polyakova, and the process is amenable to scaleup.

Graphene, a two-dimensional, honeycomb-shaped lattice of sp^2-bonded carbon atoms, exhibits high stability and structural and electronic properties that make it a candidate for applications such as transistors, solar cells, composite materials, flexible electronics and others.

Since the product launch in late August, about half of the customers hail from academia, while the other half are industrial R&D departments, Polyakova reports. “We’re seeing a good deal of interest in graphene for electronics research, but also significant interest surrounding chemical and biological sensors, optical devices and microelectromechanical systems (MEMS).”

BioDME starts fueling trucks

Last month, the world’s first plant for the production of BioDME (dimethyl ether) was inaugurated at the Smurfit Kappa paper mill in Piteå, Sweden. The pilot plant — built and operated by Chemrec AB (Stockholm, Sweden; www.chemrec.se) — uses Chemrec’s gasification technology (*CE*, October 2002, pp. 39–40) to convert black liquor from the mill into syngas, which is then cleaned and conditioned before entering a DME process-development unit, based on process technology of Haldor Topsøe A/S (Lyngby, Denmark; www.topsoe.com). The facility produces about 4 m.t./d (1,600 gal/d) of DME.

The $20-million plant is part of the European BioDME project, which is supported by the Swedish Energy Agency and the EU’s Seventh Framework Program. Volvo Trucks (Göteborg, Sweden; www.volvotrucks.com), the project coordinator, has demonstrated the first heavy-duty truck with an engine adapted for DME fuel, and will put a fleet of 14 DME trucks into operation. Preem AB (Stockholm; www.preem.se) is participating in the project by constructing four filling stations to support the DME fleet.

Electric fields boost energy production and cut operating costs of sewage and biogas plants

Last month at the IFAT Entsorga trade fair (September 13–17; Munich, Germany), Süd-Chemie AG (Munich; www.sud-chemie.com) introduced a chemical-free process that increases the energy production of wastewater-purification and biogas plants by as much as 30% while significantly reducing the disposal costs of sewage treatment plants. The electrokinetic disintegration process exposes biological sludge in sewage plants to a strong electric field, which breaks down the extra-cellular polymeric substances (cell structures and cell membranes) and stabilizes the biological sludge. As a result, the conversion of the energy contained in the biological cells of the sludge to methane gas in the biochemical processes in the digester is considerably more efficient, says the company. The energy that is produced is then used to operate the purification plant. Because only an electric field is applied (no electrical current), the energy needed for the disintegration plant is negligible.

The process was developed together with technology partners UAS Messtechnik GmbH (Viechtach, Germany; www.uas.de) and the University of Applied Sciences Deggendorf (Germany; www.fh-deggendorf.de). The first implementation of the disintegration technology was at the Bruckmühl wastewater purification plant near Bad Aibling, Germany, in late 2009. During the first six months of operation, methane gas output (thus energy production) increased by around 20%. Also, operating and disposal costs were "significantly" reduced, since the volume of flocculants used for treating sewage and the amount of sludge that required disposal were both reduced by 10%, says Süd Chemie.

The investment costs for the electrokinetic disintegration process can pay for itself in about two years, due to the reduced operating costs. ■

(*Continued from p. 14*)

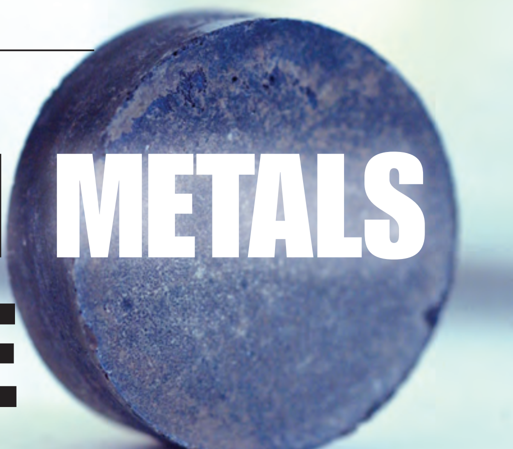
phase of new membranes. First products are to be launched at the end of 2011.

The company did not disclose any details about the membranes being developed, but the technology will complement its ion-exchange resins. The global market for membrane technology is about €1 billion, and expected to grow 10%/yr in the coming years, says Michael Zobel, head of the ION business unit.

BioPd

Researchers from the School of Biosciences at the University of Birmingham (U.K.; www.sgm.ac.uk) have discovered the mechanism that allows *Desulfovibrio desulfuricams* — a common soil bacteria — to recover palladium from industrial wastewater. The microorganisms reduce palladium from wastewater, accumulating nanoparticles of metallic Pd in their cell walls. Dubbed BioPd, these Pd-coated cells have potential applications as catalysts. ❏

RARE-EARTH METALS FOR THE FUTURE



Economics, workforce and R&D will determine the future of these critical technology metals

FIGURE 1. Rare-earth magnets similar to this one, produced at Ames Laboratory using a new process, are critical in many technology applications

As demand for rare-earth metals in a wide range of technology applications continues to increase, efforts to reestablish mining and production of rare-earth elements (REEs) is underway outside China, currently the dominant force in REE production. Future supplies of REEs and the myriad products in which they appear will depend less on absolute geological reserves and global trade politics and more on issues of economic viability, workforce development and technological innovation.

With Chinese REE exports shrinking to keep material in the country for its own rising demands, developing an REE supply chain outside China appears to be essential in meeting a global demand that is projected to grow from the current 140,000 ton/yr to over 200,000 ton/yr by 2015. Whether a diversified REE marketplace takes shape and whether global demand for REEs is met will be determined to a large extent by how chemical engineers address challenges associated with mining economically, extracting metals efficiently and developing ways to extend the current metal supplies.

TABLE 1. SELECTED END-USES FOR RARE EARTH ELEMENTS

Light rare earths	Major end-use	Heavy rare earths	Major end-use
Lanthanum	Hybrid electric-vehicle engines, metal alloys	Terbium	Phosphors, permanent magnets
Cerium	Auto catalysts, petroleum refining, metal alloys	Dysprosium	Permanent magnets, hybrid engines
Praseodymium	Permanent magnets	Erbium	Phosphors
Neodymium	Auto catalysts, petroleum refining, magnets for hard drives, lasers	Yttrium	Red color, fluorescent lamps, ceramics, metal alloy agents
Samarium	Magnets	Holmium	Glass coloring, lasers
Europium	Red color for television and computer screens	Thulium	Medical x-ray units
Gadolinium	Magnets	Lutetium	Catalysts in petroleum refining
		Ytterbium	Lasers, steel alloys

Source: U.S. Geological Survey (USGS)

Energy dependence

Issues surrounding the supply of REEs are closely interrelated with those of energy consumption. The same is true of other critical metals (box, p. 23). In many ways, meeting the demand for metal minerals depends on our access to cheap and plentiful energy, explains Andre Diederen, analyst at the not-for-profit organization TNO Defense, Security and Safety (Rijswijk, the Netherlands; www.tno.nl). "The problem is not that we will run out of metal in the earth's crust," Diederen says, "it's that mining and extracting it at current rates will become prohibitively energy intensive."

Removing ore from the ground and concentrating the metals require huge amounts of energy, and the energy required grows exponentially with lower ore grades. "Because of energy constraints, the largest parts of mineral deposits are out of reach for economically viable exploitation," Diederen says. A decades-old paradigm — that lower ore grades will be exploited when a supply gap exists — will no longer be valid without cheap and plentiful energy. And Diederen and others think the world will likely reach an oil production maximum within the next ten years and a coal production maximum in 25 years, after which, energy supply will no longer keep up with demand.

For REEs, the amount of metals in existing and undiscovered deposits is not an issue, says industry consultant Jack Lifton. "It's not about how much is there," he says, "it's about how much we can do." Extracting and refining rare earth metals is really an economic problem and a personnel workforce problem. "The capital costs are staggering" for setting up mining, refining operations and infrastructure, Lifton explains. Since every ore deposit is different, each site represents a unique chemical engineering problem, and "there are not enough chemical engineers with the [rare earth] expertise to do the job."

REEs not rare, but critical

Occupying the "lanthanide" row of the periodic table, REEs are actually moderately abundant in the earth's crust, with some more plentiful than other important metals, such as copper, gold, platinum and lead. Although relatively abundant, REE deposits are often not concentrated enough to allow economically viable extraction.

REEs are nominally divided into light and heavy rare earths, according to atomic number. Light rare earths, such as lanthanum and cerium, are more common than heavy rare earths, which make up 1 to 20% of the total rare earths in most known deposits, and may be more prone to shortage. Most REEs are found in varying concentrations together in deposits of the mineral bastnäsite, which is mined as a primary mineral. Other rare-earth material can be found in the mineral monazite, which is typically located in deposits of other ores and is recovered as a byproduct of uranium and niobium processing. Since various rare-earth oxides are often found together, separating them is a major challenge.

FIGURE 2. REEs have unique properties, which greatly complicates efforts to find alternatives in end-use products

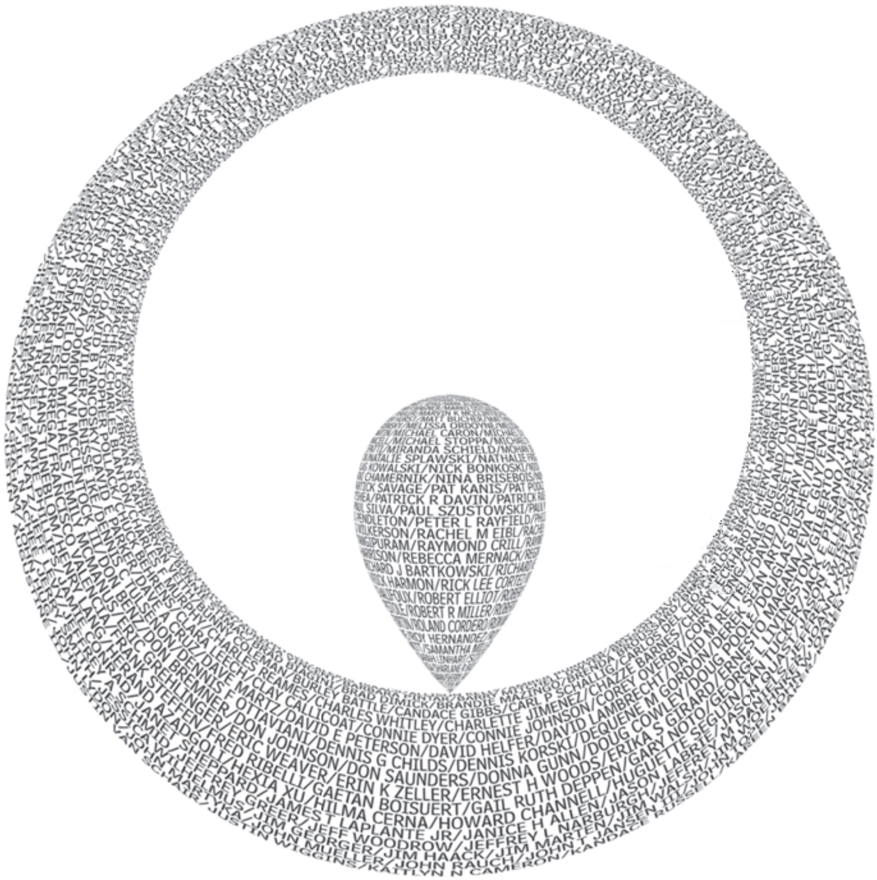
REEs have found widespread use in high-technology products because of their unique atomic properties, which make replacing them with alternatives difficult (Table 1; Figure 2).

One of the most important uses of REEs is in permanent magnets, which appear in products such as hybrid vehicles, wind turbines and computer hard drives. The strongest permanent magnet is made from alloys of neodymium, iron and boron (NdFeB magnet).

Research and development projects involving such magnets are prominent at the U.S. Dept. of Energy's Ames Laboratory (Ames, Iowa; www.ameslab.gov), one of the few places outside China where basic research related to rare earth metals is carried out. One project ongoing there is led by renowned rare-earth expert Karl Gschneidner, whose group has developed an improved process for making NdFeB magnets (Figure 1). The new environmentally friendly process eliminates waste and reduces energy consumption in producing the magnets by 40–50%. The researchers found a way to eliminate a step from the conventional process in the transformation of neodymium oxide to Nd master alloy. The strategy behind the single-step process may be applied to other areas, such as producing lanthanum master alloy for nickel-metal-hydride batteries for electric vehicles.

Chinese dominance

China owns a virtual stranglehold on rare earth production and processing, with 95% of rare-earth oxide mined and 97% of rare-earth metals refined in China. The nation is also a leader in rare-earth R&D, with several state-run laboratories for rare-earth chemistry,



utilization and training.

China has recently begun reducing exports of rare earth metals, sparking shortage fears and rising prices, but also stimulating activities toward production of rare-earth metals outside China. Chinese economic growth and its adoption of alternative energy technology are driving its export reductions, along with efforts to address mining-related environmental concerns.

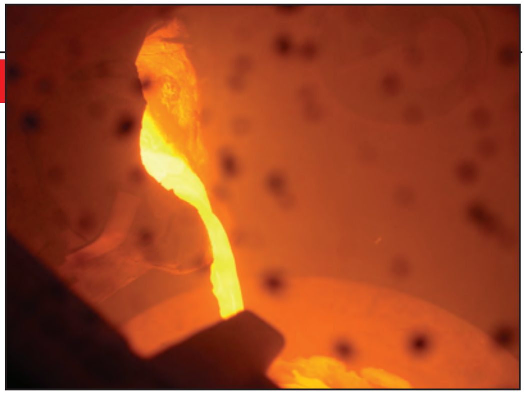


FIGURE 3. **Magnet manufacturers using REEs like this molten samarium, are among those supporting diversification of the rare earth supply chain**

Peter Dent, VP of business development at Electron Energy (Landisville, Pa.; www.electronenergy.com) says his company, a maker of samarium cobalt permanent magnets, (Figure 3) has not had trouble with supplies yet, but "we are watching our own inventories and market prices very carefully."

Most experts agree that China's gradual export restrictions are not intended to starve the world of rare-earth metals and will correspond to non-Chinese sources of rare earths becoming available. Dent's company is among many who support efforts to re-establish an alternative, non-Chinese supply chain of rare-earth metals.

A non-Chinese REE supply

Efforts on several fronts are aimed at boosting REE production outside of China, including plans to reopen former REE mines in the U.S. and South Africa, as well as develop rare-earth deposits in Australia, Canada and elsewhere.

An example of these activities is the reopening of a 55-acre rare-earth deposit at Mountain Pass, Calif. by Molycorp Minerals LLC (Greenwood Village, Colo.; www.molycorp.com). A fast-moving project is underway at the mine, which had been a major source of rare earth oxides from its start in 1953 until 1998, when mining stopped. Molycorp is currently producing rare earth oxides at a 3,000 ton/yr pace from mined materials that were stockpiled during the years that the mine was operating.

In January 2011, the firm will break ground on a separations plant capable of producing the full range of rare-earth oxides present in the ore. During the time the mine was offline, Molycorp engineers have developed a suite of processing improvements and separations technologies designed for efficiency and cost-effectiveness.

Among the improvements is a new milling process that increases recovery of rare-earth metals from the ore. Operations in China now generally achieve a 40% recovery, while the Molycorp process should boost this rate to 68% recovery. "This greater front-end efficiency continues to pay dividends in downstream processing," says Molycorp spokesperson Jim Sims.

Company engineers have also developed a system for recycling wastewater that makes the plant an almost zero-wastewater facility. In conventional REE processing, salt-laden water is a major waste stream. In addition, Molycorp will recycle the acids and bases that are needed to process rare earth oxides to avoid having to continuously transport chemical reagents to the site.

The new plant will be powered by an off-the-grid natural-gas steam-power cogeneration system, Sims explains. By mid-2012, the company will boost production to 20,000 ton/yr of rare-earth oxides. Molycorp will produce mostly lanthanum, cerium, neodymium and praseodymium at the site, but will also generate smaller amounts of samarium, terbium, europium, gadolinium, erbium and dysprosium.

Molycorp is executing a "mines-to-magnet" strategy, which seeks to engage in REE production at every point on the supply chain, from ore to refined metal oxide, to final products. As part of the strategy, Molycorp is partnering with magnet producers.

Another example of the re-emergence of a rare-earth-metals industry outside China is Avalon Rare Metals Inc.'s (Toronto, Canada; www.avalonraremetals.com) development of a rare earth deposit called Nechalacho, near Thor Lake in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Canada's Northwest Territories. Operations at the Thor Lake site will mill, crush and concentrate the minerals in the ore. Avalon is also planning to build a hydrometallurgical plant to further concentrate the 15 REEs present in the ore into a chemical concentrate. It is also conducting a scoping study for a separation plant to isolate the 15 elements into individual rare-earth oxide products.

Avalon CEO Don Bubar explains that the Thor Lake deposit has several desirable qualities that increase its potential economic viability. One advantage is that the site contains an unusually high concentration of several scarce, heavy REEs currently in high demand, such as terbium and dysprosium. In addition, the deposit contains recoverable byproducts, including zirconium, tantalum and niobium, which are valuable themselves.

Avalon has moved its process technology development into the pilot stage. An interesting aspect of Avalon's REE processing plant is a planned sulfuric-acid production facility to generate the acid required to break down the mined minerals. "The amount of sulfuric acid needed is a challenge," Bubar explains, and it makes more sense to produce it onsite rather than transport the hundreds of thousands of tons per year required to process rare earths. Avalon anticipates beginning full operations at the plant in 2015.

Governments outside China are also getting the message about the importance of rare earth metals. For example, in the U.S., the Rare Earths Supply-Chain Technology and Resources Transformation Act (H.R. 4866) was introduced by Rep. Mike Coffman (R-Colo.) in the House (a similar senate bill, S. 3521, also exists). The bills are designed to spur rare-earth minerals production, refining, purification, metals production, alloying and magnet production. Among the provisions of the bill is one that would establish a national stockpile of REEs.

Extending REE supplies

Even with a diversified set of rare earth suppliers around the world, it is likely that future demand will have to be addressed in a host of different ways. Strategies likely to be explored actively include searching for ways to improve mining and milling operations, and chemical processing approaches to maximize metal yields from the ore.

Other strategies involve finding ways to recycle rare-earth metals, such as recovering and reusing scrap material from the permanent magnet manufacturing process. Ames Laboratory researcher Alan Russell says "Recycling magnet scrap is a difficult, but not insoluble, problem," adding that research grants for tackling the problem would be helpful.

For recycling metals, the economics of collection is the key to making it viable, says Nick Morley, analyst with Oakdene Hollins.

CRITICAL METALS GO WELL BEYOND RARE EARTHS

Rare-earth metals are far from the only group of elements with clear technological importance and concern over future supplies. In 2008, the National Research Council (NRC), the research arm of the National Academies (www.nationalacademies.org), explored the relationship between metal minerals and the U.S. economy. The research group, led by industry consultant Stephen Freiman, devised a Metals Criticality Matrix that assessed the impact of supply restrictions of various metals on the economy. The analysis depends heavily on the ease or difficulty of substituting away from the mineral in question. Along with the rare earths, the NRC mentioned indium, niobium and the platinum group metals (including rhodium and palladium) as ranking high on the Metals Criticality Matrix. Others have pointed to metals such as germanium, gallium and the tungsten-group metals as also having high criticality. ❑

Rare-earth metals in post-consumer waste may be too diffuse and too difficult to extract economically, but industrial recycling may be a more achievable goal, says consultant Lifton.

TNO's Diederen points out that rare-earth recycling, as well as other metal recycling, should be viewed from more of a product lifecycle perspective. Specifically, R&D projects aimed at extending product lifetimes would be important, as would conducting upfront product design to make future recycling of the material more amenable.

Although substitutes for the rare-earth metals are difficult to find without sacrificing performance in many cases, Morley points out that it may end up being more fruitful to look for substitutes not for the rare-earth materials themselves, but for alternatives to the products and applications for which they are required.

Another strategy for extending REE supplies involves finding ways to reduce rare-earth metal content in products as a way of lessening overall demand. An example comes from Ames Laboratory, where researcher Bill McCallum is investigating how to lower the rare-earth content in the permanent magnets that are used in the traction motors of hybrid electric vehicles.

A final approach would be to find alternative sources of REEs. An example of this approach began as an offshoot of a project originally conceived for another purpose. University of Leeds (Leeds, U.K.; www.leeds.ac.uk) materials scientist Animesh Jha discovered that rare-earth metal oxides are produced as co-products in a process he and colleagues were working on for refining titanium dioxide from the mineral ilmenite. Depending on the titanium minerals they use, the rare-earth content can be up to several percent. In the titanium dioxide process, a colloidal layer is generated that was found to contain lanthanum, cerium, praseodymium and other rare-earth metals. The researchers are working on improving the recovery rate of the rare earths beyond the 50–80% presently achievable. ■

Scott Jenkins

WIRELESS, WIRELESS EVERYWHERE

Emerson Process Management

FIGURE 1. Emerson Process Management's network of Fisher wireless position monitors is helping Harcros Chemicals reduce inadvertent emissions and bad batches, as well as avoid the high costs of rework, clean up and lost materials

As new wireless devices are developed, processors are finding innovative applications throughout the plant that improve operations in a cost effective manner

To achieve success in today's marketplace of global competition, chemical processors need to improve productivity while minimizing the total cost of ownership, which requires new measures and concepts.

Wireless solutions offer far more benefits than just the elimination of cables and installation costs. Users also profit from more efficient maintenance and greater flexibility and mobility. Wireless technology can help ensure improvement of production quality and safety, and solve other business issues in plants, according to Michael Cushing, product marketing manager of pressure and temperature products with Siemens Industrial Automation Div. (Spring House, Pa.). And, as wireless standards, such as WirelessHart and ISA 100.11a are approved and wireless vendors continue developing products based on these standards, the enormous potential of wireless technology opens up completely new and unique opportunities for processors (see box, p. 29).

The low hanging fruit

Since wireless technology hit the scene a few years ago, vendors of the equipment have been touting the elimination of wires and installation costs as one of the biggest benefits. Bob Karschnia, vice president of wireless technology with Emerson Process Management (Knoxville, Tenn.), says that while this is tempting to processors because wireless instrumentation costs approximately 75% less to install than wired devices, it has an additional benefit. "Monitoring can now occur in places where it was not economically feasible before," he says. "With wireless technology processors can now install vibration monitors, temperature sensors and analytical devices to determine if hard-to-wire equipment is approaching failure and then take action to prevent that failure from causing process interruption. So you're able, in a very real sense, to improve the asset performance of the facility by eliminating unplanned failure of assets."

The fact that this type of condition-based monitoring can be done inexpensively makes it attractive to many processors who are still on the fence regarding the adoption of wireless technology. "While the chemical process industries (CPI) haven't been early adopters of wireless, we are starting to see more of them applying it to these types of applications in an effort to test out the technology and reach for the low hanging fruit," says Cliff Whitehead, business development manager with Rockwell Automation (Milwaukee, Wisc.). "This is a safe place for them to start because remote asset management and condition-based monitoring are non-intrusive to the process, yet still provide benefits. If you get misfires or have issues with getting data, it won't have a direct impact on the process. These are easy applications for those who are unsure about wireless technology to wrap their mind around."

Creative opportunities

While these applications are indeed helpful to the process, technology adopters can get more bang for their buck if they additionally embrace wireless devices as a way to improve

WIRELESS TECHNOLOGY SERVICE PROVIDERS

ABB	www.abb.com
Apprion	www.aprion.com
Emerson Process Management	www.emersonprocess.com
Honeywell	www.Honeywell.com
Invensys	www.invensys.com
Pepperl+Fuchs	www.pepperl-fuchs.com
Rockwell Automation	www.rockwellautomation.com
Siemens Industry	www.usa.siemens.com
Yokogawa	www.yokogawa.com/us

business performance. "Asset management and condition-based monitoring are excellent applications to get your feet wet, but the bigger opportunities lie in using wireless technology as a solution to solve business issues like how to achieve higher efficiencies in the plant," explains Ray Rogowski, director of global marketing for wireless business with Honeywell (Morris Township, N.J.).

One of the largest roadblocks to fully embracing wireless in this way is that most facilities are already wired and no one is going to spend money in this poor economy to rip out fully functioning wired devices and replace them with wireless just to keep up with the Joneses. So, vendors have begun to develop adapters and gateways that allow processors to reap the rewards of wireless without large investments.

For example, Emerson offers the Smart Wireless THUM Adapter, which can be installed on existing HART field instrumentation to free up diagnostics and process information that had previously been inaccessible in wired, legacy system installations.

Most HART instruments have rich diagnostics and process data, yet this information goes unused because older systems are not equipped to receive HART communications. While it's often too expensive and complicated to access these data through traditional wired methods, upgrading devices with the THUM Adapter is a cost efficient way to "see" the diagnostic and process information. The THUM is a WirelessHART device that can retrofit almost any two- or four-wire HART device to enable wireless transmission of measurement and diagnostic information. Devices with the THUM Adapter operate as components of Emerson's Smart Wireless self-organizing field networks, delivering field intelligence to enable improvements in quality, safety, availability, operations and maintenance costs.

Pepperl+Fuchs

FIGURE 2. The CorrTran MV supports WirelessHART to wirelessly provide real-time monitoring of general and localized corrosion and conductivity for early detection and preventive maintenance

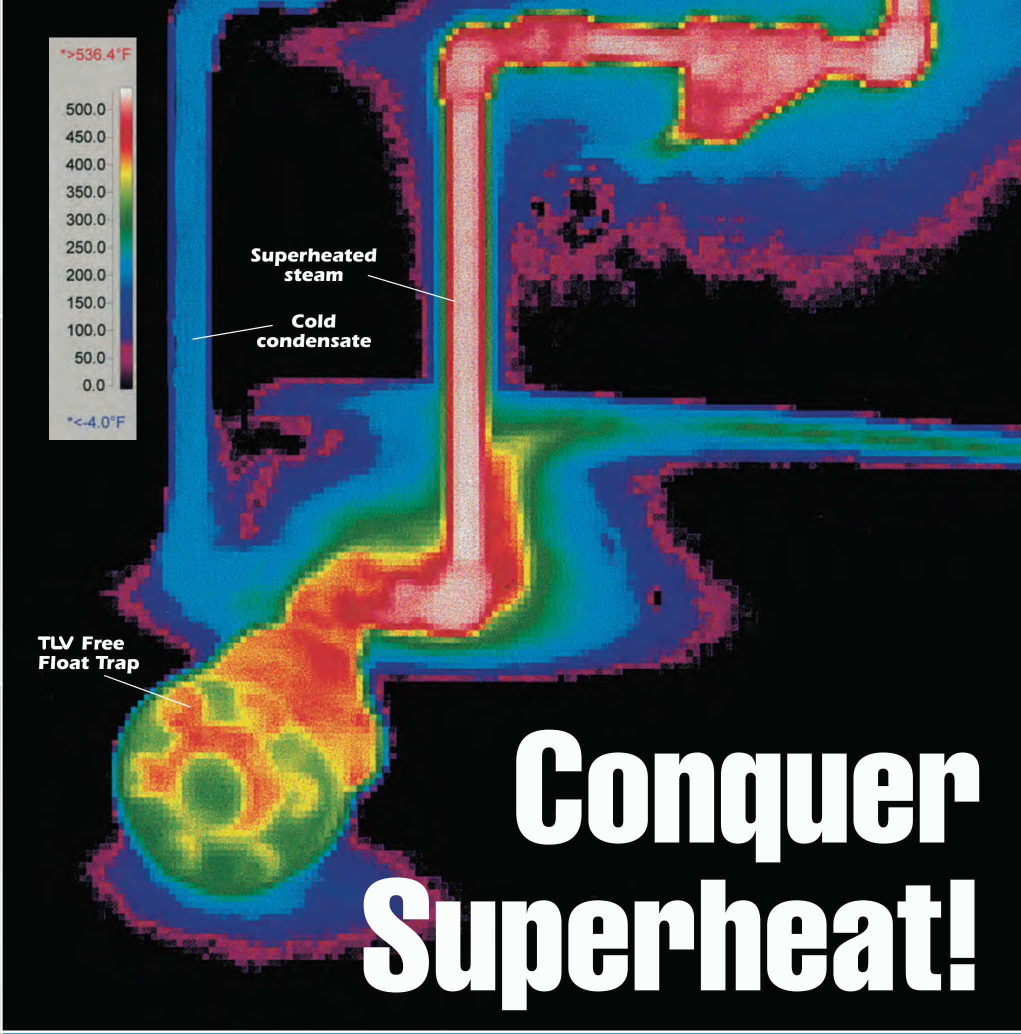
Similarly, Pepperl+Fuchs (Twinsburg, Ohio) offers a WirelessHART Adapter that connects to any existing HART device that supports HART 5 or 6 specifications, enabling it to become a WirelessHART device. These adapters mount directly into the cable gland of the existing field device and are available in various models to suit specific application needs.

At the other end of the communication path is Pepperl+Fuchs' WirelessHART Gateway, which acts as an interface between the wired structure and the wireless network. The Gateway contains the network management and uses it to organize and control the wireless network and connect this to a control or SCADA system, via a fieldbus. The signals of the field devices are received and passed on via the appropriate bus protocol in the fieldbus.

Siemens also offers the Sitrans AW200 WirelessHART adapter, which allows standard-wired HART, 4–20-mA devices to be connected to a WirelessHART network. By installing the adapter on an existing analog-wired HART device, processors can use all diagnostic information at the maintenance station without any risk of impairing operations. The company's IE/WSN-PA Link is a WirelessHART gateway for connecting a WirelessHART network to a plant host application. With the integrated network manager, it's possible to configure WirelessHART networks and optimize network performance and security settings.

Honeywell's One Wireless Adapter

650 psig
925 psig
1500 psig
1150 psig
650 psig



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Superheated steam
Cold condensate
TLV Free Float Trap
Conquer Superheat!

also attaches to any HART device and brings the ability to communicate with the wired device over the One Wireless Network. Not only does this adapter serve as a bridge between wired devices and wireless networks to rescue stranded diagnostics, but it also provides the ability to turn wired, HART-enabled devices into wireless ones.

Beyond adapters and gateways that provide access to information that will improve general operations, technology vendors are also developing specialized wireless devices, such as valve position indicators, temperature transmitters and corrosion monitors.

About one year ago, Emerson launched the Fisher 4320 wireless valve-position monitor, which the company claims is the first and only linkage-less device to provide accurate position feedback using WirelessHART communications.

Emerson Process Management

FIGURE 3. Emerson's Smart Wireless THUM Adapter can retrofit an existing two- or four-wire HART device. It enables wireless transmission of measurement and diagnostic information that was previously unavailable

Most process plants have hundreds of valves that are not connected to the control system because of high wiring costs. These valves currently provide no feedback on their actual positions, even though incorrectly positioned valves represent a significant cause of safety-related incidents. Unfortunately, users have not been able to access the position data that are valuable to the performance and safety of the plant.

The 4320 wireless position monitor changes the economics since it represents only 10 to 20% of the installed cost of a wired solution, providing users with a cost effective way to access the information. This is important to chemical processors who previously had no way to know remotely if the valves were opened or closed. "If you look at the root cause of accidents involving hazardous chemicals, it is often due to upstream valves being opened when they were thought to be closed," explains Karschnia. "This valve indicator can be used almost as an electronic lock-out tag-out system for the valves."

It is also helpful when chemical processors are cleaning and then refilling tanks. "Often the valve is opened at the bottom of the tank during cleaning and is accidentally left that way when new chemicals are put in, which results in new, good chemical going down the drain into the waste stream," he says. "The valve position monitor can help save a lot of wasted product here."

Siemens' Sitrans TF280 WirelessHART temperature transmitter provides all measured process values, as well as diagnostic information, parameters and functions via radio. The device is powered by an internal battery and designed for ultra-low power

STANDARD FARE

There's a funny saying regarding standards in the instrumentation and automation industry: "The great thing about standards is that we have so many to choose from." It's likely that this tickles the funny bone because it is so ironically accurate, and wireless standards aimed at the process industry are no exception from the rule. However, two industrial-process wireless standards seem to be taking the lead. WirelessHART and ISA 100.11a are both backed by a variety of instrumentation and automation vendors and deserve closer examination as processors begin to slowly accept and adopt wireless technology in the facility.

WirelessHART

WirelessHART technology (which is also IEC approved standard IEC 62591Ed. 1.0) provides a robust wireless protocol for the full range of process measurement, control and asset management applications. Based on the HART Communication Protocol, WirelessHART enables users to gain the benefits of wireless technology while maintaining compatibility with existing devices, tools and systems.

The HART Communication Foundation (Austin, Tex.; www.hartcomm.com), its member companies and industry representatives developed WirelessHART technology to meet the unique requirements of wireless networks operating in process plants.

Key capabilities of products that conform to the WirelessHART standard include:

- Reliability even in the presence of interference, due to technology like mesh networking, channel hopping and time-synchronized messaging. WirelessHART's coexistance with other wireless networks is assured
- Security and privacy for network communications through encryption, verification, authentication, key management and other open industry standard best practices
- Effective power management through Smart Data Publishing and other techniques that make batteries, solar and other low-power options practical for wireless devices

ISA 100.11a

A little over a year ago, the ISA 100 standards committee on Wireless Systems approved a new industry standard, ISA 100.11a, Wireless Systems for Industrial Automation: Process Control and Related Applications.

The standard is intended to provide reliable and secure wireless operation for non-critical monitoring, alerting, supervisory control, open-loop control and closed-loop control applications. The applications will focus on the performance needs, such as monitoring and process control, where latencies on the order of 100 ms can be tolerated with optional behavior for shorter latency. The standard will also provide robustness in the presence of interference found in harsh industrial environments and with legacy non-ISA 100 compliant wireless systems.

The ISA 100 standards committee has formed a subcommittee (100.12) to address the long-term convergence of the WirelessHART specification with the ISA-100.11a standard. But according to key members of the committee, it will be at least several years before products could be available for purchase with a single standard. ❏

consumption. Its design makes it suitable for direct mounting on tanks and pipes in remote parts of plants and on moving or rotating equipment for process monitoring or asset management applications.

And, Pepperl+Fuchs' CorrTran MV Corrosion Detection Transmitters can wirelessly deliver information about general and local corrosion rates and conductivity via the WirelessHART protocol. This functionality enables users to determine the effectiveness of their corrosion inhibitors, and to detect and correct corrosion issues through upkeep and preventive maintenance before they become costly problems. "We are really seeing an uptick here, especially in remote locations where they have had corrosion problems, but neglected to take measurements before," says Robert Schosker, product manager of intrinsic safety and HART solutions with Pepperl+Fuchs. "They can get those measurements and prevent corrosion problems without wires."

Honeywell's Rogowski says examples such as these represent just the beginning of how innovative use of wireless devices can improve plant function. He says additional applications might include wireless security systems for remote pipelines, as well as safety and fire systems.

"It's no secret that technology is an enabler, but there was always a trade off. 'How much does it cost to execute that solution and what's the payback if it's not mission critical?'," says Rogowski. But since wireless device prices are coming down and because installation costs are minimal, many of these and other innovative wireless solutions are not too far away from development and application, according to Rogowski. ■

Joy LePree

Fractionation Column

Zarko's challenge

Every distillation engineer west of the River Neretva is familiar with the work of Professor Zarko Olujic. His distillation laboratory at the Technical University of Delft (The Netherlands; www.tudelft.nl) is one of the largest and best facilities in the history of distillation. His work is typically funded by a consortium of companies that, most recently, included Bayer, BASF, Evonik, DSM, Montz, Koch-Glitsch, Praxair, Shell, Lummus, Akzo-Nobel, BP, ECN and Sulzer Chemtech. Zarko presently spends the majority of his time in Croatia. He consults, and he is still academically active at TU-Delft.

Zarko regularly chairs distillation and absorption sessions at AIChE meetings. He has, in fact, been named "European Liaison" to the Distillation and Absorption section of the Separations Div. Alongside Nick Urbanski of ExxonMobil, Zarko will be co-chairing six AIChE Salt Lake City sessions next month.

I am wondering now whether Zarko was in a "bad mood" when he attended the March San Antonio AIChE meeting. He seemed to be his usual cheerful, energetic self when I had lunch with him, but maybe the jet lag eventually overpowered him.

Zarko's first San Antonio presentation was regarding the HIDiC energy conservation technology. HIDiC stands for heat integrated distillation column. Basically, and briefly, with HIDiC, vapors from the stripping section are compressed (and heated) and sent to the rectifying section, and then the heat of the rectifying section is used to drive the stripping section. Zarko boldly wondered out loud why energy reduction technologies like HIDiC were not getting more attention in the U.S. He went further, wondering why column size records were being broken outside, not inside, the U.S. He referred to a European propylene tower 21.5 ft dia. and 330 ft tall (tangent to tangent)! While on a roll, he described how European companies are considering concepts like an "entire refinery in one shell," (funsters in the audience nicknamed this concept "EROS").

Zarko's second San Antonio presentation described a four-product dividing wall column (DWC). He stated that almost 100 three-product DWCs have been final-designed in Europe or built in Europe, with a certain two companies leading the way at designing and using such columns. He implied that U.S. engineering and operating companies seem to be reticent to use this technology. In response to Zarko's comment, two audience members representing U.S. companies stated, "We are working on such columns." Nevertheless, it appears that the U.S. is behind Europe regarding DWCs. In fact, at the May AIChE meeting there was only one paper on DWC's — Zarko's paper. Compare that to the European Federation of Chemical Engineering's (EFCE) distillation and adsorption meeting last month in Eindhoven, where eleven papers were presented on the topic.

I was the co-chair of the San Antonio AIChE distillation sessions. At the end of Zarko's second presentation, I stood up and asked him, "Why do you keep looking right at me?" He claimed that he was not, but his public comments during the three-day San Antonio sessions are not easily forgotten. Are the European engineers thinking outside the boxes? Are they breaking paradigms, especially regarding energy reduction, that we all ought to be breaking? ■

Mike Resetarits

Mike Resetarits is the technical director at FRI (resetarits@fri.org), a distillation research consortium headquartered in Stillwater, Okla. Each month, Mike shares his first-hand experience in this column.

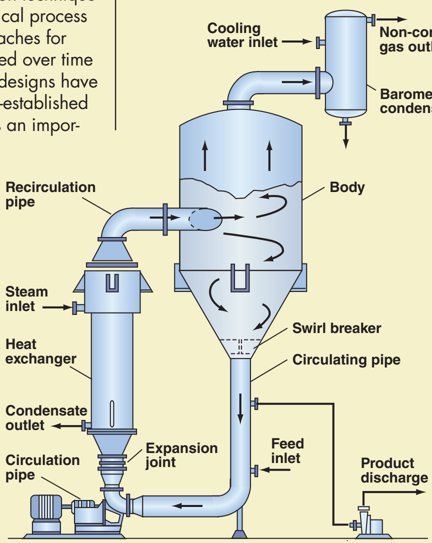
CHEMICAL ENGINEERING
FACTS AT YOUR FINGERTIPS

Department Editor: Scott Jenkins

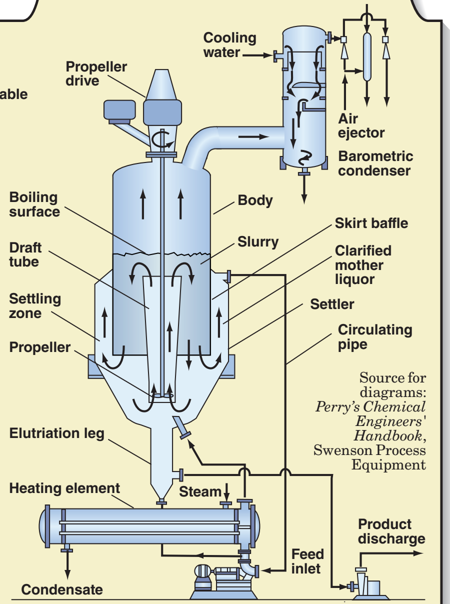
MSMPR Crystallization equipment

Crystallization is a key purification technique for various sectors of the chemical process industries (CPI). Several approaches for industrial crystallization have evolved over time and highly specialized crystallizer designs have been developed, especially in long-established industries. Solution crystallization is an important unit operation because the process can generate high-purity products from solutions containing significant levels of impurities with relatively low energy input.

One scheme for classifying this equipment is according to the method used to suspend the growing crystals. In this scheme, a class of equipment known as mixed-suspension, mixed-product-removal (MSMPR) crystallizers is most important for the CPI.



Forced-circulation (evaporative) crystallizer



Draft-tube-baffle (DTB) crystallizer

Source for diagrams: *Perry's Chemical Engineers' Handbook*, Swenson Process Equipment

MSMPR

MSMPR crystallizers, also known as magma-circulation crystallizers, have found widespread application in the CPI for continuous crystallization. In this configuration, a feed solution is continuously introduced into the crystallizer, which is equipped with a mechanism to create supersaturation. An agitation device allows mixing of the feed with the contents of the crystallizer and also maintains a uniform suspension in the mother liquor inside the crystallizer. A stream of slurry is continuously removed from the crystallizer in such a way that the fractions of solid particles and the particle size distribution in the slurry inside the equipment equals that of the slurry removed from the crystallizer.

EXAMPLES

Among the group of MSMPR-type crystallizers, some of the most common are the forced-circulation (FC), draft-tube (DT) and draft-tube-baffle (DTB) crystallizers.

Forced-circulation crystallizers

This type of MSMPR crystallizer consists of a body through which a slurry of growing crystals flows, and a tube-and-shell heat exchanger, which increases temperatures without vaporization (diagram, left). Heated slurry returns to the body via a recirculation line, where it mixes with the body slurry and raises the temperature locally, near the point of entry. During the consequent cooling and vaporization to achieve equilibrium between liquid and vapor, the supersaturation created causes deposits on the swirling body of suspended crystals until they leave again through the circulating pipe. The lower limit for economic continuous operation of forced-circulation crystallizers is 1–4 ton/d of crystals, and the upper limit for a single vessel is 100–300 ton/d of crystals. Units in parallel can reach higher capacities.

DTB and DT evaporator-crystallizers

A number of designs have been developed with circulators located within the body of the crystallizer in an effort to reduce the head against which the circulator must pump. Internal circulators reduce the power input and circulator tip speed, and thereby reduce the rate of nucleation, which is influenced significantly by mechanical circulation. The DTB is an example (diagram, right). In this type, a large, slow-moving propeller is surrounded by a draft tube within the body that directs the slurry to the liquid surface to prevent solids from short-circuiting the zone of most intense supersaturation. Slurry that has been cooled is returned to the bottom of the vessel and recirculated through the propeller, where heated solution is mixed with the recirculating slurry. A fines-destruction feature is common, where a heating element is used to raise the temperature of the solution removed from a settler to destroy the small crystalline particles that are withdrawn. The baffle can be omitted in cases where fines destruction is not needed or wanted.

In DT and DTB crystallizers, the circulation rate is generally much greater than that achieved in a forced circulation device. Therefore, DT and DTB crystallizers are applied when it is necessary to circulate large quantities of slurry and minimize supersaturation levels within the equipment. These types are commonly used in the production of granular materials, such as ammonium sulfate, potassium chloride and other inorganic and organic crystals for which product in the range of 8 to 30 mesh is required.

OPERATING PRINCIPLES

Basic good-operating principles for solution crystallization apply regardless of what type of crystallization equipment is used. The following represent some of these concepts:

- Control the level of supersaturation to ensure low nucleation rates
- Maintain an adequate slurry density to provide sufficient surface area to relieve supersaturation by the deposition of solute. Crystallizers should operate with a minimum 10 wt.% suspended crystals (slurry density)
- Contact the supersaturated liquor quickly with crystals to avoid losses due to time decay
- Destroy excess nuclei via fines destruction configurations. Seeding the crystallizer with fines will lower crystal size
- Minimize secondary nucleation by keeping mechanical energy input and crystal attrition as low as possible
- Maintain high slurry densities. In general, high densities can produce larger average crystal size as long as crystal attrition is not a negative influence
- Minimize solids buildup by eliminating localized heat- and mass-transfer gradients
- Ensure adequate velocities and operation at low temperature gradients across heat-exchange equipment
- Avoid fluctuations in operating conditions, such as vacuum, residence time and concentrations. Employ wash nozzles at liquid interfaces
- Provide a chemical environment (impurities and additives) that favors the desired crystal shape, purity and size distribution
- Maintain longer crystal retention times, which can result in less liquor occlusions in the crystals
- Keep the feed to the crystallizer slightly unsaturated

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3. Perry's Chemical Engineer's Handbook, 7th ed. McGraw-Hill, New York, 1997.
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People

WHO'S WHO

Keiser

Kulp

Crofton

Roberts

Duncan

Bill Keiser joins **NewAge Industries** (Southampton, Pa.), a maker of plastic tubing, as director of quality.

Mark Kulp becomes sales manager of **Hawk Measurement** (Middleton, Mass.), a manufacturer of positioning and flow-measurement technology. *Wayne Osborne* joins the firm as technical support specialist.

Huntsman (The Woodlands, Tex.) appoints *Derek Crofton* supply chain director for its Polyurethanes Div. in the Americas.

Suzanne Costanza becomes director of sales at **Paratherm** (West Conshohocken, Pa.), a maker of heat transfer fluids.

Tom Henson joins **Industrial Scientific Corp.** (Pittsburgh, Pa.), a maker of gas-detection systems, as director of product management, marketing and knowledge.

Ted Roberts joins **Deacom** (Wayne, Pa.), a provider of enterprise resource planning software for chemical manufacturers, as senior sales engineer.

Bruce Duncan is named national sales account manager for construction services for Dow Roofing Systems LLC, a subsidiary of **Dow Chemical Co.** (Midland, Mich.).

Wood Group Surface Pumps (Houston) welcomes *Ryan Ballard* as applications engineer.

Measurement-device maker **NDC Infrared Engineering** (Irwindale, Calif.) names *Robert Schartner* North America field operations manager. ■

Suzanne Shelley

Cover Story

Industrial Insulation Systems: Material Selection Factors

To provide the desired functions while being exposed to harsh environments, insulation material should be carefully selected and specified to meet the design goals

Gordon H. Hart
Artek Engineering, LLC

David W. Yarbrough
R&D Services, Inc.

FIGURE 1. This photo shows insulated pipes with metal jacketing over the insulation. Due to the lack of dents, this insulation probably insulates as well as it did when first applied

Thermal insulation systems can provide several functions on piping and equipment in industrial facilities. Some of these are: reduction in energy loss, process control, personnel protection, emissions reduction, condensation, freeze protection, and noise reduction. In the chemical process industries (CPI), thermal insulation systems are often subjected to severe environments that might include either very high or very low service temperatures, weather exposure, physical abuse, exposure to corrosive chemicals, and, in an accident scenario, fire. To provide the desired functions while being exposed to these environments over a long time period, the insulation materials should be carefully selected and the installation details specified to assure that the design goals are met. In industrial facilities, this can be challenging.

REASONS FOR INSULATING

The reasons for insulating pipes and equipment can vary from system to system and from facility to facility. The first inch of thermal insulation usually reduces heat loss by at least 85% and several inches usually reduces it by about 95% compared to what it would be from uninsulated surfaces. This insulation thermal performance, in turn, allows the facility owner to achieve several goals, including the following:

- To control process temperatures, a necessity for the plant to successfully achieve production and quality goals
- To control energy costs
- To provide personnel protection on above-ambient service temperature systems by keeping the surface temperatures below the maximum design value, often 130–140°F when protected with sheet-metal jacketing
- To reduce greenhouse gas emissions, such as CO_2, by significantly reducing heat loss compared to uninsulated surfaces
- On below-ambient systems, to minimize surface condensation of water from the surrounding ambient air. This, in turn, prevents further waste of thermal energy and prevents wet walking surfaces, located beneath the cold surfaces, that can pose a danger to plant personnel
- In geographic areas where air temperatures may dip well below freezing for extended periods of time, to prevent either freezing of the liquid in the process pipes or a decrease of the liquid's viscosity to a point where it can no longer be pumped
- Properly designed, to provide sound control by helping to absorb emitted noise
- To provide fire protection, against petrochemical fires, for specified periods of time, such as 1 or 3 h

These are the usual objectives in insulating piping and equipment at industrial facilities. A wide variety of insulation materials and accessories are available to accomplish them.

MATERIALS AND ACCESSORIES

The components making up thermal insulation systems can be categorized as follows: thermal insulation, protective jacketing, water vapor retarders, sealants, mastics, adhesives and cements, and attachments. Each of these materials provides an important function in the insulation system in which they are used.

Above ambient materials, design

The thermal insulation material is what provides the energy savings. Every different material has a temperature versus thermal-conductivity curve, which can be used in calculations to determine the required insulation thickness for targeted energy savings. While some materials have much lower thermal conductivities than others in the temperature range

TABLE 1. PHYSICAL PROPERTIES OF SOME INSULATION MATERIALS, WITH ASTM MATERIAL STANDARDS, TYPICALLY USED FOR ABOVE AMBIENT SERVICE IN CPI FACILITIES

	Mineral fiber pipe	Mineral fiber pipe	Mineral fiber pipe	Mineral fiber blanket	Mineral fiber board	Calcium silicate pipe & block	Perlite pipe & block
ASTM Material Standard	C547, Type I	C547, Type II, III, & V	C547, Type IV	C553, Type VII	C612, Type IV, A, B	C533, Type I	C610
Max. Use Temperature, °F	850	1,200	1,000	1,200	1,200	1,200	1,200
Thermal conductivity at 200 °F mean[1]	0.31	0.31	0.31	0.34	0.30 to 0.34	0.45	0.55
Thermal conductivity at 400°F mean[1]	0.51	0.45	0.45	0.55	0.42 to 0.55	0.55	0.66
Thermal conductivity at 600°F mean[1]	0.64	0.65	0.65	0.81	0.63	0.66	0.80
Compressive resistance, min., lbf/in.^{2} (C165)	N/A	N/A	N/A	Not stated	0.347 at 10%	100 at 5%	60 @ 5%
Density, lbm/ft^3 (C167)	3 to 6	6 to 8	3 to 6	Not stated	Not stated	15 max	10 to 14
Flexural strength, min., lbf/in.^{2} (C201)	Not stated	Not stated	Not stated	Not stated	Not stated	50	45
pH	8 to 9.5	8 to 9.5	8 to 9.5	8 to 9.5	8 to 10	9 to 11.5	9 to 11
Surface burning characteristics (E84)[3]	25/50	25/50	25/50	25/50	25/50	0/0	0/5
Non-combustible (E136)	Not stated	Not stated	Not stated	Not stated	Not stated	Non-combustible	Non-combustible
Contains corrosion inhibitors[2]	No	No	No	No	No	Yes	Yes

Notes: 1. Thermal conductivity values are in units of Btu·in./h·ft^2·°F Pipe insulation is tested per ASTM C335 and blanket, board, and block insulation is tested per ASTM C177
2. Not included in the referenced ASTM material specifications
3. Flame spread index / Smoke developed index

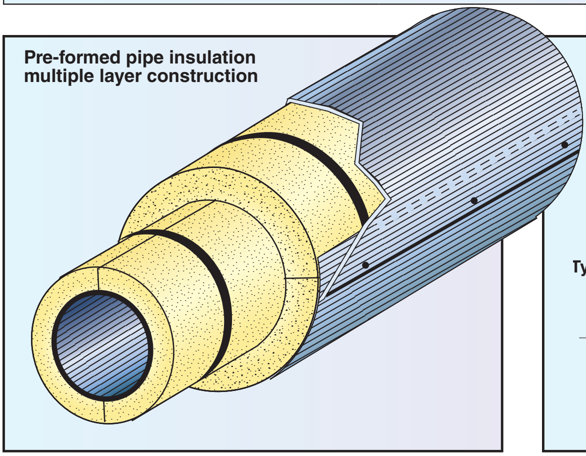

FIGURE 2. This diagram shows the correct way to install a double-layer insulation system for use at process temperatures greater than 500°F. Note that both the lap joints and butt joints are staggered to prevent the occurrence of a direct path between the outer metal jacket and the inner, hot pipe surface (Source: National Commercial & Industrial Insulation Standards, 5th ed., 1999, Plate No. 1)

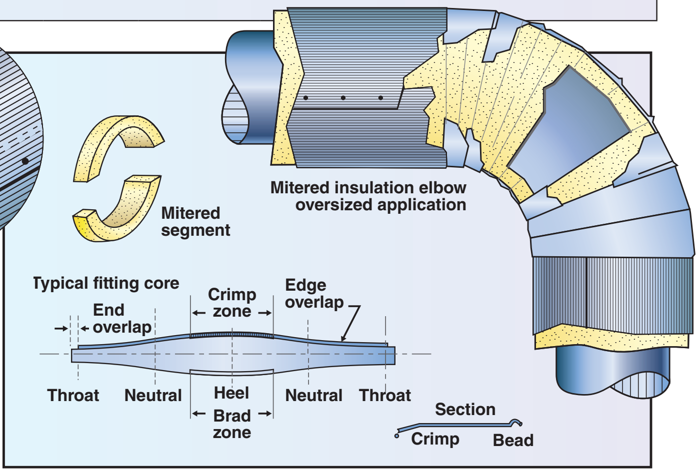

FIGURE 3. This figure shows the correct way to install a single or double layer insulation system on a 90-deg, long radius elbow on a high temperature line. Note the use of insulation miters and sheet metal gores (Source: National Commercial & Industrial Insulation Standards, 5th Edition, 1999, Plate No. 11)

of application, in most applications there is adequate clearance for several inches of insulation. When space for insulation is not available, then a material of lower thermal conductivity can be selected.

Every type of insulation has different properties. A list of some properties, for several insulations commonly used in CPI facilities at above ambient temperatures, is given in Table 1 (with values for each taken from the listed ASTM material standard [*1*]).

Reviewing these properties, it is apparent that there are significant differences between these insulation materials. For example, while calcium silicate has greater thermal conductivity values at given mean temperatures, and has greater density than most of the mineral fiber materials, it also has very high compressive-resistance and flexural-strength values (and these values are not in the ASTM standards for the mineral fiber materials because, in comparison, they are probably not sufficiently high to merit being listed). Furthermore, all calcium silicate and perlite insulation materials are rated as non-combustible, when tested per ASTM E136, whereas some of the mineral fiber materials are and some are not; hence, this property is

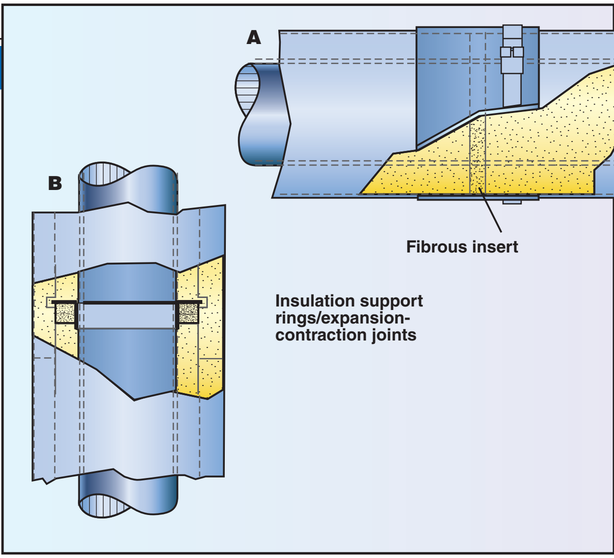

FIGURE 4. Drawing A shows how to install an expansion / contraction joint using a flexible, compressible fibrous insert between sections of rigid insulation. Drawing B shows how to install support rings on vertical pipes (Source: Midwest Insulators Contractors Association, 1999)

not listed in the ASTM standards for the mineral fiber products. Finally, both North-American made calcium silicate and perlite insulations contain corrosion inhibitors that help prevent the occurrence of corrosion under insulation (CUI).

In applications with service temperatures above 500°F, double-layering of the insulation with staggered joints (as opposed to using only a single layer) is recommended. Figures 2 and 3 show how the lap and butt joints should be staggered. Figure 3 also shows how to insulate an elbow on a high temperature system.

When using rigid insulation materials at these temperatures, the use of compressible mineral-fiber expansion joints to prevent large gaps from opening up during plant operation, as shown in Figure 4, is recommended.

Protective metal jacketing, when properly sealed and banded, can provide excellent protection of the insulation from the elements and in some cases, from leaking chemicals. Aluminum jacketing — per ASTM C1729, properly installed and maintained and normally with a minimum thickness of 0.016 in. — can provide effective protection from the weather. Aluminum and galvanized steel jacketing, of course, are subject to corrosion in the presence of certain chemicals so their use should be limited to applications where it will not be subjected to leaking corrosive liquids. Stainless steel jacketing should be used if contact with corrosive fluids is anticipated.

Below ambient materials, design

A summary of properties for insulation materials used in CPI facilities at below ambient temperatures, is given in Table 2.

The extremely low water-vapor permeability of cellular glass insulation which is less than 0.005 perm-inch* is of particular note. Permeability is obtained using test method ASTM E96, Method B (known as the water or "wet cup" method). Properly installed, sealed, and maintained on below-ambient-temperature pipes and equipment, cellular glass provides an excellent barrier against the migration of water vapor to the cold surfaces where it may condense. If condensation occurs, the water will be absorbed by the insulation material, increasing its thermal conductivity. Cellular glass, however, absorbs very little water even if water vapor condenses on the cold surface under the insulation.

FACTORS AFFECTING SYSTEM DESIGN

Generally, the chemical facility owner would like the insulation system to provide the design thermal performance for as long as possible without having any adverse effects on piping and equipment and without compromising either the health or safety of the employees or the community. To do this, the facility owner should consider the following questions prior to selecting insulation materials and designing the insulation system.

- Where is the insulation to be installed?
- What are the system thermal requirements?
- How long should the system last?
- Is corrosion of the surfaces beneath the insulation a concern?
- What are the health and safety requirements?
- What are the chemical resistance requirements?

There can be other issues. For example, appearance and aesthetics may be of importance. Sometimes insulation systems are installed indoors and sometimes outdoors. If outdoors, then the insulation system must withstand wind, rain and sunshine. This is more typical than indoor applications for a chemical plant but it is the first issue to address. With outdoor applications, the system must prevent rain water from flowing into the insulation system while withstanding wind loads.

Above ambient system design

Thickness determination. The system thermal requirements are often expressed as a maximum acceptable heat loss per unit length of pipe or heat loss per unit area of a vessel. Or, it can be expressed as a maximum surface temperature, for personnel protection. So, for example, if we consider the following case: an 8-in. NPS horizontal pipe with a 700°F fluid flowing through it on a 20°F day with a 15-mi/h wind, the maximum allowable heat loss might be specified as a rate of heat loss per unit area of 50 Btu/(h·ft^2). The required minimum thickness of a particular insulation material, such as calcium silicate, can then be determined by calculation.

The program 3E Plus is useful for calculating required insulation thicknesses (for more, see "Insulation Design: Faster and a Lot More Exact," *CE*, March 1997, pp. 66–72). The program can be downloaded from the North American Insulation Manufacturers Association at www.pipeinsulation.org. Input and output screens for 3E Plus are user-friendly and quickly mastered.

An insulation system should be designed to last a minimum of ten years. Generally, the greater the compressive resistance and the greater the flex

* A perm-inch is the U.S. unit for the permeability coefficient of water vapor through a material at a given temperature, typically 0 or 23°C. At 0°C, one perm-inch equals about 1.45322 x 10^{-12} kg/(m·Pa·s).

TABLE 2: PHYSICAL PROPERTIES OF SOME INSULATION MATERIALS, WITH ASTM MATERIAL STANDARDS, OFTEN USED FOR BELOW AMBIENT SERVICE IN CPI FACILITIES				
	Elastomeric tube & sheet	**Cellular glass block & pipe**	**Polystyrene pipe**	**Polyisocyanurate**
ASTM material standard	C534, Grade I	C552, Type I	C578, Type XIII	C591
Max. use temperature, °F	250°	800°	165°	300°
Min. use temperature, °F	–297°	–450°	–297°	–297°
Rigid or flexible	Flexible	Rigid	Rigid	Rigid
Thermal conductivity at –100°F mean[1]	0.21	0.22	0.181	0.17 to 0.19
Thermal conductivity at 0°F mean[1]	0.264	0.27	0.221	0.18 to 0.20
Thermal conductivity at 75°F mean[1]	0.28	0.31	0.259	0.13 to 0.23
Compressive resistance, min., psi (C165)	N/A	60 at failure	20 at 10%	16 to 125 at 10%
Density, lb/ft^3 (C167)	3 to 6.5	6.1 to 8.6	1.6	1.8 to 6.0
pH	6.5 to 7.5	7 to 8	Not stated	Not stated
Surface burning characteristics (E84)	25/50	5/0	Not stated	25/50[2]
Water vapor permeability (perm-inch) (E96)	0.10 (Dry Cup Method A)	0.005 (Wet Cup Method B)	1.5 (Dry Cup Method A)	2.0 to 4.0 (Dry Cup Method A)

Notes: 1. Thermal conductivity values are in units of $Btu{\cdot}in./h{\cdot}ft^2{\cdot}°F$ 2. Surface burning characteristics may vary with thickness

strength, the more durable the insulation material. For example, since calcium silicate has a minimum compressive resistance of 100 psi, it resists compression much more effectively than mineral-wool and fiberglass insulation materials, which have compressive strengths 100 to 1,000 times less. While mineral-wool and fiberglass insulation materials insulate very effectively, they simply do not have the physical strength of calcium silicate. If strength — specifically resistance to compression and flexing — is important, then calcium silicate may be preferable for that particular application.

Further, the stiffer the insulation jacketing, the more protection it will provide and hence the longer it will last, all other factors being the same. Hence, properly installed calcium silicate jacketed with Type 304 stainless-steel jacketing — at least 0.3-in. thick (22 gauge) and banded in place with 0.20-in. wide banding every foot of pipe length — will be a very durable insulation system. Insulation systems with mineral-wool and aluminum jacketing can be susceptible to foot traffic and vibration induced damage. While these systems can last a long time in some circumstances, for instance when there is not a high degree of foot traffic or vibration, the facility owner should recognize the physical limitations of such systems. While it is not recommended that workers walk regularly on this or any other insulation system, a system consisting of calcium silicate with stainless-steel jacketing can withstand some foot traffic much better than lower-compressive-strength insulation materials, such as mineral wool and fiberglass. Ultimately, these properties impact the system's durability and longevity.

Corrosion. Corrosion under insulation (CUI) is always a concern for all outdoor applications and for below ambient applications. CUI, on a mild-steel pipe, is a consequence of water, oxygen, temperatures between about 120 and 300°F, and time. Further, corrosion is accelerated with the presence of leachable chlorides. In theory, the prevention of CUI is simple: keep the insulation dry, and in the process, keep the external pipe surface dry. That, in turn, can be achieved by maintaining the metal jacketing system sealed, including the joints. While this is simple in theory, it is challenging in practice, especially when maintenance budgets are inadequate to pay for personnel to make necessary repairs. Nevertheless, there is no substitute for selection of appropriate materials, a good specification, good installation, and good maintenance.

Since perlite contains a hydrophobic agent, it repels water. If water is absorbed, CUI is inhibited by sodium silicate, which is used as a binding agent. Calcium silicate absorbs water but when used at temperatures above 300°F, CUI will not occur. Further, like perlite, calcium silicate, at least North American material, contains significant quantities of a corrosion inhibitor. If the material becomes wet, these soluble chemicals start inhibiting corrosion.

Inorganic insulation materials have resistance to a wide variety of corrosive chemicals and solvents. Mineral-wool and fiberglass insulation materials (mineral fiber), calcium silicate, perlite, and cellular glass are highly resistant to a wide variety of such chemicals. The plastic and rubber foams, such as flexible elastomeric, polystyrene, and polyisocyanurate, are susceptible to attack by organic solvents. Therefore, when such solvents are present, one of the inorganic insulations should be used.

In most cases, chemical resistance of the insulation system starts with the jacketing. As discussed previously, if alkaline or acidic liquids pose a threat to aluminum jacketing, then stainless steel should be used. However, some of the recently developed multi-ply laminates, now commercially available, are also highly corrosion resistant and worth consideration. Many also have pressure-sensitive adhesives on one surface and, hence, seal extremely well. One such multi-ply jacket consists of 13 plies and is 0.015-in. thick. Calcium silicate insulation, with this type of jacket factory installed, is also commercially available and provides a means for both reducing installation labor and providing a tightly sealed, highly corrosion-resistant jacket.

In the case of removable/reusable flexible insulation blankets, the new ASTM Specification C1695 can be referenced. For protection against corrosive chemicals and organic solvents, these blankets are covered with either a silicone-coated, woven glass-fiber blanket or a PTFE-coated woven glass fabric. Both offer good protection against a wide variety of chemicals

FIGURE 5. Shown here are two insulators installing single-layer calcium silicate pipe insulation at a petroleum refinery

and solvents although the PTFE-coated fabric is more resistant.

Below ambient system design

For below ambient applications, water vapor condensation inside the insulation is a major concern, hence, the insulation system must have a very low water-vapor permeance**. A system permeance of less than 0.01 perm is recommended for chilled-water systems exposed to outdoor conditions. The permeance rating for the materials should be obtained using ASTM E96, Wet Cut Test Method B for water vapor transmission, including the effects of joints. For very low service temperatures or continuous low-temperature operation, the use of so-called "zero permeance" jacketing is recommended. These generally have a minimum thickness of 0.006 in. and consist either of a corrosion resistant, multi-ply laminate jacketing (possibly with a pressure sensitive adhesive) or of low permeability epoxy mastic applied over an open weave scrim around the insulation. For cryogenic systems, thicker, more robust vapor-retarder jacketing is recommended. This type of jacketing made of either a polymer bitumen or butyl rubber with a thickness of up to 0.055 in. is commercially available. Of course, the use of properly sealed cellular-glass insulation can by itself achieve a water-vapor-tight insulation system on below ambient temperatures since it has a water vapor permeability of less than 0.005 perm-inch (so, a five-inch thick cellular glass system would provide a permeance of less than 0.001 perm).

Regardless of which combination of jacketing and insulation materials are selected to provide the low permeance, the installation details and system maintenance are critical to the longterm thermal performance of the system. Once the system has started to absorb significant quantities of perhaps greater than 2 vol.%, then the system performance will probably be unsatisfactory due to increased insulation thermal conductivity. Water vapor transmission (*WVT*) for a given time is calculated using Fick's law, rearranged as Equation (1).

$$WVT = P \cdot A \cdot t \cdot \Delta(VP) \quad (1)$$

Where P is the system permeance in units of weight/(area · time · pressure), A is area with the same area units as used in permeance, t is the time with the same units used in permeance, and $\Delta(VP)$ is the vapor pressure difference in the same units of pressure used in permeance. *WVT* represents water vapor transmission and will then be in the same units of weight used in permeance. In IP units, permeance is usually expressed in units of grains of moisture / (h·ft^2· in. Hg) where a grain is 1/7,000th of a pound.

For a low-permeance insulation material with a permeability of p and thickness T covered with a vapor retarder jacket with a permeance P, the insulation system permeance, P_{sys}, can be calculated using Equation (2).

$$P_{sys} = 1 / (T / p + 1 / P) \quad (2)$$

For a given insulation material, selection of insulation thickness is often achieved using 3E Plus with the "Condensation Control" Calculation Type, for ambient conditions of the Ashrae Design Dry-Bulb Temperature, a 90% RH (relative humidity), and a 0-mi/h wind speed (which is worst case). For Tampa, Fla., for example, that design temperature is given in the Ashrae table as a 78.4°F dew point temperature. Using either a psychrometric chart or a calculator (and 3E Plus has a built-in psychrometric calculator) for 90% RH, we can see that these conditions are about equivalent to an 81°F dry-bulb temperature. So, when using 3E Plus, the designer would input 81°F, 90% RH, and 0-mi/h wind speed as the ambient conditions. For a given pipe diameter, operating temperature, and jacket type, the program will determine the minimum thickness to prevent surface condensation at these conditions. Note that since the pipe is located outdoors, the program is not selecting an insulation thickness at which surface condensation will never occur. Rather, it is determining the thickness to prevent surface condensation with 0-mi/h wind and relative humidity levels up to 90%. At higher relative humidity levels and 0-mi/h wind, surface condensations may well occur.

NEW MATERIALS AND TECHNOLOGIES

Corrosion protection gel

To prevent CUI, there is a commercially available compound, with a thick, gel-like consistency, that can be applied to the pipe surface prior to being insulated (this gel material can be used for process temperatures up to 350°F). When properly installed, it excludes both oxygen and water from the surface of the pipe. In addition, it has a chemically active ingredient that reacts with steel to form a protective layer. In tests, this material has been shown to significantly reduce external surface corrosion. Combined with corrosion inhibitors contained in some insulation materials, this solution provides redundancy in preventing CUI. For those with interest in this material, see Ref. 2.

Aerogel insulation blankets

Aerogel blanket insulation has become commercially available in the last ten years. This type of insulation has apparent thermal conductivities, *ka*, in the range 0.10 to 0.15 Btu·in./h·ft^2·°F at 75°F. Various forms of aerogel insulation are designed for applications from –300 to 1,200°F. Characteristic *ka* versus temperature data are available showing *ka* around 0.07 at –300°F to 0.70 at 1,200°F. Because of the low *ka*, the insulation is produced in thin sheets, 0.2- to 0.4-in. thick and in rolls 5-ft wide and 100- to 200-ft long. It is often installed by spiral wrapping around pipes mul-

** Permeance is the rate of water vapor transmission between two surfaces of a material for specific conditions. The U.S. unit of permeance is the perm. (Permeability is permeance times thickness)

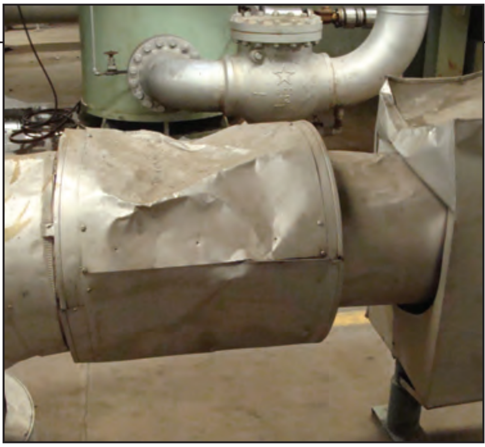

FIGURE 6. This photo shows a heavily dented insulation system with mineral wool. While this material insulates very well when new, it has a very low compressive resistance, compared to calcium silicate or perlite, and hence does not have the durability necessary for some applications

FIGURE 7. This photo shows several pipes completely insulated with removable and reusable insulation blankets made with coated-glass fiber fabrics. This type of insulation has the advantage of being able to be removed without damage to allow inspections and maintenance of the piping and equipment, then reinstalled with minimum extra labor

tiple times to get the desired thickness. This insulation is sometimes specified due to its water repellency. It is reasoned by some specifiers that when rain water bypasses the protective jacket, rather than making the insulation wet, the water is repelled. In so doing, it is reasoned, the insulation and the pipe surface never becomes wet, hence, CUI never occurs. While this explanation sounds plausible, this has not been proven. Furthermore, with no corrosion inhibitor, it is not clear that CUI will in fact never occur. Basically, time and experience will tell.

There are aerogel insulations with zero-flame-spread test results. This insulation is available for applications with limited space for insulation since one-half or less thickness is required to achieve the thermal resistance of many traditional insulations. Note, however, that commercially available aerogel blankets do not meet the ASTM E136 requirements for non-combustibility.

ASTM Committee C16 is currently developing a specification for flexible aerogel insulation.

Microporous insulation

While it is not a new material, microporous insulation finally has an ASTM material specification: C1676. This provides minimum or maximum acceptable values (maximum acceptable values of apparent thermal conductivity) for a variety of different properties and is available for use up to temperatures over 2,000°F. At lower mean temperatures, up to about 200°F, the thermal conductivity values for microporous materials are generally a little greater than those of the aerogel blankets. However, at mean temperatures above about 200°F, microporous insulation's thermal conductivity values are lower than those of the aerogel blankets. For example, at a 600°F mean temperature in a flat configuration, the thermal conductivity for microporous board is about 0.16 Btu·in./h·ft^2·°F whereas that for aerogel blankets is about 0.25 Btu·in./h·ft^2·°F. Most types of microporous insulation meet the non-combustibility requirements of ISO 1182.

Contribution to corrosion?

ASTM has a relatively new test procedure, C1617, titled, "Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals." This test procedure provides a method for determining the contribution by thermal insulation of corrosive chemicals that can contribute to CUI of mild steel. ASTM C16 members are working on developing threshold values for acceptability to be input to material standards. While it is expected that this will be done in the next year or so, C1617 is only a test procedure and hence it does not include any pass-fail criteria.

Thermal insulating coatings

A number of thermal insulating coatings are marketed for use on above ambient-temperature surfaces up to about 350°F. These coatings, when applied at thicknesses in the range 0.025 to 0.25 in., provide a modest thermal resistance. The apparent thermal-conductivity values at 75°F are generally in the range 0.3 to 0.5 Btu·in./ft^2·h·°F thus yielding R-values (thermal resistance) in the range 0.05 to 0.83 ft^2·h·°F/Btu.

While low-emittance coatings exist, most of these coatings have relatively high thermal-emittance values. Application of a thin coating of high-emittance material to a relatively low-emittance surface can increase the rate of heat loss. When applied to bare metal surfaces, the coating will have a small impact on heat flow that depends on the thickness.

Coatings have application where space is limited or shapes are not conducive to conventional insulation materials. Conventional coatings can provide some reduction in surface temperature and as a result contribute to burn protection. A surface temperature reduction of 60–90°F is possible for coatings with ka on the low end of the above range, high thermal emittance, and thickness of 0.025 in. Increasing the coating thickness will, of course, decrease the surface temperature but can be expensive.

Coatings based on aerogel technology are available with very low ka. A 0.025-in. thickness of aerogel-based coatings can reduce surface temperature by as much as 150°F according to the manufacturers.

Note that there is no ASTM specification for thermal insulating coatings and no task force has yet been started to write such a specification.

SUMMARY

Thermal insulations at CPI facilities can provide several functions. When a system is designed correctly with selection of appropriate, high quality materials, installed correctly, and maintained correctly, it can provide many years of service and reduce operating cost. However, some materials are physically stronger, with higher compressive resistance values, than others and hence, in a real-world environment, are more durable, providing greater longevity.

Corrosion under insulation, while long a problem at CPI facilities, can today be successfully addressed by using either insulation with chemical inhibitors, applying protective gels to the pipe prior to insulation installation, or a combination of both. For given insulation systems, appropriate thicknesses can readily be determined by using publicly available software such as 3E Plus. For below ambient insulation systems, particular attention must be paid to excluding water vapor from the insulation system for many years by using either very low permeability insulation, very low permeance and tightly sealed jacketing, or a combination of both. High performance insulations are available for special cases especially when space is limited. Thermal insulating coatings can be used to reduce burn risk when the use of conventional insulations is not practical. ■

Edited by Gerald Ondrey

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1. The ASTM standards: C 533, C 534, C 547, C 552, C 553, C 578, C 591, C 610, C 612, C 1617, C 1676, C 1695, C 1729, and E 96 are contained in Vol. 04.06 of the ASTM Annual Book of Standards. The ASTM standards E 84 and E 136 is contained in Vol. 04.07 of the Annual Book of ASTM Standards. ASTM International, West Conshohocken, PA. www.astm.org.
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Improving Control Valve Performance

The control valve is a focal point for improvements to both process performance and economics

James Beall
Emerson Process Management

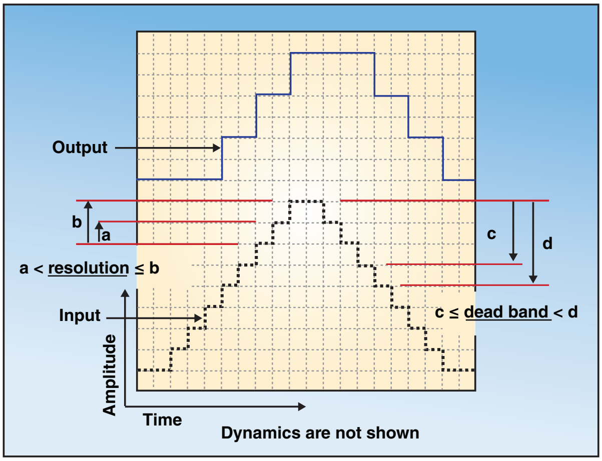

FIGURE 1. Dead band and resolution, illustrated here, are key static-response parameters for control valves

Improvements to the performance of basic, regulatory control systems have a great return on investment and are some of the least expensive control improvements to make [*1*]. Control valves have a major impact on control loop performance and, therefore, improvements in valve performance can have significant economic benefits. This article shows how poor control-valve performance can be identified and corrected to achieve these benefits. A plant example is used to demonstrate these methods.

In addition to corrective actions, comprehensive control-valve specifications, based on process requirements for new applications, can provide quicker plant startups and immediate economic savings.

The control valve system

In this article, the control valve is considered to be a dynamic system, from the input signal through to the flow coefficient that determines the fluid flowrate through the pipe. The control valve system includes the valve, actuator, motion conversion mechanism, stem or shaft, closure member (such as plug, ball or disc) and other valve accessories. Examples of valve accessories include current to pressure transducer (I/P), positioner, air booster relay, dampener and air set. So, when a change of the input signal to the control valve occurs, the I/P and positioner must respond to move the actuator, which must move the motion conversion mechanism, which must move the stem or shaft, which must move the closure member, which must change the flow coefficient. As you can see, there is a lot of opportunity for problems.

The key to control valve performance is creating a measurable change in flow through the valve in response to small, input step changes (1% and less). A change in flow indicates that the valve's flow coefficient has actually changed in response to a change in the input signal. If the actual flow through the control valve is not available or is not measured, then the valve stem, shaft or actuator movement may be used to estimate the response of the valve. However, the movement of the valve stem, shaft or actuator may not be an accurate representation of the actual change in the valve flow coefficient for all changes of the input signal to the valve. For example, the inboard end of the shaft of a rotary valve might move in response to a change in the input to the control valve but the actual flow coefficient might not change because shaft *windup* occurs and the valve closure member does not move. In some cases the *actuator position* may be used to measure the control valve response and this adds yet another potential discrepancy between the input to the control valve and the actual change in the valve flow coefficient. However, it is important to note that the response of the valve flow coefficient can be no better than that of the stem, shaft or actuator position.

Control valve performance

The performance of a control loop will be limited by the poorest performing component in the loop, such as the transmitter, the controller tuning or the final control element. Note that for most control loops, the final control element is a control valve. One study of over 5,000 control loops revealed

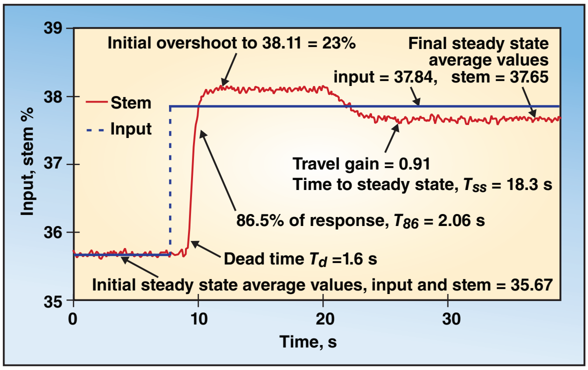

FIGURE 2. This graphs shows the response of a control valve to a step input (reprinted with permission from EnTech Control Valve Dynamic Specification V3.0)

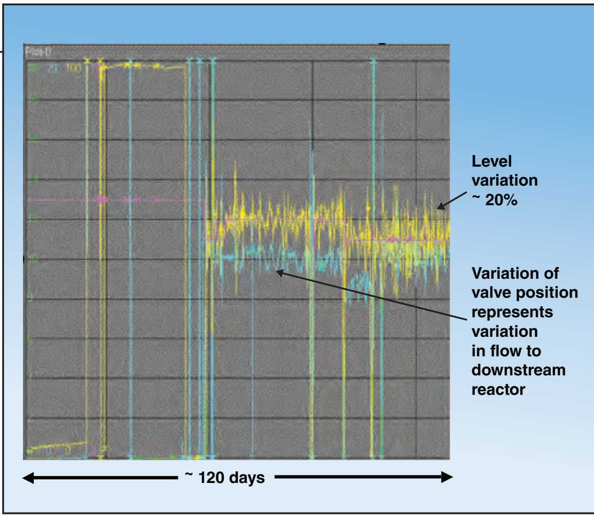

FIGURE 4. In the plant example, the reactor level was not well-controlled

that poor control-valve performance negatively impacted control loop performance on 30% of these loops [2].

Important aspects of control valve performance include the static response, the dynamic response and the valve trim size and flow characteristics. The International Society of Automation's (ISA) technical reference, ANSI-ISA-TR75-25-02, explains the concepts of control-valve static- and dynamic-response metrics [3]. ISA standard ANSI-ISA-75-25-01 is a test procedure to measure the static and dynamic response of a control valve system [4]. However, this standard does not prescribe what response requirements should be specified in order to achieve the desired control-valve performance for a particular application. The EnTech Control Valve Dynamic Specification V3.0 provides guidance on specifying the static- and dynamic-response parameters and the valve trim size and flow characteristics to achieve the desired process control performance [5].

Static response. So, what are these control-valve response parameters and what do they mean to process control performance? Static response refers to measurements that are made with data points that are recorded after the device has come to a rest. Key static-response parameters for control valves include travel gain, dead band and resolution [3]. *Travel gain*, *Gx*, is the change in closure member position divided by the change in input signal, both expressed in percentage of full span. The closure member is the portion of the valve trim that moves to change the flow through the valve. If there is no signal characterization inside the valve system, the travel gain should be 1.0. In other words, travel gain is a measure of how well the valve system positions its closure member compared to the input signal.

Dead band is defined as "the range through which an input signal may be varied, with reversal of direction, without initiating an observable change in output signal" [6]. With respect to control valve performance, if the process controller attempts to reverse the position of the control valve, the valve will not begin to move until after the controller output has reversed an amount greater than the dead band. A large dead band will negatively impact control performance.

Another key static-response parameter is *resolution*. Resolution is defined as "the smallest step increment of input signal in one direction for which movement of the output is observed" [3]. Resolution will cause the control valve to move in discrete steps in response to small, step input changes in the same direction. This occurs as the valve travel *sticks* for the amount of resolution after completing the previous step in the same direction. Similar to dead band, a larger resolution will negatively impact control performance. Figure 1 illustrates dead band and resolution.

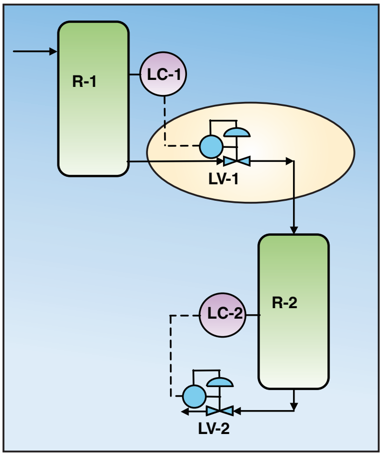

FIGURE 3. In this plant example, the level controller output went directly to the control valve positioner

Dynamic response. The second aspect of control valve performance is the dynamic response. Dynamic response is the time-dependant response resulting from a time-varying input signal [4], and includes dead time, step response time and overshoot. The ISA technical reference ANSI-ISA-TR75-25-02 [3] provides the following definitions for these dynamic response parameters:

- *Dead time* — The time after the initiation of an input change and before the start of the resulting observable response
- *Step response time* — The interval of time between initiation of an input-signal step change and the moment that the dynamic response reaches 86.5% of its full, steady state value. The step response time includes the dead time before the dynamic response
- *Overshoot* — The amount by which a step response exceeds its final, steady state value (refer to Figure 24 of ANSI/ISA-51.1-1979 (R1993)). Usually expressed as a percentage of the full change in steady state value

Figure 2 shows the dead time, step response time and overshoot for a

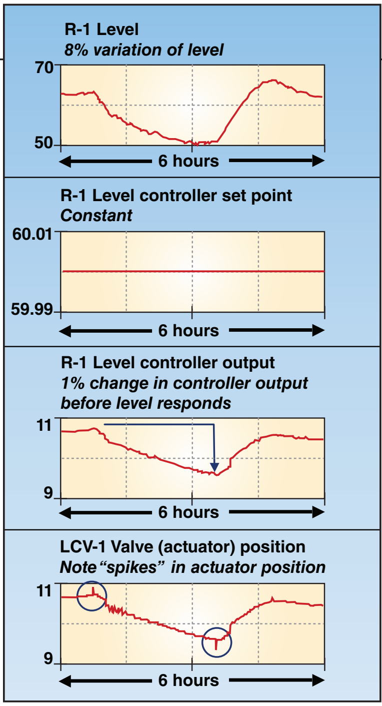

FIGURE 5. Trend plots suggest that the control-valve closure member may not be moving until the controller output has moved more than 1% after a direction reversal

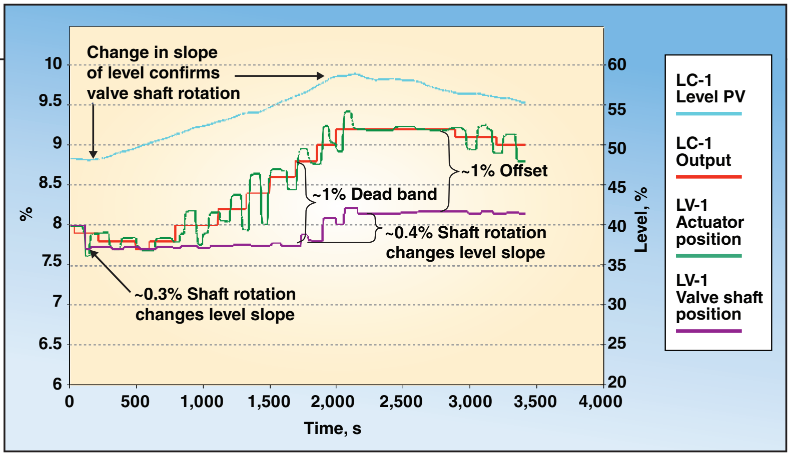

FIGURE 6. Tests of the control valve, LV-1, revealed a problem with positioner performance, and excessive dead band and resolution

control valve response to a step input change. In this case, stem position in percent of travel is used as the control valve "output".

It is important to note that the dynamic response of a control valve varies depending upon the size of the input step change. Four "ranges" of step sizes to help understand the static- and dynamic-response metrics are defined in the technical reference [3]:

- Region 1 is defined as small input steps that result in no measurable movement of the closure member within the specified wait time
- Region 2 is defined as the input step changes that are large enough to result in some control-valve response with each input signal change, but the response does not satisfy the requirements of the specified time and linearity
- Region 3 is defined as step changes that are large enough to result in flow coefficient changes, which satisfy both the specified maximum response time and the specified maximum linearity
- Region 4 is defined as input steps larger than in Region 3 where the specified magnitude-response linearity is satisfied but the specified response time is exceeded

Region 1 is directly related to dead band and resolution. Region 2 is a highly nonlinear region that causes performance problems and should be minimized. Region 3 is the range of input movements that are important to control performance. The dynamic response parameters, dead time and response time, are applicable in this region. Regions 1, 2, 3 and 4 correspond to regions A, B, C and D as defined in Ref. 5.

Process control issues

A very important aspect of process control is the *process gain*, which is defined as the ratio of the change in process variable to the change in controller output that caused the change. For good process control, it is desirable for the process gain to be within a certain range and to be consistent throughout the operating range of the valve. If the process gain is too high, valve non-linearities are amplified by the process gain and process control performance deteriorates. If the process gain is too low, the range of control is reduced. Changes in the process gain over the range of operation result in poorly performing regions in the closed-loop controller response. Two characteristics of a control valve impact the process gain: the size of the valve trim and the inherent flow characteristic of the valve. If the valve trim is oversized, the process gain will be higher than it would be for an appropriately sized valve. The inherent flow characteristic of the valve — typically linear, quick opening or equal percentage — will impact both the magnitude and the consistency of the process gain over the operating range. Therefore, proper valve sizing and trim characteristics are important in achieving good control-valve and process-control performance.

Plant example

An actual plant example will be used to illustrate some key aspects of control valve performance. In this example, a valve that is typically used for on-off applications was modified to also perform as a throttling control valve. There are good on-off valves and there are good throttling valves, but it is very difficult to have a valve that is good at both functions. Some of the characteristics of a good on-off valve are as follows:

- Low leakage shutoff
- Line size (usually)
- Compact and light weight
- No positioner required
- Trim options not required (nor available)
- Actuation is usually open or closed with little "positioning" capability
- Less-expensive purchase price

Some of the characteristics of a good throttling control valve are as follows:

- May have significant leakage when closed
- The body is smaller than line size (usually)
- Valve and accessories require more space
- Valve positioner is usually included
- Various trim size and characteristics available
- Actuation has "positioning" capability
- More expensive purchase price

In this plant example, the on-off valve was outfitted with a high-performance, digital valve positioner and "tight fitting" shaft-to-actuator *keyways* and *keys* in an effort to provide good throttling performance. The valve was used for level control of a reactor where the level controller output went directly to the control valve positioner as shown in Figure 3. In this process, it is important to control the level in reactor

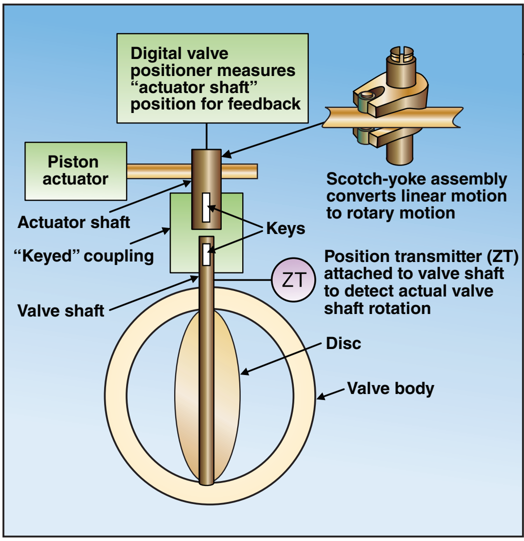

FIGURE 7. Many of the features of this control valve construction were appropriate for on-off valve performance, but were inherently problematic for throttling performance

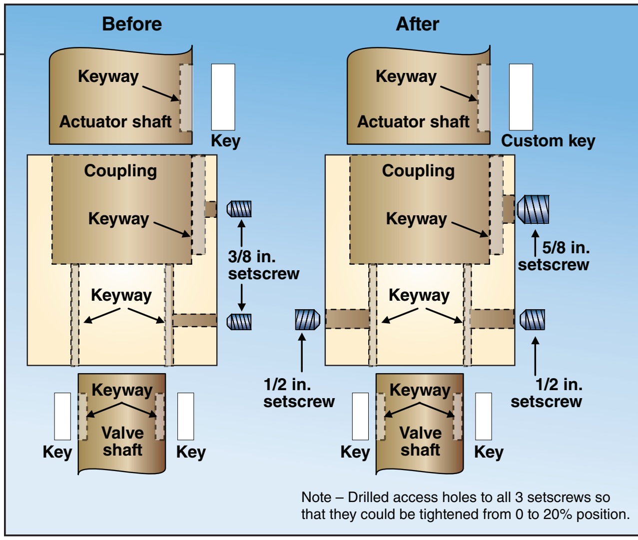

FIGURE 8. Improvements were made to the actuator coupling system on the control valve, LV-1

R-1 to maintain a consistent residence time. It is also important to avoid large changes in the flow from R-1 to R-2 that will upset the R-2 level. The control valve, LV-1, provided tight shutoff as desired, but the control performance of the level loop was poor and caused level disturbances and unplanned reactor shutdowns. Figure 4 shows the poor performance of the reactor level control.

One of the first questions that arose in this plant example was whether or not the level controller, LC-1, was properly tuned. The tuning was checked and, although it was not optimum, it was not the source of the level variations. A closer look at the trends of the LC-1 process variable and output as well as the actuator position in Figure 5 suggests that the control-valve closure member may not be moving until the controller output has moved more than 1% after a direction reversal. In other words, the control valve had a combined dead band and resolution of approximately 1%, which represents 10% of rate since the valve is operating at about 10% of full travel.

Testing the control valve. A special test apparatus was installed on the control valve to measure the rotation of the valve shaft. The valve design was such that the valve closure member, a disc, was solidly attached to the valve shaft and the shaft was large in diameter so that shaft windup should not be significant. Assuming there were no other process disturbances during the test, the slope of the level process variable can be used to detect a change in the actual flow coefficient of the valve. The response of the actuator position, the valve shaft and the change in flow coefficient can be compared to the input signal. The input signal to the control valve (the output of the controller) was stepped in increments of 0.1% and 0.2% with a reversal in direction. Figure 6 shows a plot of key variables during the test. The test revealed that the actuator position was "hunting" with about a 0.3% peak-to-peak magnitude. Furthermore, the valve shaft response exhibited a dead band of about 0.8% and a resolution of about 0.2%. Since the control valve was only operating at 8–10% of its capacity, 1% of combined dead band and resolution is a very large non-linearity. And, for a process with an integrating response, the presence of a dead band will cause a continuous limit cycle in the level and the flow through the valve. In summary, this test revealed a problem with positioner performance and excessive dead band and resolution. The tuning test performed earlier showed that the process gain was excessively high, which amplified the control valve problems. The fact that the valve only operated at 8–10% of its capacity indicates that it is oversized, which contributed to the high process gain.

The role of control-valve construction. Figure 7 shows details of the construction of the control valve and its actuator. The construction has several characteristics that can cause dead band. First, any clearance in the key ways and keys in the coupling will cause dead band. When the valve was initially built, set screws had been used to press into the keys in an attempt to reduce slippage between the coupling and the shafts. Another source of dead band in this design is the scotch-yoke assembly that converts the linear motion of the actuator to the rotary motion of the actuator shaft. By design, the scotch-yoke assembly must have clearance between the moving parts, but clearance creates dead band [7]. Note that the position of the actuator shaft, not that of the valve shaft, is used for position feedback to the digital valve positioner. Thus, the positioner will measure the position of the actuator shaft and is unaware of the fact that the valve shaft position may differ from the actuator shaft by as much as 1%.

Many of the features of this control-valve construction were appropriate for on-off valve performance, but were inherently problematic for throttling performance. In summary, the investigation revealed the following problems with the valve:

- Oversized valve creates high process gain, which amplifies valve non-linearities
- Slack in actuator-to-valve shaft coupling, which creates dead band
- Slack in the scotch yoke assembly, which results in dead band
- Poor tuning in digital valve positioner, which results in excessive dead band, resolution and a variation in travel gain

The solution. The recommended solution for this plant example was to

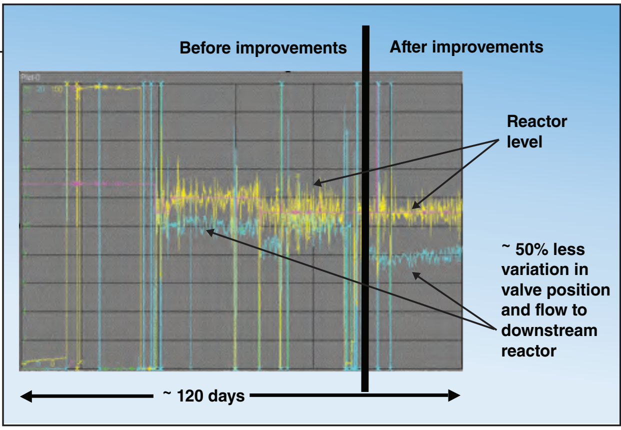

FIGURE 9. The reactor level control improved with interim control-valve improvements

Fisher Controls International

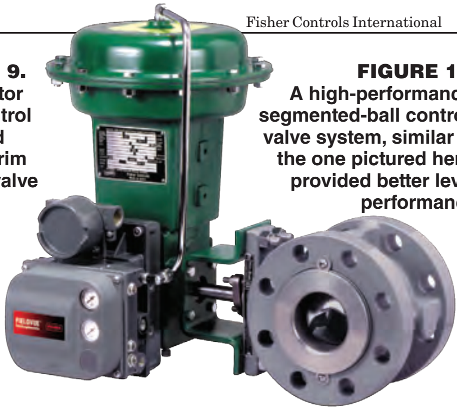

FIGURE 10. A high-performance, segmented-ball control-valve system, similar to the one pictured here, provided better level performance

replace the control valve with one that is properly sized and has better throttling control performance and sufficient on-off characteristics (in this case a tight shut-off). And, the valve positioner should be tuned properly for the optimum response.

In an effort to provide more immediate improvement in the reactor level control, the following interim improvements were made to the control valve: reduce the slack in the actuator coupling system; and improve the tuning of the digital valve positioner. To reduce the slack in the actuator coupling system, new keys were machined with a tighter fit in the keyways. Then, additional and larger set screws were installed in the coupling to press on the keys. Figure 8 shows the changes made to the actuator coupling system. The valve positioner was tuned to provide a faster response time, improve its travel-gain performance and to reduce the tendency to hunt or oscillate.

The interim efforts to improve the control valve performance were beneficial and helped to improve the reactor-level-control performance and reduce the frequency of unplanned reactor *trips* due to level control disturbances. Figure 9 shows the reactor's level control performance before and after the interim improvements were made.

The complete recommended solution was to replace the original 18-in. valve with a 12-in. high-performance, segmented-ball, throttling control valve with a spring and diaphragm actuator. This control valve system, similar to the one shown in Figure 10, is specifically designed for throttling applications. A high-performance, digital valve positioner was included and was properly tuned to achieve the optimum performance. The new control valve provided even better reactor level performance and allowed a 10% production-rate increase and a significant economic benefit. ■

Edited by Dorothy Lozowski

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Crossover Applications for the ASME-Bioprocessing Equipment Standard

William M. Huitt
W.M. Huitt Co.

The content of the ASME-BPE Standard is universal and can be applied broadly throughout the CPI to meet the needs of complex engineering designs and operations

Because the global chemical process industries (CPI) encompass so many varied industry segments — including the conversion of raw materials and intermediates into chemicals and petrochemicals, fats and oils, paints and coatings, food and beverages, the refining of petroleum, the production of pharmaceuticals and others — there is considerable overlap in terms of the types of equipment, instrumentation, pipe, tubing and design elements, as well as industry codes (mandatory) and standards (voluntary) that are used during the design, construction and operation of CPI facilities. In many cases, a given set of codes and standards created for one industry segment will, quite possibly, contain content that is meaningful and relevant to facilities operating in other sectors. For instance, the ASME-Bioprocessing Equipment (BPE) Standard was created for the pharmaceutical industry but can be useful in the biofuel and chemical industries, too.

Across the spectrum of the more than 200 American National Standard (ANS) developers (organizations accredited by the American National Standards Institute, ANSI) to develop industry standards, and the more than 10,000 American National Standards that are published by ANS developers, there is ongoing effort to ensure harmonization among those standards.

As a result of this harmonization effort, engineers at a CPI facility can readily make use of multiple industry standards on a single project without concern about conflicting statements between those standards. That is not to say that a more stringent requirement will not exist in one standard over another. Such a situation is easily rectified by including, in proprietary specifications and guidelines, a statement that specifies that "the more stringent requirement shall govern."

When adopting existing industry standards, the project team draws upon the consensus of committees of industry experts whose efforts have been undertaken to ensure that the pertinent subject matter has been thoroughly assessed, analyzed, debated, and voted on at multiple levels, reaching broad consensus and culminating in the publication of the accredited standards.

What this means for the end user is that unless a project is regulated by a specific code that has been adopted as part of a prevailing federal, state or municipal regulation, the project team is free to specify — through contract stipulations or project specifications — the most appropriate set of codes and standards that are required to meet the varied requirements of a project or facility. For example, the project team may specify ASME B31.3 – Process Piping as the main compliance piping code for a given project, with or without exceptions. In addition, the project requirements will likely dictate the need to reference specific requirements published in other relevant codes and standards — beyond those spelled out in B31.3.

For instance, the project requirements may include standards for components and materials of construction (MOC), as well as specialized needs from other standards, such as the BPE Standard, or requirements for boiler external piping, which is not covered by B31.3 but is instead covered by ASME B31.1 – Power Piping. Component- and material-related standards — that is, different standards related to such items as pipe, fittings and flanges — are generally adopted in their entirety. However, users may also pick and choose optional, individual manufacturing requirements contained within those standards when those requirements are specifically needed.

When adopting a piping code such as B31.3 as a base code for a project, other piping codes and standards can be referenced for compliance when the following occurs:

1. The referenced requirement is not already contained in the base code
2. The referenced requirement is more stringent than that contained in the base code, or
3. The referenced requirement does not conflict with a "not permitted" statement in the base Code. For example: B31.3 Para. 306.4.4(c) a flared lap is not permitted under severe cyclic conditions

Even though a project has adopted

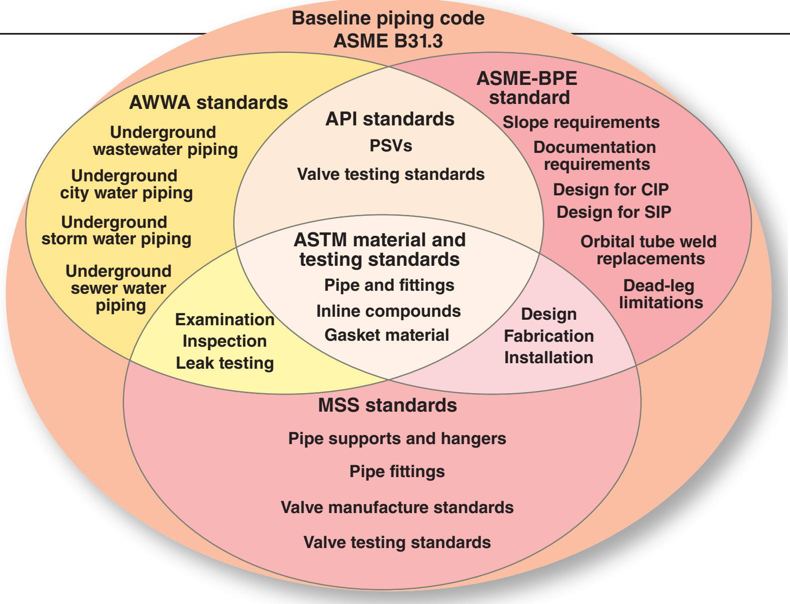

FIGURE. This rather simplistic Venn diagram provides a basic representation of the possible codes and standards used on a project in a CPI facility

a base piping code (either by the authority of government regulation or by decision of the project team), the engineer should look to other relevant standards to help define additional project requirements beyond those covered in the base code. Rather than spending time and money defining requirements that may be needed but are not covered by ASME B31.3 or ASME B31.1, the engineer should look to other existing standards that are able to provide detailed, vetted requirements to match the project's needs. A good case in point is the BPE Standard.

The Figure (above) shows how a given project's many codes and standards requirements may be represented graphically in a rather simplistic Venn diagram. Such a diagram shows the necessary piping codes and standards for a given CPI project and shows how they overlap and commingle within the framework of the project or within the infrastructure of plant operations and maintenance. In actuality, such a diagram will be much more complex due to the volume of codes and standards that are required by any CPI project or plant.

Where the BPE applies

The BPE Standard was developed in an effort to instill a sense of continuity and standardization into an industry that seriously needed it — the pharmaceutical industry. However, while the initial impetus for the creation of the BPE Standard was, and still remains, to meet the needs of the pharmaceutical industry, its content is more universal and can be used in many other CPI sectors.

In fact, the BPE Standard, first issued in 1997, dovetails nicely with the ASME B31.3 Process Piping Code, the essential piping code for the CPI. The initial BPE Standard consisted of the following six parts, which is discussed in greater detail further on:

- Part GR — General Requirements
- Part SD — Design for Sterility and Cleanability
- Part DT — Dimensions and Tolerances for Stainless Steel Automatic Welding and Hygienic Clamp Tube Fittings
- Part MJ — Material Joining
- Part SF — Stainless Steel and Higher Alloy Surface Finishes
- Part SG — Equipment Seals

The most recent version of the BPE Standard (which, at this writing, is the 2009 issue) looks much different than its inaugural predecessor, and has content that is much more encompassing and broad-ranging with the addition of these three parts:

- Part PM — Polymer-Based Material (added in the 2002 issue)
- Part MMOC — Metallic Materials of Construction (added in 2009)
- Part CR — Certification (added in the 2009 issue)

In the next publication of the BPE Standard, there will be an additional section added: Part PI — Process Instrumentation. This Part will cover requirements for the design, installation, and application of process instrumentation. The word "process" in the title of this Part also includes utility fluids, such as purified water, water for injection (WFI), clean steam and other utilities that come in contact either directly with the product or indirectly through contact with the product-contact surface during cleaning or sanitization (Note: The product-contact surface includes the internal tubing, component and equipment surface that comes in contact with raw materials and utilities that also come in contact with the product).

Hygienic operations. At the core of the BPE Standard is the need to install piping systems and equipment that will become (and will remain) hygienically clean by making them drainable and easily cleanable to a microscopic level. Residual hold-up of product cannot be tolerated in pharmaceutical operations, nor can a system that facilitates the onset and growth of bioburden. As a result, such systems must be designed in a way that allows them to be properly cleaned or sterilized in place.

Certain aspects of cellulosic biofuel processing and other CPI processes have a need for such hygienic operations, but for altogether different reasons. For instance, in bioprocessing operations, it is necessary to create an environment that will promote the growth and activity of a living organism or bacteria, in order to perform a step in the process.

The problem lies in the fact that the environment created for the selected bacteria is also beneficial to bacteria that may be detrimental to the process. In order to keep detrimental bacteria in check and allow the process to remain stable and viable, it is imperative that a segment of the piping system have sterilize-in-place (SIP) capabilities, to allow the needed cleaning to be carried out at periodic time intervals. Similarly, ethanol manufacturing processes must be designed with clean-in-place capabilities (CIP) for the fermenters, the beer well, the filtrate tanks and propagators as well as other segments of the process stream, to prevent residue buildup on equipment and piping.

When designing a process that requires CIP or SIP capabilities, there are specific piping and equipment design requirements that need to be met. These include requirements related to minimum slope, maximum acceptable dead-leg, internal weld finish, fitting and fabrication tolerances, surface finishes, and so on. These are all design considerations needed to accommodate CIP or SIP protocols. The design attributes needed to integrate CIP and SIP into a system can be found in the BPE Standard.

Sloped piping and maximum acceptable dead-leg criteria. Similarly, designing a process system that may not necessarily be concerned with bacteria may still have a need for sloped piping and maximum acceptable dead-leg criteria. The criteria for these design elements exists as vetted information within the BPE Standard, and thus can simply be referenced in a specification drawn from the BPE Standard, rather than basing design criteria on some arbitrary rule-of-thumb principal.

Documentation requirements. Meanwhile, while facilities that are outside the realm of strict biopharmaceutical manufacturing may not require the same exacting documentation trail all CPI facilities do require varying degrees of documentation related to material, fabrication, examination, and testing. Nonetheless, facilities whose documentation records are not required to be as extensive as those required by the biopharmaceutical industry can still benefit from the portion of the standard that relates to documentation requirements.

Specifically, the laundry list of documentation that is specified in the BPE Standard can be utilized by other industries simply by selectively referencing that part of the standard. Rather than a company having to write out a proprietary requirement — one that may already be contained in a vetted industry standard — the company can simply reference the respective segment of the standard that spells out the needed requirement.

Content of the standard

As noted earlier, while the BPE Standard dovetails with, and references to, many aspects of B31.3, it is markedly different in both layout and content. Nonetheless, the discussion below shows how universal the nine current parts of the BPE Standard are for many diverse facilities throughout the CPI.

Part GR — General Requirements. This section sets the tone and defines the scope of the standard. It defines terms that are specific to the bioprocessing industry and other terms that may have originated elsewhere and been adopted by the BPE standard with a slightly different interpretation.

Part SD — Design for Sterility and Cleanability. Part SD provides discussion on how to design cleanability and sterility into a system. It also covers specific design issues with regard to instrumentation, hose assemblies, filtration and other equipment. In addition to hydrostatic testing, this section also touches on testing fundamentals for spray balls, drainability, cleanability and sterility. It also provides a listing of documentation that can be selected by, and used for, industries beyond bioprocessing.

This section is one place in which the BPE Standard diverges from the main focus of the B31.3 format. For instance, while B31.3 is developed around the cornerstone of safety and system integrity, the BPE, while integrating safety and integrity, is focused mainly on providing acceptable criteria for system design.

Since its inception, the SD subcommittee has taken on the task of researching accepted industry design practices that are currently being used in the bioprocessing industry. This is an effort to validate, and, where necessary, rectify those largely unqualified design practices and criteria, through the development of new and appropriate design criteria for adoption into the BPE Standard.

Part DT — Dimensions and Tolerances. This section has basically standardized many of the practices in the bioprocessing industry. Prior to the availability of the BPE Standard and Part DT, there were no industry-standard dimensions on fittings and valves, and no common set of manufacturing tolerances. This meant that components from one manufacturer to the next were not necessarily interchangeable — a situation that has long presented a nightmare for many projects — and that all fittings had to be purchased from the same manufacturer to ensure compatibility.

Part MJ — Material Joining. This section touches on all aspects of the welding of pressure vessels, tanks, tubes and fittings, and provides guidance on acceptable requirements related to material selection, inspection, examination and testing. It also discusses joining processes and procedures, weld joint design and preparation, weld-acceptance criteria, procedure and performance qualification and documentation requirements. Several tables list weld-acceptance criteria, and detailed graphics illustrate acceptable and unacceptable welds.

Part SF — Surface Finish. A crucial element in the ability to attain and maintain a clean system is in the quality of the finish on the product-contact surface. Whether in the bioprocessing industry or other sectors in which at least a segment of the processing scheme involves bioprocessing (such as biofuels production),

TABLE. R_a READINGS FOR PRODUCT-CONTACT SURFACES

Mechanically polished		
R_a max.		
Surface designation	μ-in	μm
SF0	No finish requirement	No finish requirement
SF1	20	0.51
SF2	25	0.64
SF3	30	0.76
Mechanically polished[1] and electropolished		
R_a max.	μ-in.	μm
SF4	15	0.38
SF5	20	0.51
SF6	25	0.64

General notes: (a) This table replaces previously published Tables SF02, SF-4, SF-6, SF-8, and SF-10.
(b) All R_a readings are taken across the lay, wherever possible.
(c) No single R_a reading shall exceed the Ra max value in this table
(d) Other R_a readings are available if agreed upon between owner/user and manufacturer, not to exceed values in this table.
Note: (1) or any other finishing method that meets the R_a max

Source: ASME-Bioprocessing Equipment (BPE) Standard.

the cleanability of the product-contact surface is crucial (Table). In addition to Part SF providing the methods by which surface finishes are classified, it also spells out the acceptance criteria for compliance.

Part SG — Equipment Seals. This part covers equipment seals, and provides a classification scheme that describes the required integrity of a seal under specific service conditions.

Part PM — Polymer-based Materials. Added to the Standard in 2002, this section covers criteria related to both thermoplastics and thermosetting materials. It touches on design considerations, joining methods, interior product-contact surfaces and materials of construction.

Part MMOC — Metallic Materials of Construction. This section was first published in the 2009 issue of the BPE Standard. Its incorporation into the standard was driven by the growing importance of alternative materials of construction beyond Type 316L stainless steel. The main objective of this section is to help system designers and facility owners improve system quality and sustainability, and to improve compatibility with fluids that are too aggressive for Type 316L stainless steel.

Adding Part MMOC allows the standard to elaborate and expand its information on metallic materials in a centralized and comprehensive way. This section offers a definitive listing of acceptable materials in their various forms, and provides further information on Pitting Resistance Equivalent Number Rankings (PREn), corrosion test references for alloys, discussion points on superaustenitics, duplex stainless steels, nickel alloys, ferrite content restrictions and much more.

Part CR — Certification. This part was first included in the 2009 publication of the standard, and gives users a way to ensure that the tubing and fittings they purchase are compliant with BPE Standard requirements. This is achieved through a well-defined and implemented certification program for compliance with the BPE Standard by those manufactures, fabricators, and service providers that qualify. The certification process is a multi-faceted program based on an in-depth Quality

Management System (QMS) program that is defined in Part CR.

Specifically, the program requires that the applicant for certification create a QMS manual, as defined in the BPE Standard, which is expected to mirror the quality program actually being used in their production process. Among many other requirements, the manual should reflect a company's organizational hierarchy, inspection protocols, materials-handling procedures (from receiving through manufacturing and shipping), process for segregation of materials, inspection-personnel qualifications, reject-resolution and documentation needs.

Extras within the Standard

The 2009 publication of the BPE Standard contains more than 60 figures, 60 tables and 9 non-mandatory appendixes — all developed to make the compliance requirements more explicit for the user. The figures represent everything from fitting dimensions to mechanical seals, and include acceptable nozzle projections, side- and bottom-nozzle pads, vessel sight-glass mounting design, double mechanical-cartridge-seal design, single dry-running contact seal, weld profiles, design diagrams and more.

In addition to the many tables on dimensions and tolerances for the manufacture of fittings, additional tables provide weld-acceptance criteria for: welds on pressure vessels and tanks, welds on pipe, welds on tubing, and tube-attachment welds. Another table provides acceptance criteria for the mechanically polished product-contact surface of stainless steel and higher alloys, and a table of surface-finish designations.

The tables, graphics, and intellectual information contained in the BPE Standard are the product of a very structured data-refining process. The supporting research data, while not necessarily included in the body of the standard, is, in many cases, valued information. The Non-Mandatory Appendices section houses much of this information. This section contains information that is deemed to be useful to readers, but is not appropriate for codification. Presented in this way, the information in this section can be published for use while still remaining segregated from the requirements of the standard, should the entire standard be adopted as code.

For instance, some of the topics covered in the Non-Mandatory Appendixes include:

- Appendix A – Slag
- Appendix B – Material Examination Log and Weld Log
- Appendix C – Slope Measurement
- Appendix D – Rouge and Stainless Steel
- Appendix E – Passivation Procedure Qualification
- Appendix F – Corrosion Testing

- Appendix G – Ferrite
- Appendix H – Electropolishing Procedure Qualification
- Appendix I – Vendor Documentation Requirements for New Instruments

Wrap up

While this article provides a cursory overview of the BPE Standard, the major take-away should be the understanding that a great deal of useful, vetted information is available in the many American National Standards that are available today. While some may require compliance from a regulatory standpoint, others may be adopted and specified voluntarily.

As noted earlier, it is not necessary to adopt an entire standard if all you need are isolated sections. If, for example, a given project only needs some or all of the content on CIP requirements from the BPE Standard, then users can reference just that segment, which will then become a part of the contractual requirements for a project or facility.

The same holds true if your project is handling, say, hydrogen gas. There may be circumstances in which it may be practical to require compliance with isolated segments of a Compressed Gas Assn. (CGA) Standard such as G-5 "Hydrogen" and/or G-5.4 "Standard for Hydrogen Piping Systems at Consumer Locations." It would then be appropriate to adopt and reference that segment of the CGA standard.

There are numerous standards (from ASME, API, CGA, and others) that are required to deliver the necessary codes and standards to a project. Without harmonization efforts by the developers of today's standards, the usefulness of industry standards would most likely be diminished by conflicting requirements and overlapping stipulations. However, with harmonization and self-familiarization, the engineers' effort to select and employ the many available standards is made much easier and more relevant today. ■

Edited by Suzanne Shelley

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Lessons in Feedstock Change

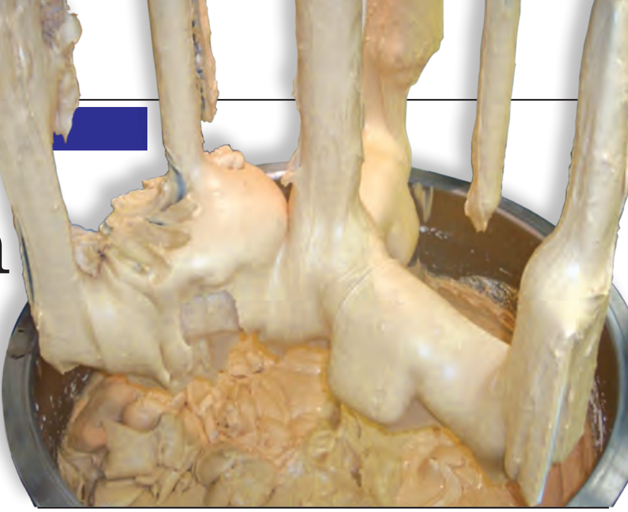

FIGURE 1. Early in development, lab testing is vital to identify the most effective combination of mixing agitators and optimize the process

Many renewable materials offer environmental and financial benefits, but some come with a mixing challenge — higher viscosity

Steve Pung and **Rick Hammers,**
Columbia Forest Products

Ken Langhorn,
Charles Ross & Son Co.

These days, there seem to be more reasons than ever to change feedstocks throughout the chemical process industries (CPI). Whether environmental, or more directly based on financial and market drivers, big benefits usually require big changes. This is especially true in switching to many renewable feedstocks, which either add or compound challenges related to processing solids.

When Columbia Forest Products embarked on a three-year project to change feedstock for its flagship product line, the company took on the special challenge that every market leader faces when it assumes the role of first-mover toward a new technology. The largest manufacturer of hardwood plywood and veneer in North America, Columbia Forest Products chose to switch all seven of its manufacturing plants in North America from an adhesive based on urea formaldehyde (UF) to a new adhesive technology based on soy protein. The transition represented a paradigm shift, both technologically and culturally. It was a high-stakes business decision, since the company was betting its future on the success of the changeover.

Assessing risks

The risk and impact of a feedstock change can vary substantially from one case to another. Key variables include the following:

- The magnitude of change required in production
- Maturity and sophistication of the technology involved
- Awareness and experience among company employees of new technologies needed
- The company's ability to rally key partners to support the company through the changeover and afterward
- The willingness of company employees to embrace new technology and welcome change

Large-scale changes in feedstock do not necessarily present great risk. In some cases, a change in feedstock simply reflects a strategy to create more options for plant inflows and outputs, and become more competitive. In the petroleum industry, for example, a refinery may be adapted to accept new crude-oil feedstocks and allow the operator to respond more nimbly to fluctuations in the price, availability and quality of historic feedstocks.

In such cases, the primary goal is greater flexibility in production, not a metamorphosis. Although the cost of changing feedstock may be high, the task is well-understood, since it has been studied and modeled by legions of researchers, consultants and vendors. The risk is comparatively low.

A switch in feedstock sometimes represents a permanent and inflexible process change, though it may still pose no great challenge or risk in processing. This is often true when modifying the flavor or nutritional profile in a food product, for example — when ingredients change, but key process parameters and in-plant production methods remain essentially the same.

In contrast, Columbia Forest Products' experience with changing feedstock was a process that presented a formidable technical challenge and great risk, with no guarantee of great return. The company was not hedging against market fluctuations or impending regulation. It wasn't implementing a temporary feedstock change to capitalize on a blip in commodity pricing. It had no well-documented model to follow, since it was the first to adopt a radically different adhesive technology.

When the company changed feedstock, it made a permanent, all-in commitment to abandon one feedstock for another, reformulate its flagship product line and overhaul its production method throughout North America — all with no increase in the end-product cost to buyers. There was no turning back.

Seizing opportunities

The opportunity for a strategic feedstock change often results from the convergence of growing market demand and a new development in an enabling technology. In the case of Columbia Forest Products, demand had been apparent for years, but a feedstock change also required a breakthrough in adhesive technology.

UF-based adhesives emerged in the 1950s, and they have been used to manufacture hardwood plywood ever since. Compared to earlier adhesives (which, ironically, included a primitive form of soy-based adhesives), those based on UF were simple to mix, strong and water-resistant, easy to

EQUIPMENT FOR MIXING HIGH-VISCOSITY MATERIALS

Soy solids loading of more than 30% can be challenging with regard to viscosity and thixotropy (the property of certain viscous materials to become less viscous over time when shaken, agitated and so forth). At viscometer spindle speeds of 5 rpm and 10 rpm, the team recorded batch viscosities of 200,500 cps and 180,400 cps respectively.

The high-speed disperser in this dual-agitator mixer (Figure 2) provides plenty of shear to mix the soy flour with water and other minor additions. But at this level of viscosity, the batch material will not flow readily, which inhibits the ability to achieve homogeneity. It also raises the risk of creating localized zones of excessive heat build-up in the vicinity of the disperser.

For supplemental agitation, we rely on a low-speed, low-shear anchor agitator. The two-wing anchor orbits the periphery of the vessel, removes material from the bottom and wall, and feeds the stationary high-shear device. By stimulating vigorous flow throughout the vessel, the anchor allows us to apply intense shear with the disperser and accelerate the batch cycle.

The two agitators in a dual shaft mixer rotate independently, on stationary axes — a robust design suitable for mixing materials of moderate viscosities. (Note: For viscosities up to 8–10-million cP, a transition would be required to equipment in which the agitators themselves orbit the batch in a planetary motion and physically contact all the material in the vessel, even with limited flow.)

FIGURE 2. In production, dual disperser blades apply high shear, while a two-wing anchor scrapes the vessel's sidewall and bottom, promoting flow, then complete discharge

In production, the pairs of mixers and tandem holding tanks that were provided for Columbia Forest Products' plants ranged in capacity from 300 gal and 500 gal to 500 gal and 750 gal. Like the mixers, each supplemental holding tank was also equipped with a slow-speed anchor agitator. The anchor in each holding tank simply keeps the finished batch moving, prevents stratification before use, and helps to ensure consistent performance of the adhesive. ❑

apply, and inexpensive.

UF is a thermosetting resin derived from natural gas through the intermediates of ammonia for urea and methanol for formaldehyde. Raw materials were plentiful and supply easily kept pace with demand, which was driven mainly by the home building and remodeling markets. Hardwood plywood is used widely for interior applications including high-end residential and commercial cabinetry, fine furniture, architectural millwork and commercial fixtures. (Plywood designed for construction sheathing and other exterior applications is typically manufactured with an adhesive based on phenol formaldehyde, which is more weather resistant.)

Starting in the 1980s, UF attracted criticism because it was found to be a source of formaldehyde off-gassing in homes. Especially when exposed to rising levels of moisture and heat, adhesives and other products made with UF resins release free formaldehyde into the atmosphere. Emission rates are highest immediately after product installation and gradually decline, but they continue long afterward.

Evidence of the health risks associated with high concentrations of free formaldehyde in household air mounted steadily. Finally, in 2004, the International Agency for Cancer Research declared that it had reclassified formaldehyde from a suspected carcinogen to a known carcinogen.

Meanwhile, demand was also growing among the architecture and design community for cost-effective alternatives to construction products made with UF-based materials. In a market characterized by unmet demand and a call for change, an opportunity was developing. But the technology had not yet emerged to make a change possible.

In 2003, the enabling adhesive technology finally came to light. Comprised of cost-effective soy proteins and an amino acid that served as a cross-linking agent and wet-strength resin, the new adhesive offered fast curing and high bond strength, even when wet — an ideal combination to enable a switch away from UF adhesives.

The benefit of widescale support. An unequivocal commitment from top management greatly improves the likelihood that a feedstock change will be successful. As the transition team moved forward, it soon recognized the value of this high-level commitment. Approvals came quickly. Resources were made available promptly, whenever they were needed. The priority assigned to the project was never in doubt.

Beginning transition

The team, led by authors Steve Pung and Rick Hammers, devoted most of 2004 and early 2005 to testing and process development.

Recruiting technological partners. The next step after exploratory testing is to recruit the partners necessary to make the venture successful. In this particular case, Dr. Li at the University of Oregon had discovered the adhesive, and the university held the patent. Hercules (now Ashland Chemical), which owned the cross-linking resin technology and licensed Columbia Forest Products to develop its use for wood products, would provide technical support related to process chemistry. Cargill would supply food-grade soy flour and related technical support.

By mid-2004, the team recognized it would need another development partner to provide technical guidance and equipment related to mixing. The soy adhesive was quite different than the UF adhesive that had been used for years, with many more process variables to control. Chief among these was a substantial increase in viscosity.

Testing reveals challenges of handling higher-viscosity materials. The R&D group has since lowered the viscosity of the adhesive dramatically, but the original formulation of the new, soy-based adhesive was more than 200,000 cP during the mix cycle

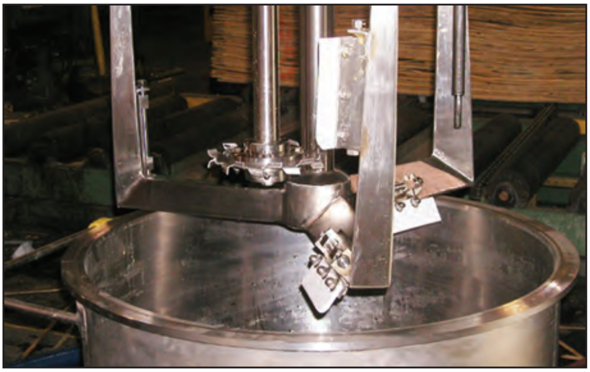

FIGURE 3. In-plant tests were conducted with a mixer equipped with a high speed disperser and an anchor designed to generate axial and lateral flow

FIGURE 4. With systematic experimentation during in-plant tests, the process is optimized — and later automated

(Figure 1). Since the UF-based adhesive only reached 4,000–6,000 cP, feedstock presented a huge technical shift in this regard.

The team arranged a series of process tests with Ross, the mixing equipment partner. The tests were run on laboratory- and pilot-scale mixing equipment, using actual soy-based adhesive ingredients to replicate conditions on the process line. A successful laboratory test identified a dual-shaft mixer, equipped with a high-speed disperser and a three-wing anchor agitator, as the optimal solution (Figure 3; see box, Equipment for Mixing High-Viscosity Materials). Columbia Forest Products rented a 100-gal mixer for the pilot phase of development.

The team established its development center in the company's plant in Klamath Falls, Oregon. With the mixer operating alongside a dedicated glue spreader, the team systematically explored the influence of key process variables, including pH, soy solids load, cross-linker concentration and various experimental additions designed to modify tack and other properties.

Testing began in earnest in late 2004 using 24 × 24-in. samples of seven-ply hardwood plywood made in the forest products laboratories at Oregon State University. A battery of tests was required to fully assess the performance of each sample, which made this a laborious process. Industry-standard tests for each trial panel included the following: a dry shear test, a cyclic-boil shear test, and a decisive three-cycle boil test.

During this initial phase, viscosity immediately emerged as the most persistent challenge the team would face during testing and rollout. Coaxing the 200,000+ cP material to flow on the glue spreader was difficult, and the adhesive was extremely difficult to pump. On numerous occasions, with pumps bogged down, lines locked up or a hose blown, team members carried glue to the spreader in 5-gal pails to continue tests, while handling equipment was being repaired.

Because of the higher viscosity of the adhesive, breakdowns, repairs and upgrades were routine. But the challenge in handling higher-viscosity material was really only half technical. The team also had to overcome its own expectations about the capabilities of the existing equipment.

The team found that plant staff accustomed to handling much lower viscosities tend to underestimate the challenge of pumping the thicker adhesive. During the rollout, staff in virtually all of Columbia Forest Products' North American plants were determined to move it with existing equipment, but failed. Eventually, the decision was made to upgrade to high-capacity progressive cavity pumps and similarly robust ancillary equipment in every plant.

In-plant trials

In-plant trials are immensely beneficial, because they generate data in conditions that mimic actual production (Figure 4). But in most companies, where floor space is limited for non-production activities, testing occurs near ongoing production lines with employees nearby who are not directly involved in the tests. In such cases, the development team should remain sensitive to the image that testing presents to others. Dramatic "failures" in a test phase are usually not disturbing to members of a development team. After all, a "failure" is simply another data point that helps to define process limits. But when tests are conducted in full view of others in the plant, the sight of seemingly "unsuccessful" tests can be demoralizing.

In the first full-scale mill tests, as process variables were scaled up from test sizes to full-size plywood sheets, negative results were inevitable. The moisture content in the first panel was too high, for example, because the solids content had been lowered in order to lower viscosity — with offsetting adjustments to other additives to prevent a loss in performance. This caused the panel to stick to the press.

In other tests, excessive steam pressure in the hot press essentially blew the panels apart — until the formulation returned to a higher solids content (and consequently, higher viscosity).

After this first round of tests, naysayers predicted failure: "You'll never be able to make plywood with glue this thick. It just won't work!"

In fact, further changes to the adhesive formulation soon produced positive results. But along with the optimal formula for mixing the adhesive, another discovery was made: the importance of anticipating the impact on internal audiences when conducting in-plant testing. The unflagging confidence of plant employees, along

LESSONS LEARNED

For feedstock transitions on any scale, our collective experience left us with these essentials for a successful changeover:

1. Obtain an unequivocal commitment from top management before launching a feedstock change
2. Identify key technical challenges in advance, and assemble the transition team with appropriate expertise and resources to address each one specifically
3. Assess the need for additional equipment and expertise conservatively — especially when transitioning to a process in which you will be handling higher levels of viscosity, it's easy to underestimate the need for robust equipment
4. As engineers, we focus instinctively on technology challenges. Expect human challenges, too. The urge to resist change is part of human nature
5. Never underestimate the importance of making production personnel believers. Make them partners in development, and co-owners of the success that follows
6. Identify believers. Encourage them to speak up and rally others
7. Identify skeptics. With patience, respect and solid information, make them believers
8. Communicate often and explicitly with all staff to reinforce the importance of the mission
9. Cultivate strong, collaborative relationships with key partners — including customers who will benefit from the change, especially if those customers are asking for it
10. Expect to be derailed along the way, and be prepared to respond when it happens
11. Celebrate success at every opportunity ❑

with their enthusiasm for the basic changeover concept, is essential for a successful rollout.

Employee owners: Tough critics, strong supporters. The success of a profound process change in any production environment requires a strong commitment from the production staff. This is especially true in employee-owned companies like Columbia Forest Products. When employees own a stake in the future of the company, they must be convinced the change is positive and likely to succeed. Lingering doubts about the wisdom of the change and the security of their stake in the company will inevitably slow progress. Fortunately, once employee-owners are convinced, they are also likely to maintain a high level of engagement and drive the process forward.

At Columbia Forest Products, enthusiasm generally remained high once the company's CEO and board explained the goal of the program and challenged the staff to roll the process out to all our plants. We had many "high-energy" discussions along the way, but a fairly competitive atmosphere developed and company-wide morale remained high thereafter.

Surmounting rollout hurdles

In most companies operating numerous production facilities, plant-to-plant differences (such as legacy equipment, environmental conditions, and management style) can be quite significant. With many variables in play, the rollout of a major process change should be sequential, flexible and adaptive.

Following this approach, each successive installation provides additional experience and insight and enables the transition team to continuously refine the manufacturing process and improve efficiency.

In planning the three-year rollout, the team anticipated that each plant would represent a unique set of technical challenges, as follows:

1. Variation in other feedstock. Columbia Forest Products plants are dispersed geographically, from Canada to Arkansas, Oregon, North Carolina, Virginia and West Virginia. Wood feedstock, the other major component of plywood besides the adhesive, varies dramatically from region to region. White fir in the Pacific Northwest presents a different set of physical properties (especially density and absorption of moisture) than aspen in Canada or yellow poplar in the Eastern U.S. Each species required adjustments in the formulation and application of the adhesive.

2. Legacy equipment. The new mixing equipment for each plant would vary somewhat in capacity, while the essential designs for the mixer and holding tank would remain consistent. But each plant operated with a unique array of legacy equipment available for handling and applying the adhesive.

3. Process line design differences. The seven plants included a mix of fully automated and semi-automated lines, which required adhesive formulations that differed significantly in curing time and application.

4. Ambient temperature differences. Because of their geographic dispersion, the plants operated in vastly different climates. Regional variations in elevation, relative humidity and ambient temperature — and substantial seasonal temperature variations in some locations — required site-specific testing and adjustment.

With all of these differences to account for, from plant to plant and within certain plants individually, the rollout essentially presented seven separate opportunities (one for each plant) to re-balance all of the technical variables and optimize the process.

On the human side of the equation, each plant also presented a unique combination of personalities, attitudes and experience among managers and equipment operators.

While collaborating with the process development team, the management team in each plant was empowered to manage the rollout locally. This proved an important factor in sustaining a high level of energy throughout the rollout. From the start, each local team owned the rollout and the success they achieved.

Inevitably, the staff at each location included stubborn skeptics and avid supporters. As demonstrated in this particular feedstock switch, quickly addressing both skepticism and support with information, converts skeptics and reinforces the enthusiasm of the program's supporters. Another important strategy is to consistently explain the importance of the program for the company and the vital role that each plant will play.

Increased onsite control

The changeover from UF-based adhesive to the soy-based alternative led to a change that was far more profound than a simple upgrade in equipment. Until the switch, Columbia Forest Products' supplier oversaw most of the mixing of the adhesive. The UF chemistry was entirely in the supplier's hands; the adhesive formulations were monitored and controlled by its staff. The role of the operators at each plant was minor and required only basic expertise in mixing. Local mixing was generally limited to adding

FIGURE 5. Since the transition, Columbia Forest Products has assumed more responsibility for onsite mixology and gained more control over the quality and consistency of its end-products

catalyst and a wheat-flour or pecan-shell filler in a low-viscosity batch.

With the changeover, each plant assumed much greater responsibility for onsite mixology (Figure 5). Tanker trucks still arrive daily from a resin supplier — now, delivering the soy-adhesive cross-linker. But today, instead of simply receiving a readymade adhesive resin, plant production teams make their own adhesive onsite using food-grade soy flour from Cargill, the cross-linker from Ashland, and a variety of other additions.

This shift has brought about three significant changes in the processing culture at each plant.

1. Knowledge base. Columbia Forest Products developed a strong base of company-wide mixing expertise and operational expertise at each plant. The company's adhesive technology team, along with the local expertise developed at each plant, has made Columbia Forest Products stronger, more versatile and more innovative at the process level. Process improvement never stops.

2. Ongoing partnerships. The company strengthened its ongoing partnerships with key suppliers. By leveraging its resources, Columbia Forest Products has greatly increased its collective ability to innovate and continue improving its products.

3. Controlling the company's destiny. By becoming a more active partner in production, Columbia Forest Products acquired greater control over the company's future success.

Bottom-line results

Columbia Forest Products' feedstock changeover concluded late last year. Although the company has now produced nearly 40-million hardwood-plywood panels using the soy-based adhesive, process optimization continues.

Panels produced with this method are completely free of volatile organic compounds (VOCs) from the adhesive during production and thereafter. They contribute no added VOCs to the atmosphere, whether in the communities that surround production plants, in the workshops where finished cabinets and furniture are made, or in homes, offices and hospitals — anywhere end-products using these panels are installed. Overall plant emissions have been reduced by up to 90%. VOCs detected in the ambient atmosphere inside the plants have declined similarly. ■

Edited by Rebekkah Marshall

Authors

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Rick Hammers is a project manager in the Technology Group of Columbia Forest Products. (Email: RHammers@columbiaforestproducts.com.) He has more than 18 years of experience in the production of various types of wood panels. Hammers has held positions of lab technician, technical director, plant manager, and new product development coordinator for leading domestic and international panel manufacturers. He has a B.S. in industrial technology from the University of Nebraska, Omaha.

Ken Langhorn, Technical Director at Charles Ross & Son Company (710 Old Willets Path, Hauppauge, NY 11788; Phone: 800-243-7677; Email: klanghorn@mixers.com; Website: www.mixers.com), has published many articles on mixing and blending technology. Formerly an R&D specialist at Ross, he holds multiple patents for innovations in high shear and high viscosity mixing. As manager of the Ross Test & Development Center, he oversees a large program of testing and process optimization for customers, along with operations in the company's adjacent analytical laboratory.

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A full line of air-powered tube expanders and rolling motors for creating steel-to-steel mechanical seals in boilers, heat exchangers and condensers is available for sale or rent from this company. The Millhog tube expanders and rolling motors (photo) are air-powered and feature precise torque control from 25 to 325 ft-lb. Once the proper torque level is established, this setting can be retained so that each time the throttle is engaged, the tool will stall when it reaches the desired tube expansion. The Mollhog is offered in five kits to accommodate tubes from 1 in. I.D. to 4-1/4 in. O.D., and 1 to 20 Ga wall thickness. Configurations include straight and right-angle rolling motors for straight and flared rolls. — *ESCO Tool, a unit of ESCO Technologies, Inc., Holliston, Mass.*
www.escotool.com

Angle-seat globe valves with flanged connections

Used mainly for the control and regulation of steam, water and slightly corrosive fluids, the Type 507 (manual operation) and Type 514 (pneumatically actuated) globe valves (photo) are now available with flanged connections in nominal sizes DN 15–50. The flanged valve bodies are made of cast stainless steel 1.4435 (ANSI 316L). The flanges can be installed and removed more easily compared to butt-weld and threaded connections, says the manufacturer. — *GEMÜ Gebr. Müller Apparatebau GmbH & Co. KG, Ingelfingen-Criesbach, Germany*
http://www.gemue.de

These float traps are both compact and reliable

Steam traps of the UNA 1 range combine the technical properties of a reliable compact-type float trap with minimum dimensions. Used wherever condensate has to be discharged continuously without backing up, these float traps feature a rolling ball regulator that ensures steam-tight shutoff, even with small condensate flowrates. The flow direction is easily converted from horizontal to vertical, and vise versa, which leads to simplified stock keeping and more flexibility. The float traps are available in ductile iron, cast or stainless steel. — *Gestra AG, Bremen, Germany*
www.gestra.com

Reduce NOx emissions from boilers, regardless of fuel type

Suitable for use in package, industrial and utility boilers ranging from single to multi-burner wall-fired, Turbo and other boiler types, the ECOjet ultra-low NOx burners (photo) offer ultra-low (below 30 ppm NOx) emissions with little or no fluegas recirculation. Ignition is achieved using a reliable, self-cleaning and low-maintenance Centronics High Energy Direct Spark Ignitor, a burst-mode ignition with flashing indicator that allows operators to observe the ignitor condition during operation. Staged gas design provides extremely stable flames, up to 20-to-1 burner turndown, hot standby and precise furnace warm-up. Ultra low NOx emissions are achieved on most gaseous fuels (natural gas, propane, refinery gas, landfill gas and off gases), and low NOx emissions are achieved on all liquid fuels (No. 2 through No. 6 fuel oil and ultra-heavy fuels, such as pitch and bitumen). — *Hamworthy Peabody Combustion Inc., Shelton, Conn.*
www.hamworthy-peabody.com

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Save space and piping with this trap-valve station

The patented Stainless Steel Trap Valve Station (TVS) is ideally suited for any steam piping installation. Since most of the piping joints needed to properly install a steam trap

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and shut-off valves are eliminated, typical required space is reduced by 16 in., and installed costs are significantly lower, says the manufacturer. The TVS 4000 is a connector that packages two piston-style isolation valves, test valve and stainless-steel strainer with blowdown valve into one connector. This connector can accommodate a choice of either inverted bucket, disc, thermostatic or thermostatic wafer-style steam traps. — *Armstrong International, Three Rivers, Mich.*
www.armstronginternational.com

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This firm offers customized and optimized shell-and-tube condensers for steam, solvent and vacuum systems, in a wide range of materials, including stainless steel, low alloy, Duplex or Super Duplex, Inconel, Hastelloy, Monel, nickel, copper, 904L, Alloy 20, and carbon steel. Its shops are ASME U, U2, R Stamp Certified, and equipment can also be delivered with CE certification according to the Pressure Vessel Directive. Heat exchangers have been fabricated with 4.4-m dia. and 27-m lengths, covering pressures up to 105 kg/cm^{2}g and temperatures to 6,000°C. — *Dipesh Engineering Works, Mumbai, India*
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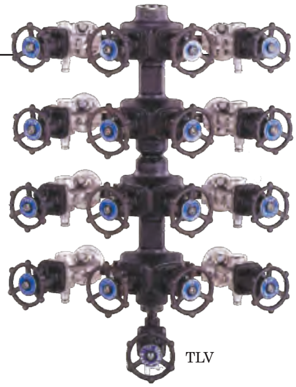

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www.spirax.com

This all-in-one system features a small footprint
This tracing manifold, trap station and condensate manifold system using the new M Series compact and high-performance steam tracing and condensate systems (photo) reduces design and specification time on tracing projects, says the manufacturer. Longterm maintenance and replacement costs can be minimized because the M-Series, pre-engineered manifolds, V-Series bellows-sealed valve stations and QuickTraps are built to last. Design features include a high-durability forged-carbon-steel body and built-in, stellite-hardened bellows sealed valves designed for 3,000 duty cycles, which help conserve energy and improve safety by eliminating steam leaks. Compact design and fewer welds mean less potential leak points and less non-destructive examination checks. A fully outfitted M-Series can have a footprint as small as 18-in. wide. — *TLV Corp., Charlotte, N.C.*
www.tlv.com ■

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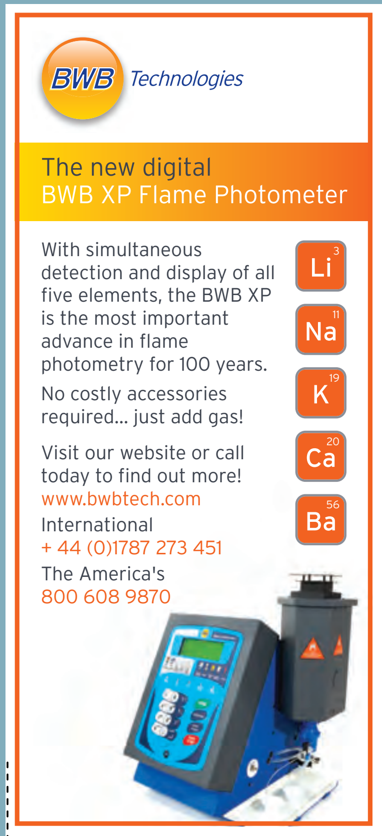

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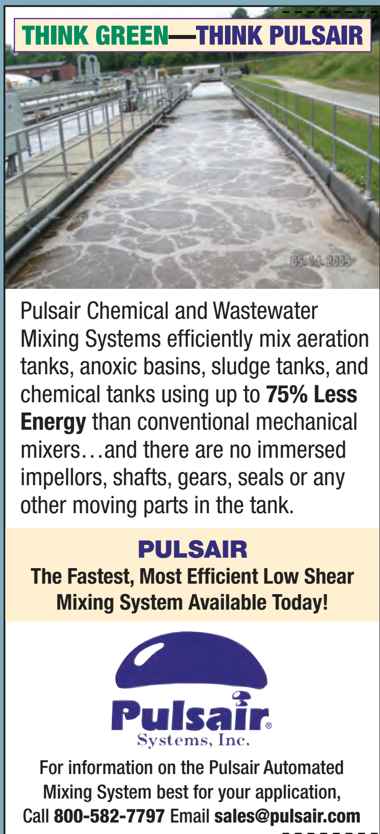

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11 Rubber & Misc. Plastics
12 Stone, Clay, Glass, Ceramics
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14 Engineering, Design & Construction Firms
15 Engineering/Environmental Services
16 Equipment Manufacturer
17 Energy incl. Co-generation
18 Other____________

JOB FUNCTION

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21 Plant Operations incl. Maintenance
22 Engineering
23 Research & Development
24 Safety & Environmental
26 Other____________

EMPLOYEE SIZE

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29 10 to 49 Employees
30 50 to 99 Employees
31 100 to 249 Employees
32 250 to 499 Employees
33 500 to 999 Employees
34 1,000 or more Employees

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42 Heat Transfer/Energy Conservation Equipment
43 Instrumentation & Control Systems
44 Mixing, Blending Equipment
45 Motors, Motor Controls
46 Piping, Tubing, Fittings
47 Pollution Control Equipment & Systems
48 Pumps
49 Safety Equipment & Services
50 Size Reduction & Agglomeration Equipment
51 Solids Handling Equipment
52 Tanks, Vessels, Reactors
53 Valves
54 Engineering Computers/Software/Peripherals
55 Water Treatment Chemicals & Equipment
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57 Chemicals & Raw Materials
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59 Compressors

1	16	31	46	61	76	91	106	121	136	151	166	181	196	211	226	241	256	271	286	301	316	331	346	361	376	391	406	421	436	451	466	481	496	511	526	541	556	571	586
2	17	32	47	62	77	92	107	122	137	152	167	182	197	212	227	242	257	272	287	302	317	332	347	362	377	392	407	422	437	452	467	482	497	512	527	542	557	572	587
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13	28	43	58	73	88	103	118	133	148	163	178	193	208	223	238	253	268	283	298	313	328	343	358	373	388	403	418	433	448	463	478	493	508	523	538	553	568	583	598
14	29	44	59	74	89	104	119	134	149	164	179	194	209	224	239	254	269	284	299	314	329	344	359	374	389	404	419	434	449	464	479	494	509	524	539	554	569	584	599
15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	360	375	390	405	420	435	450	465	480	495	510	525	540	555	570	585	600

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BUSINESS NEWS

PLANT WATCH

Spheripol process technology is chosen for new PP plant in China

September 15, 2010 — LyondellBasell's (Rotterdam, The Netherlands; www.lyondellbasell.com) Spheripol process technology has been selected by Pucheng Clean Energy Chemical Co. for a new 400,000-ton/yr polypropylene (PP) plant to be built in Pucheng County in the Peoples Republic of China. Startup is planned for 2013.

Veolia to deliver water treatment technologies to beverage company

September 3, 2010 — Veolia Water Solutions & Technologies (VWS; Saint Maurice, France; www.veoliawaterst.com) has been awarded a contract by a major beverage producer to provide process water-treatment technologies for an additional CDS (carbonated soft drinks) production site on existing manufacturing facilities in Vietnam. The technologies will include a high-end reverse osmosis system for CSD water-treatment installation, with a treatment capacity of 25 m^3/h. Additional technologies will include iron reduction, sand and activated-carbon filtration.

Solvay increases fluoroelastomer production capacity

September 2, 2020 — Solvay S.A. (Brussels, Belgium; www.solvay.com) has decided to increase the production capacity for peroxide-curable fluoroelastomers in the Solvay Solexis plant at Spinetta Marengo, Italy. Solvay is investing €10 million in the capacity increase, which is expected to start producing in the first half of 2012.

Outotec to build iron-ore sinter plant for SAIL in India

September 2, 2010 — Outotec Oyj (Espoo, Finland; www.outotec.com) has won an order from Steel Authority of India Ltd (SAIL) for an iron-ore sinter plant for SAIL's Bhilai Steel Plant in Chhattisgarh. The new sinter plant is part of SAIL's program of expanding the annual capacity of the Bhilai Steel Plant to 7-million metric tons (m.t.) of crude steel. Outotec's scope includes technical services for a sinter plant with a capacity of 3.7-million m.t./yr. The new plant is expected to become operational in 2012.

Hangzhou Hangding Nylon orders PA-6 plant

September 2, 2010 — Uhde Inventa-Fischer (Domat/Ems, Switzerland, and Berlin, Germany; www.uhde-inventa-fischer.com) and Hangzhou Hangding Nylon Tech. Co., a company under Sanding Holding Group, Zhejiang Province, P.R. China, have signed a contract for the delivery of a PA-6 polymerization plant to produce 47,000 m.t./yr of textile grade chips, based on Uhde Inventa-Fischer's technology. Startup of the plant is planned before Chinese New Year 2012.

KBR lands contract for LiOH-operation expansion

August 31, 2010 — KBR Inc. (Houston; www.kbr.com) has been awarded a contract to provide engineering and procurement services to Chemetall Foote Corp. (www.chemetalllithium.com) — a subsidiary of Rockwood Holdings, Inc.— for the addition of lithium hydroxide production at its current operation in Kings Mountain, N.C. The project is funded in part by a $28.4 million grant from the U.S. Department of Energy (DOE; Washington, D.C.; www.energy.gov) to expand and upgrade the production of lithium materials for advanced transportation batteries. The project is expected to be completed by the end of 2011.

SABIC signs alcohol-technology licensing agreement

August 30, 2010 — Saudi Basic Industries Corp. (SABIC; Riyadh, Saudi Arabia; www.sabic.com) has signed an agreement with Lurgi GmbH (Frankfurt, Germany; www.lurgi.com), for the technology licensing and engineering that will allow SABIC to produce oleo-chemicals at its affiliate, Saudi Kayan Petrochemical Co., following the completion of new facilities to be constructed in Jubail, Saudi Arabia. Startup of the new production line is planned for the end of 2013 and will utilize renewable feedstock technology. The new oleo-chemical plant is said to be the first of its type in the Middle East. The complex will be designed for the production of 83,000 ton/yr of distilled natural alcohols.

Shell and Cosan sign JV for ethanol production

August 25, 2010 — A $12-billion joint venture (JV) between Shell International Petroleum Co. (Shell; The Hague, The Netherlands; www.shell.com) and Cosan S.A. (Cosan; Brazil; www.cosan.com.br/) moved closer to reality when the two companies signed binding agreements. The proposed JV, which still requires regulatory approval, will produce and commercialize ethanol and power from sugar cane and distribute a variety of industrial and transportation fuels through a combined distribution and retail network in Brazil. With an annual production capacity of over 2 billion liters, the proposed JV will be one of the world's largest ethanol producers.

MERGERS AND ACQUISITIONS

JGC and Abengoa Solar to jointly own two CSP plants in Spain

September 3, 2010 — JGC Corp. (Yokohama, Japan; www.jgc.co.jp) and Abengoa Solar (Seville, Spain; www.abengoasolar.com) have formed a partnership to own two 50-MW concentrating solar power (CSP; for more on CSP technology, see Solar's Second Coming, *CE*, March 2009) plants in El Carpio (Córdoba), Spain. Abengoa Solar, which will operate both facilities, will retain control of the project with a 74% stake. The power plants will be the first commercial CSP plants invested in by any Japanese company. The two 50-MW CSP plants represent a total investment of more than €500 million. The two 50-MW CSP plants, which are already under construction by the Abengoa companies Abener and Teyma, are expected to start their commercial operation in early 2012.

Lonza enters viral-based manufacturing with Vivante GMP Solutions acquisition

August 30, 2010 — Lonza (Basel, Switzerland; www.lonza.com) has purchased Vivante GMP Solutions, Inc. (Houston; www.vivante-gmp.com). The acquisition advances Lonza's strategy to broaden its biologics custom-service offering for the growing viral vaccine and gene therapy markets. Vivante's employees have joined Lonza and will operate as Lonza's Viral-Based Therapeutics Business.

Eka Chemicals divests water-treatment chemical site

August 27, 2010 — Eka Chemicals AB (Bohus, Sweden; www.akzonobel.com/eka) has agreed to divest its water-treatment-chemicals production activities located in Vetlanda, Sweden, to Feralco Nordic AB (www.feralco.com). The polyaluminum chloride products produced at this site are used for a number of flocculation applications both within the pulp-and-paper industry and by various municipalities. This divestment does not involve any of Eka Chemicals' other water treatment activities. ■

Dorothy Lozowski

FOR ADDITIONAL NEWS AS IT DEVELOPS, PLEASE VISIT WWW.CHE.COM

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Economic Indicators

2010 | 2009 | 2008

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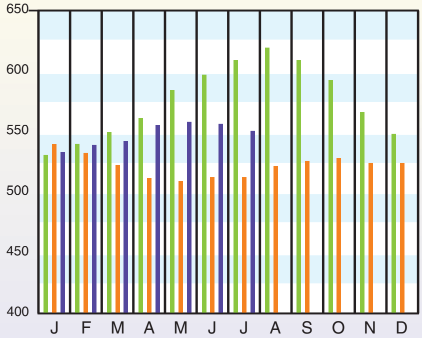
CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957-59 = 100)	July '10 Prelim.	June '10 Final	July '09 Final
***CE* Index**	550.7	556.4	512.1
Equipment	659.2	668.1	601.2
Heat exchangers & tanks	611.1	628.7	542.8
Process machinery	626.0	632.1	589.8
Pipe, valves & fittings	821.7	818.5	732.1
Process instruments	416.8	419.4	387.8
Pumps & compressors	902.4	898.4	898.5
Electrical equipment	481.6	482.2	459.1
Structural supports & misc	679.7	697.5	615.9
Construction labor	328.5	326.7	327.5
Buildings	506.5	509.4	487.0
Engineering & supervision	338.4	339.1	346.5

Annual Index:
2002 = 395.6
2003 = 402.0
2004 = 444.2
2005 = 468.2
2006 = 499.6
2007 = 525.4
2008 = 575.4
2009 = 521.9

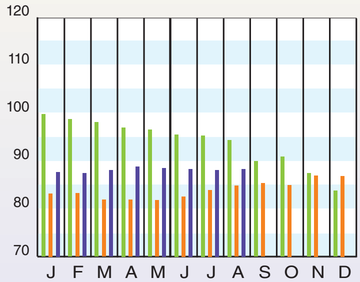
Starting with the April 2007 Final numbers, several of the data series for labor and compressors have been converted to accommodate series IDs that were discontinued by the U.S. Bureau of Labor Statistics



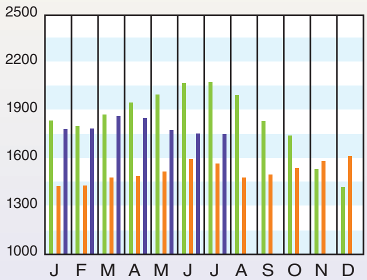
CURRENT BUSINESS INDICATORS

	LATEST			PREVIOUS						YEAR AGO		
CPI output index (2007 = 100)	Aug. '10	=	88.3	Jul. '10	=	88.1	Jun. '10	=	88.3	Aug. '09	=	84.8
CPI value of output, $ billions	Jul. '10	=	1,754.3	Jun. '10	=	1,756.4	May. '10	=	1,780.7	Jul. '09	=	1,570.0
CPI operating rate, %	Aug. '10	=	71.4	Jul. '10	=	71.1	Jun. '10	=	71.3	Aug. '09	=	67.4
Producer prices, industrial chemicals (1982 = 100)	Aug. '10	=	260.3	Jul. '10	=	258.7	Jun. '10	=	267.7	Aug. '09	=	241.0
Industrial Production in Manufacturing (2007=100)	Aug. '10	=	90.6	Jul. '10	=	90.5	Jun. '10	=	89.8	Aug. '09	=	85.3
Hourly earnings index, chemical & allied products (1992 = 100)	Aug. '10	=	153.6	Jul. '10	=	153.1	Jun. '10	=	153.7	Aug. '09	=	149.0
Productivity index, chemicals & allied products (1992 = 100)	Aug. '10	=	118.7	Jul. '10	=	119.9	Jun. '10	=	120.8	Aug. '09	=	119.7

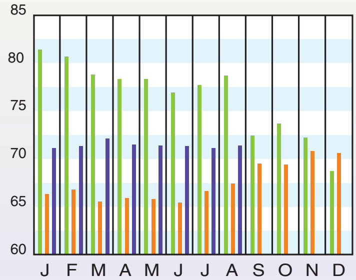
CPI OUTPUT INDEX (2007 = 100)



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



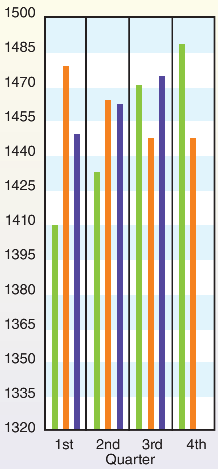
Current Business Indicators provided by Global Insight, Inc., Lexington, Mass.

MARSHALL & SWIFT EQUIPMENT COST INDEX

(1926 = 100)	3rd Q 2010	2nd Q 2010	1st Q 2010	4th Q 2009	3rd Q 2009
M & S INDEX	1,473.3	1,461.3	1,448.3	1,446.5	1,446.4
Process industries, average	1,534.4	1,522.1	1,510.3	1,511.9	1,515.1
Cement	1,530.0	1,519.2	1,508.1	1,508.2	1,509.7
Chemicals	1,505.2	1,493.5	1,481.8	1,483.1	1,485.8
Clay products	1,518.3	1,505.6	1,496.0	1,494.3	1,495.8
Glass	1,428.5	1,416.4	1,403.0	1,400.1	1,400.4
Paint	1,542.1	1,527.6	1,515.1	1,514.1	1,515.1
Paper	1,444.5	1,430.1	1,416.4	1,415.8	1,416.3
Petroleum products	1,637.0	1,625.9	1,615.6	1,617.6	1,625.2
Rubber	1,579.3	1,564.2	1,551.0	1,560.5	1,560.7
Related industries					
Electrical power	1,419.2	1,414.0	1,389.6	1,377.3	1,370.8
Mining, milling	1,576.7	1,569.1	1,552.1	1,548.1	1,547.6
Refrigeration	1,804.8	1,786.9	1,772.2	1,769.5	1,767.3
Steam power	1,502.3	1,488.0	1,475.0	1,470.8	1,471.4

Annual Index:

2002 = 1,104.2	2004 = 1,178.5	2006 = 1,302.3	2008 = 1,449.3
2003 = 1,123.6	2005 = 1,244.5	2007 = 1,373.3	2009 = 1,468.6



CURRENT TRENDS

Capital equipment prices (as reflected in the *CE* Plant Cost Index) declined for the second consecutive month in July, an unusual phenomenon given that equipment prices typically peak around August of each year. According to IHS Global Insight, Inc., prices for most carbon steel products are likely to see subdued increases in September, small declines in October and sharp drops in the following months.

Meanwhile, Current Business Indicators from IHS Global Insight show that the CPI operating rate rebounded in July from its June setback.

Visit www.che.com/pci for more on capital cost trends and methodology ■

Circle 41 on p. 66 or go to adlinks.che.com/29255-41