CHEMICAL ENGINEERING

March 2011

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Batch Control

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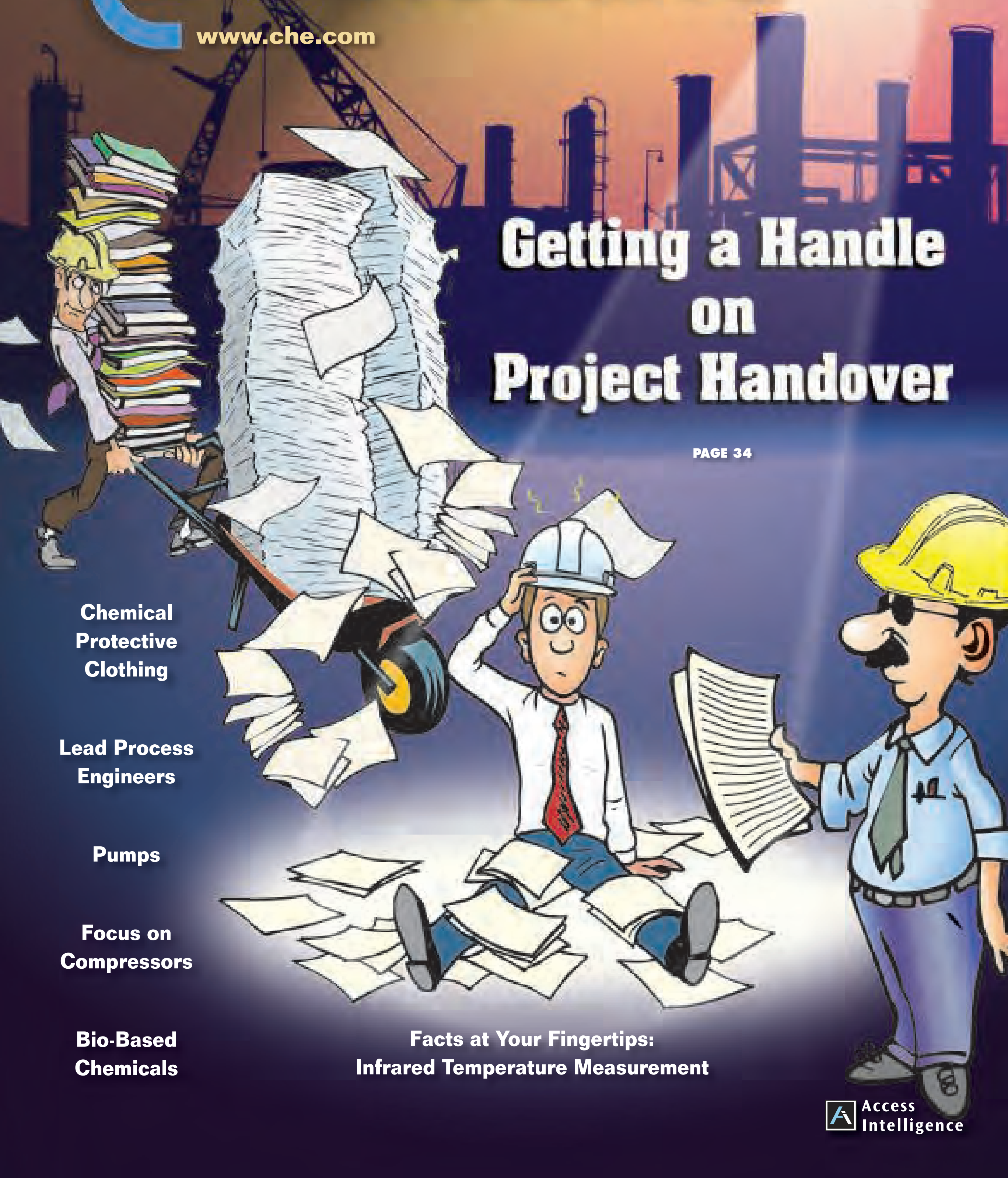

Getting a Handle on Project Handover

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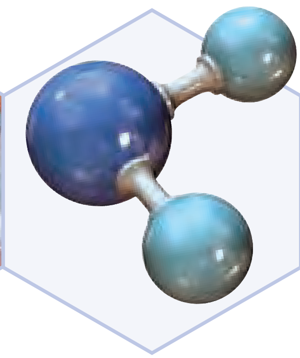

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Editor's Page

It's the IYC. Plug in. Reach out.

The United Nations (U.N.) has named 2011 the International Year of Chemistry (IYC). The designation has given rise to a host of programs, initiatives and events, the collection of which has afforded the chemical community a unique opportunity to pursue the IYC's stated goals of increasing public appreciation of, interest in and enthusiasm for chemistry. Leading the yearlong effort are the U.N. Educational Scientific and Cultural Organization and the International Union of Pure and Applied Chemistry, in collaboration with a host of professional societies, institutions and chemical companies around the globe.

While large international organizations may be crucial in providing the IYC's framework, the year's ability to effect lasting change rests squarely on the shoulders of passionate individuals. The degree to which individuals from the chemical process industries (CPI) engage and participate at the local, regional and national levels will largely determine whether the IYC becomes a transformative force in improving science policy and education, or a historical sidenote.

The North American launch of the IYC, hosted by the Chemical Heritage Foundation (www.chemheritage.org) in Philadelphia last month, represented a call to action for chemical professionals of all types to contribute to the broader IYC effort of raising public awareness of the power, promise and wonder of chemistry and chemical technology. The launch featured a group of esteemed panelists assembled to discuss the central role chemistry will play in addressing the most challenging issues of our planet, including providing energy, food, water and healthcare for a growing global population. Panelist Andrew Liveris, Dow Chemical Co. (Midland, Mich.; www.dow.com) CEO, was among those calling on attendees to seize the opportunity this year to be advocates for change. He also maintained that generating dialogue on chemistry's role in society was important, and argued that the chemical industry should insert itself more fully and more frequently into public-policy discussions.

Prior to the event, I spoke with Katie Hunt, Dow's director for innovation sourcing and sustainable technologies, who also emphasized the need for individual initiative in the IYC. "We want to put a human face on chemistry, so we need scientists to be more visible. Scientists are great at talking to each other — what we need to do is get better at talking to everyone else," Hunt said.

Facing the complex challenges associated with sustainably providing energy, food, water and healthcare for the world's growing population is daunting, but Hunt, like the event panelists, clung to optimism. "We have the capability to solve the toughest challenges, but it takes engagement," she said. "We need to train scientists to communicate with science teachers, or to speak to their local communities, or to mentor students, or to educate legislators, all in an effort to make chemistry more accessible and familiar to all, especially to the next-generation of scientists."

Other panelists, including former National Science Foundation director Rita Colwell and event moderator Daniel Nocera, an MIT professor, echoed the importance of communication and early science education.

Many professionals across the CPI were drawn to their chosen profession because of its central and critical role in meeting society's needs for materials, energy, water, food and medicine. Now, those in the chemistry community have a chance to take ownership of chemistry's future by engaging their local communities, inserting the voice of chemistry into the political system, and inspiring future scientists. The IYC website (www.chemistry2011.org) contains a host of opportunities for involvement, as well as a virtual forum to develop ideas for events and programs, and tools to help execute them. So plug in and reach out. ■

Scott Jenkins, Associate Editor

Editor's Page

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Scott Jenkins, Associate Editor

Letters

Good safety article, unsafe photo

In general, I learn a great deal from your publication and the January 2011 issue was no different. However I would like to point out that in the article "Effective Plant Safety Management", the photograph on p. 50 shows a worker in an articulating boom lift without a safety harness. (The worker is wearing a belt, which is no longer allowed unless used only as a positioning device, and could cause serious harm in a fall protection situation). This seems to go against the point of the article, which by the way was excellent.

I realize that the publication is intended for a larger audience than the U.S., but wearing fall protection is law here, and at a minimum it should be considered a best practice globally.

Joshua L. Stockwell, ARM, CSP
Sr. Risk Control Consultant-Construction, Columbus, Ohio

Process pump control

Figure 1 in the Cover Story of the November 2010 issue, Process Pump Control, depicts a centrifugal pump flow control loop with the flow measurement located downstream of the flow control valve. An important part of the pump and controls selection process is the process control design. A more typical approach would be to locate the flow measurement upstream of the flow control valve. Flow characteristics upstream of the valve are generally more conducive to flow measurement than those downstream. Though the article focuses on various aspects of process pump control, there is no discussion of the design considerations associated with the control scheme as specifically depicted in Figure 1.

David Warfield
Houston, TX

Author replies:
The referenced illustration showing the flowmeter downstream of the control valve was labeled "typical centrifugal pump control system," while the reader is correct that an upstream location is "more typical." The focus of the article was to raise awareness of key differences between centrifugal and rotary positive displacement (PD) pump control schemes and to highlight inherent advantages of rotary PD pumps for continuous processes, variable processes, and process scaleup.

John Hall
Product Manager, Viking Pump — A Unit of IDEX Corp.

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Patents for Chemicals, Pharmaceuticals and Biotechnology: Fundamentals of Global Law, Practice and Strategy, 5th ed. By Philip Grubb and Peter Thomsen. Oxford University Press-USA. 198 Madison Avenue, New York, NY 10016. Web: oup.com. 2010. 592 pages. $235.00.

Reviewed by Daniel H. Miller, Esq.
Attorney-at-Law, Reston, Va.

This book examines global patent law as it affects the chemical, biological and pharmaceutical industries. Rather than taking a legal case-study approach, it provides a practical discussion of everyday issues and decisions faced by global patent practitioners in these complex industry segments. Focusing mainly on the patent systems in the U.S., U.K. and Japan, the five-section book effectively summarizes the practical utility of the Patent Cooperation Treaty (PCT) international application process, as well as the domestic filing procedures for each region.

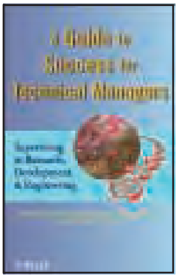
Despite its status as a global patenting text, the book does not address in any depth the Chinese market as it relates to intellectual property rights. Perhaps the exclusion of detailed discussion of patenting in China reflects a view that the value of spending money on patenting and patent enforcement in that region is questionable.

Part I provides a good summary of the history and the rise of the patent system, and discusses the recent push toward international harmonization of patent laws. Part II explores the life of a patent and the procedures necessary to obtain and maintain valid patent rights in the U.S. and U.K. markets. Although the section offers a good overview of the process and timeframes required, an experienced practitioner may need a more-detailed discussion. For example, the important topic of restriction practice deserved more detailed coverage, including reasons for why restriction occurs. Also, given the increased use of PCT international filings, the reader would benefit from a discussion of the differences among entering via a national stage application, claiming priority from a PCT filing, and a traditional U.S. filing.

Part III comprises chapters discussing industry-specific patent issues, including the unique requirements that arise for genes, plants and animal-related developments. This informative section addresses specific hurdles for patenting technologies from polymers to genetically altered animals.

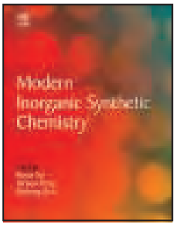
Among the most useful sections is Part IV, which details patent applications and obtaining a patent, including how to write specifications (patent descriptions) and claims. These topics are particularly useful, as many patenting texts exist without finding such practical gems. The final section deals with ownership of the patent, issues that arise with transfer of ownership and co-ownership, infringement and licensing agreements. The section on licensing is particularly strong for its discussion of strategies for cross-licensing, including specific details such as types of clauses to consider or exclude from a particular licensing agreement.

While not a how-to book, the authors provide an excellent compilation of practical strategies and "best practices" that leave the reader with a sense of the internal workings of a seasoned, professional global-patent practitioner who is tackling complex patent issues in the chemical, biological, and pharmaceutical industry — a rare treat.



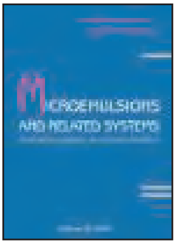
A Guide to Success for Technical Managers: Supervising in Research, Development & Engineering. By Elizabeth Treher, David Piltz and others. John Wiley & Sons Co., 111 River St., Hoboken, NJ 07030. Web: wiley.com. 2010. 318 pages. $59.95.

Diffusion-controlled Solid-State Reactions: In Alloys, Thin Films and Nanosystems. By Andriy Gusak, T.V. Zaporozhets and others. John Wiley & Sons Co., 111 River St., Hoboken, NJ 07030. Web: wiley.com. 2010. 498 pages. $200.00.



Modern Inorganic Synthetic Chemistry. Edited by Ruren Xu, Wenqin Pang and Qisheng Huo. Elsevier Inc., 30 Corporate Drive, 4th floor, Burlington, MA 01803. Web: elsevier.com. 2010. 590 pages. $325.00.

Successful Sealing with Elastomers. By the European Sealing Association. ESA, Tegfryn Tregarth, Gwynedd LL57 4PL, U.K. Web: europeansealing.com. 2010. E-book. $61.59.



Microemulsions and Related Systems: Formulation, Solvency and Physical Properties. Edited by M. Bourrel and Robert Schechter. Editions Technip, 25 rue Ginoux, 75015 Paris. Web: editionstechnip.com. 2010. 420 pages. $224.00.

The Art of Process Chemistry. Edited by Nobuyoshi Yasuda. John Wiley & Sons Co., 111 River St., Hoboken, NJ 07030. Web: wiley.com. 2010. 298 pages. $205.00.

Modern Electroplating. By Mordechay Schlesinger. John Wiley & Sons Co., 111 River St., Hoboken, NJ 07030. Web: wiley.com. 2010. 736 pages. $149.95.

Corrosion Resistance of Aluminum and Magnesium Alloys. By Edward Ghali and R. Winston Revie. John Wiley & Sons Co., 111 River St., Hoboken, NJ 07030. Web: wiley.com. 2010. $149.95.

Ullman's Encyclopedia of Industrial Chemistry, 7th ed. Edited by Barbara Elvers and others. John Wiley and Sons Co., 111 River St., Hoboken, NJ 07030. Web: wiley.com. 2010. $10,490.00. ■

Scott Jenkins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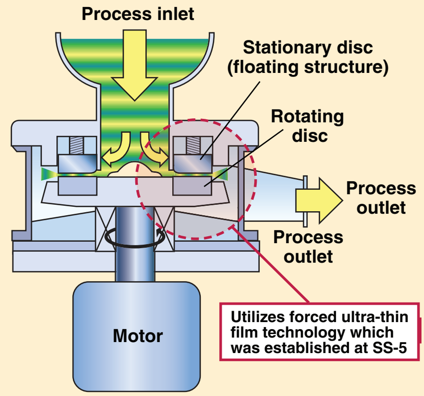
Chementator

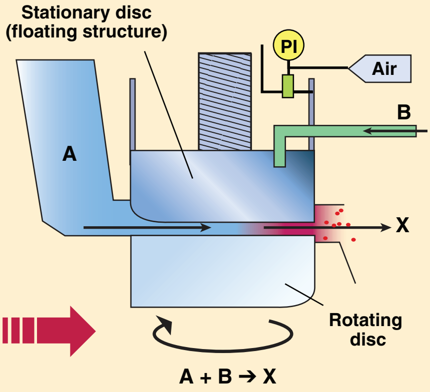
Edited by Gerald Ondrey March 2011

A scaled up microreactor for mass production

M Technique Co. (M Tech; Osaka, Japan; www.m-technique.co.jp) has commercialized the Ulrea SS-300, a scaled up version of the Ulrea SS-11 — a forced thin-film microreactor. With a production capacity nearly ten times higher than its predecessor, the Ulrea SS-300 is suitable for mass production of organic, inorganic and biochemicals as well as for producing micro- and nanoparticles and crystals.



Ultra-thin high-shear disperser (breakdown: SS-5)



Forced thin-film reactor (reaction and buildup: Ulrea SS-11)

The Ulrea technology is based on the company's Clear SS-5 dispersion system (diagram, left), which consists of two facing, ring-shaped discs. In the Ulrea, the stationary disc has been modified to allow introducing a second reactant (B) into the thin film of reactant A (diagram, right). Mixtures are forcefully dispersed between the two discs, one of which is stationary but free to float on the fluid film, and the other disc is rotated at high speed (about 300–3,600 rpm). The high shear stress generated in the boundary layer (a few microns thickness) results in ultra precise dispersions emerging from between the discs.

Unlike alternative microchannel reactors, the Ulrea does not clog due to the rotating disc, which leads to a self-discharge of any solids that may build up, says Daisuke Honda a researcher at the company's R&D dept. The floating structure allows the reactor to utilize much smaller reaction flow channels (1–30 µm versus 50–500 µm for conventional microreactors), which leads to improved mass and heat transfer (and thus better reaction control). The system is also said to be easier to scale up, says Honda.

The discs of the Ulrea SS-300 have a 30-cm dia., and the company is now developing a 70-cm-dia. version for even higher capacities. In addition to performing reactions, the Ulrea can also be used for fabricating spherical micro- and nanoparticles of metals (Ni, Cu and Pt) Pt-Pd alloys, metal oxides and pigments.

Vegetable-oil-based chemicals plant soon to be fully operational

In spring of this year, Archer Daniels Midland Co. (ADM; Decatur, Ill.; www.adm.com) plans full operation of a chemical plant based on soybean and canola oils as renewable feedstock. Products of the plant will include refined glycerin, propylene glycol and ethylene glycol.

Crude vegetable-derived oils are obtained through a process in which soybeans and canola seeds are crushed, dehulled and conditioned, and vegetable oil is extracted. The crude vegetable oil is refined, and a transesterification process generates crude biodiesel fuel and glycerin. A series of distillation and evaporation steps yields glycerin that meets U.S. Pharmacopeia specifications for purity.

The glycerin can also be subjected to a catalytic hydrogenolysis process to produce propylene glycol (PG), the first renewable route to a chemical with both industrial uses — such as engine coolants, antifreeze, paints and coatings, and liquid detergents — as well as high-purity uses in personal care products, food flavorings and in pharmaceutical excipients.

Key to the development of the renewable PG process was a selective catalyst for converting glycerin to PG that was licensed by ADM from Pacific Northwest National Laboratory (Richland, Wash.; www.pnl.gov).

ADM designed its new plant with an annual manufacturing capacity of 100,000 metric tons (m.t.) of bio-based PG, which will be priced competitively compared to petroleum-derived PG, says Paul Bloom, ADM's business director for evolution chemicals.

CO_2 for plastic

Last month, a pilot plant that produces an intermediate for polyurethane, using carbon dioxide as feedstock, started up at Chempark Leverkusen, Germany. The plant — designed, built and operated by Bayer Technology Services GmbH (Leverkusen; www.bayertechnology.com) — is part of the so-called Dream Production project, a €9-million collaboration between Bayer, RWE Power, RWTH Aachen University and the CAT Catalytic Center (which is run jointly by RWTH and Bayer). The kilogram-scale pilot plant features a proprietary zinc-based catalyst developed by scientists at Bayer and the CAT center. If the testing phase goes well, industrial production of CO_2-based plastics should start in 2015, says Bayer.

CO_2 for urea

Mitsubishi Heavy Industries, Ltd. (MHI; Tokyo, Japan; www.mhi.co.jp) has signed a license agreement for CO_2-recovery technology with National Fertilizers Ltd. (NFL; Noida, India; www.nationalfertilizers.com). NFL will use the technology to increase urea production at its existing Vijaipur Plant in Guna District, Madhya Pradesh State. The CO_2-recovery plant

(*Continues on p. 12*)

Note: For more information, circle the 3-digit number on p. 62, or use the website designation.

Improved ethylene-oxide scrubber design can meet stringent regulations

Improvements in the design of ethylene oxide (EtO) scrubbers made by The Clean Air Group, Croll Reynolds Co. (Parsippany, N.J.; www.croll.com) have helped users meet increasingly stringent regulations for EtO emissions, as well as meet tower height restrictions. "Our designs have achieved efficiencies of 99.99% or greater for removal of ethylene oxide, compared to 99–99.9% with alternative technologies," says Carolyn Byszewski, manager of The Clean Air Group.

The highly flammable and corrosive EtO — the simplest epoxide — is used as a raw material for manufacturing a range of personal care products, as well as a sterilization agent in healthcare settings. Environmental regulations on EtO emissions from chemical producers and sterilizers have tightened in many areas because of EtO's carcinogenic and teratogenic properties. To eliminate it, EtO undergoes acid-catalyzed hydrolysis to form ethylene glycol in a scrubber.

Croll Reynolds offers designs with efficient tower packing that maximizes contact between the contaminated gas and the scrubbing liquid, as the downward-flowing, scrubbing liquid meets the upward-flowing, EtO-containing gas. The company's scrubber designs allow hydrolysis to occur at ambient (or lower) temperatures in the reactor tank, which reduces the reactor tank size and avoids interruption of the scrubbing process.

Croll Reynolds has developed a continuous split-column design that is capable of meeting the strictest EtO regulations without breaking local-zoning tower-height regulations. The split-column tower makes use of coordinated, automatic control valves to allow lower-profile tower heights of below 25 ft, as opposed to 40–45 ft in a single-column tower of equivalent efficiency. The company has also invented proprietary reactor technology to minimize back-mixing of unhydrolyzed liquid with reacted material.

(*Continued from p. 11*)

is scheduled for completion in June, 2012.

MHI's proprietary KS-1 solvent will be used to recover CO_2 from fluegas released at the fertilizer production process, which uses natural gas as fuel. The captured CO_2 (99% purity) will be used as feedstock for urea synthesis from ammonia. The KS-1 solvent was jointly developed by MHI and Kansai Electric Power Co. (Osaka, Japan). The CO_2 recovery plant will utilize MHI's KM CDR process (*CE*, January 2008, p. 12), which captures approximately 90% of the CO_2 from fluegas. Tecnimont ICB Pvt. Ltd. (Mumbai, India; www.ticb.com) will construct the plant.

CO_2 capture

A new high-pressure process for removing CO_2 from natural gas has been tested in a joint

(*Continues on p. 14*)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Graphene improves the performance of water deionization

A research team from the University of South Australia (Adelaide; www.unisa.edu.au) and the East China Normal University (Shanghai; www.ecnu.edu.cn) has developed a capacitive deionization technology (CDI) that uses graphene-like nanoflakes as electrodes, instead of conventionally used activated carbon (AC) materials. The team claims that the graphene-based electrodes offer better performance than conventional CDI systems that use AC electrodes.

In CDI, water flows between pairs of electrodes held at a potential difference of 1–2 V. The negative electrode attracts and holds positively charged ions such as calcium, magnesium and sodium, while the positively charged electrode attracts and holds negative ions such as chloride, nitrate and silica. When the electrodes become saturated, the applied potential is removed, and the ions are released and flushed out. For each gallon of brackish water fed to the process, more than 80% emerges as fresh, deionized potable water. Compared to alternative desalination methods, CDI does not generate secondary pollution, and is cost-effective and energy efficient because it aims to remove only the salt ions, which are a small percentage of the feed solution.

"Although having a larger surface area (989.54 m^2/g) than graphene nanoflakes (222.01 m^2/g), AC has a much lower electrosorptive capacity, 13.73 µmol/g, compared with 23.18 µmol/g for graphene nanoflakes," says team member Linda Zou of the University of South Australia. The team believes graphene nanoflakes have a larger effective surface area than that of AC because the nanoflakes have an interlayer surface that is more accessible to ions, while AC has a large fraction of inaccessible micropores. Another possible reason for the high conductivity of graphene nanoflakes, the team believes, is the presence of conductive graphitized chunks in the nanoflakes, caused by the incomplete graphene preparation from the graphite precursor.

(Continued from p. 12)

collaboration of BASF SE (Ludwigshafen, Germany; www.basf.com), JGC Corp. (Yokohama; www.jgc.co.jp) and Inpex Corp. (Tokyo, both Japan; www.inpex.co.jp). The tests — carried out at Inpes's Koshijihara natural-gas plant in Nagaoka city — demonstrated the performance of the new gas-treatment process, which is said to enable a 25–35% reduction in the cost of CO_2 recovery and compression. The HiPact Process (high-pressure, acid-gas capture technology) is a joint development of BASF and JGC.

Heat transfer by wire

Scientists at Fractal Antenna Systems Inc. (Waltham, Mass.; www.fractenna.com) have demonstrated a new method of heat transfer based on a complex pattern of fractals built into an infrared (IR) resonator. Fractal

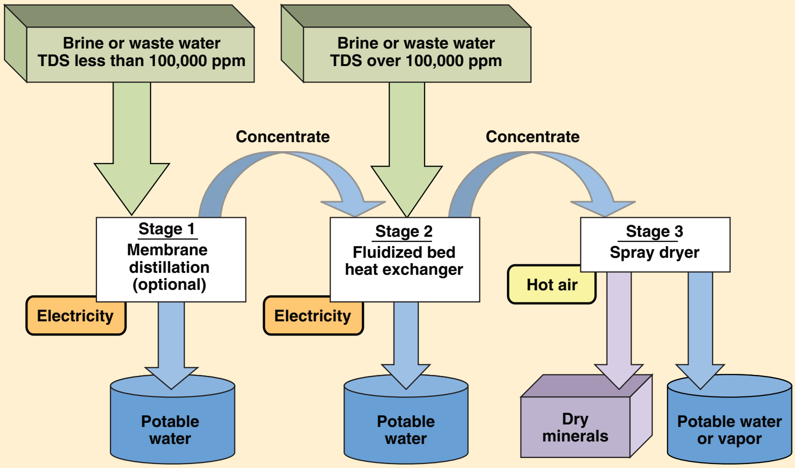
(Continues on p. 16)

Zero-liquid-discharge desalination system offers brine disposal alternative

A desalination system developed by Watervap LLC (Marble Hill, Ga.; www.h2ovap.com) separates saltwater of any concentration into highly purified water and dry solid minerals with high efficiency. The company's Zero Liquid Discharge (ZLD) process represents a low-cost alternative to brine waste disposal in oil and natural gas production, as well as other industries, such as processed meats and mining.

Oil and gas producers typically transport waste saltwater to deep-well injection sites for disposal, adding $3–8/bbl in production cost. The ZLD system offers a way to generate re-usable or saleable dry minerals and water, or to drastically reduce volumes of saltwater requiring transport, explains Watervap co-founder Robert Wright.

The three-stage ZLD process employs field-tested, off-the-shelf components and a proprietary fluidized-bed heat exchanger (FBHX) system to convert 95–97% of the original saltwater volume to purified water and dry salt. The heat exchanger is designed to handle salt water with total dissolved solids (TDS) concentrations from 50,000 to 350,000 ppm. As salt solution enters the FBHX, the process takes advantage of the solution's inverse solubility property to crystallize salt inside vertical tubes. "With a self-scouring design, the heat exchanger prevents fouling in the tubes even at high-TDS levels," says Watervap co-founder Robert Wright.



The heated mixture of crystallized solids and liquid is then transferred to a specialized flash evaporator, where additional fresh water vapor is separated. A vacuum compressor converts the generated vapor to a hot liquid, which is used to heat fluid entering the FBHX. The highly concentrated solution exiting the FBHX is then sprayed into a chamber with heated airflow, where the remaining water is vaporized.

Watervap's patented technology has been demonstrated in a 2,500-gal/d unit, and the company hopes to license its technology.

A new catalyst for C-C and crossed-coupling

Tokyo Chemical Industry Co. (TCI; Tokyo; www.tokyokasei.co.jp) is planning full-scale production of a new palladium-complex catalyst, trade-named SingaCycle-E1, for performing Heck-Mizoroki carbon-carbon coupling reactions and the Suzuki-Miyaura cross-coupling reaction — both reactions of importance for producing pharmaceuticals. TCI says SingaCycle-E1 offers enhanced activity and improved stability over conventional catalysts used for such reactions, and believes the catalyst may also be used for electronic materials.

Developed in collaboration with the National Public Research Institute of Singapore (www.nus.edu.sg), SingaCycle-E1 — Chloro[(1,3-dimesitylimidazol-2-ylidene)(*N,N*-dimethylbenzylamine)palladium(II)] — has two ligands. One is *N*-hetero cyclic carbene (NHC), a highly-active and robust ligand widely used in the cross-coupling reactions. The other is a palladacycle ligand containing an elimination unit formed when the catalyst is activated. The catalyst performance is optimized by adjusting the combination of NHC ligand and the ligand to be eliminated from palladacycle.

The company says the catalyst is stable and easy to handle in atmospheric condition, and could be used over a wide range of scales, from laboratory to commercial mass-production. Storage stability is also good. The catalyst is soluble in many organic solvents, slightly soluble in acetonitrile, methanol and acetone, and is insoluble in aliphatic hydrocarbons. Solutions of the catalyst can be stored for at least two weeks, says TCI.

(*Continued from p. 14*)

shapes are built by scaled repetitions of a simple pattern. By juxtaposing the fractal resonators on a layered grid, the team was able to generate surface waves that transfer IR energy. Although related to conventional radiative heat transfer, this new method exploits the coupling of surface waves, and so can be easily redirected, where radiative heat cannot. The work demonstrates the possibility of transferring heat analogous to the way electric current is conducted on a wire, without the delays associated with heat capacities and cooling rates, says the company, adding that efficient fractal metasurface heat transfer is 2–5 years away.

Radiation detection

Engineers from Oregon State University (OSU; Corvallis; www.oregonstate.edu) have developed a new type of radiation detection and measurement device that can be used for cleanup of sites with radioactive contamination. The device may also find applications in monitoring processes in the nuclear energy industry or possibly medical applications using nuclear tracers. Ludlum Instruments (Sweet-

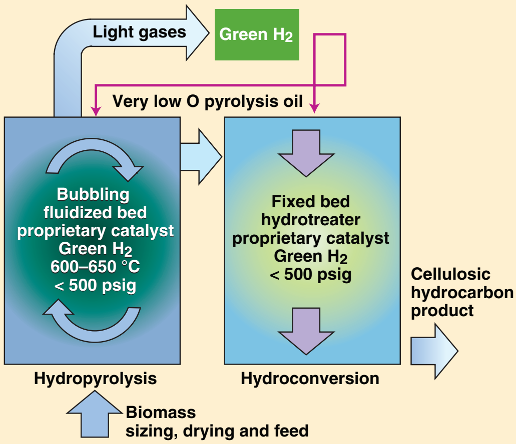
(*Continues on p. 18*)

Scaleup is set for a biomass-to-fuels process

The Gas Technology Institute (GTI, Des Plaines, Ill.; www.gastechnology.org) has signed an exclusive worldwide licensing agreement with CRI/Criterion Inc. (Houston; www.cricatalyst.com) to commercialize a GTI process for converting biomass directly into cellulosic gasoline and diesel fuel blendstocks. The technology, called Integrated Hydropyrolysis and Hydroconversion (IH_2), is a two-step, continuous process that can accept virtually all classes of biomass, says Alan Del Paggio, vice-president upstream and renewables for CRI/Criterion.

In the first step ground biomass is pyrolyzed in a bubbling, fluidized-bed reactor at 600–650°C and 300–500 psig, to produce pyrolysis oil that is a mixture of aromatics and alkanes. Pyrolysis takes place in the presence of hydrogen, which combines with oxygen in the feed to form water, thereby reducing the oxygen content of the pyrolysis oil from 10–40 wt.% to below 0.5 wt.%. The reaction is promoted by a proprietary base-metal catalyst.

Oxygen removal is critical, says Del Paggio, since high levels of oxygen in the product would require further hydrotreating in the refinery, where the resultant water and acidity would cause corrosion. "Green" hydrogen for oxygen removal and for hydrotreating (see below) is obtained by reforming the light gases that exit the top of the reactor, thus avoiding the need to locate a plant near a H_2 source. Del Paggio notes that the pyrolysis step is exothermic, whereas conventional pyrolysis is endothermic and produces highly corrosive oils that contain a significant amount of oxygen and water.



The second step of the IH_2 process is a conventional hydrotreater, which polishes the pyrolysis oil for refinery blendstock. Hydrotreating takes place at 300–500 psig and 100–150°C, using cobalt-molybdenum or nickel-molybdenum catalysts. The operating conditions and catalysts can be tailored to favor the production of higher fractions of gasoline, diesel or jet fuel, says Del Paggio. GTI has tested the process in the laboratory and a 50-kg pilot plant is scheduled to start up in the fall. CRI/Criterion is negotiating with various industries to build and operate demonstration plants prior to commercializing the technology.

Plans move forward for the first U.S. uranium plant in 30 years

Energy Fuels Inc. (Lakewood, Colo.; www.energyfuels.com) has been granted a radioactive materials license by the Colorado Department of Public Health and Environment for the first uranium mill to be built in the U.S. in 30 years. Energy Fuels says the approval of the license is "the most significant hurdle" to be passed before it builds the Piñon Ridge Mill near Naturita, Colo. The company plans to start construction in 2011 and initiate production in 2012.

The 500-ton/d plant will convert ore from two nearby uranium mines (currently in care and maintenance) into about 850,000 lb/yr of yellowcake (U_3O_8) and 3.7 million lb/yr of vanadium pentoxide (V_2O_5). The plant will be a zero-discharge facility, says senior vice president Gary Steele. For example, ore will be milled in a semi-autogenous grinding (SAG) mill, rather than a ball or rod mill, for better emissions control. Also, the tailings ponds will be triple-lined. The liners will consist of two 60-mil sheets of high-density polyethylene (HDPE), backed by a geocomposite clay liner — clay sandwiched between two layers of HDPE.

Otherwise, the process will be conventional. Uranium and vanadium will be leached from the ore by concentrated sulfuric acid. Uranium will be extracted from the acid by a kerosene solvent, then the solvent will be mixed with water to precipitate the metal. Vanadium will be recovered in a similar manner, but at a different pH.

Steele says the plant is a response to the rapidly growing global demand for nuclear fuel for electrical power plants. He adds that at present there is only one operating uranium mill in the U.S. ■

(*Continued from p. 16*)

water, Tex.) was contracted to produce the first instruments, and the OSU Office of Technology Transfer is seeking a licensee for commercial development. The electronics systems for the patented spectrometers will be produced by spinoff company, Avicenna Instruments LLC (Corvallis, Ore.; http://avicennainstruments.com).

Unlike other detectors, the OSU device is more efficient, and is able to quantify both gamma and beta radiation at the same time. Conventional methods require two types of detectors as well as time-consuming chemical tests, says David Hamby, OSU professor of health physics. Accurate results are obtained in 15 min compared to half a day, he says. ❏

BIO-BASED CHEMICALS POSITIONED TO GROW

Whether designed as drop-in replacements to fossil-fuel-derived substances or new formulations altogether, some renewable building blocks are breaking market barriers

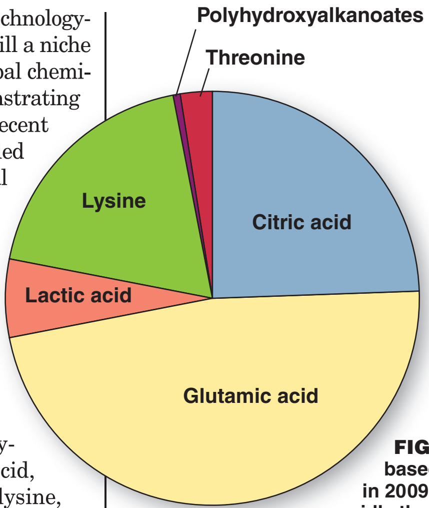


FIGURE 1. Generally, the biotechnology-based chemicals with the least consumption in 2009 (left) are expected to grow the most rapidly through 2014 (Table, below)

WORLD CONSUMPTION OF BIOTECHNOLOGY-BASED CHEMICALS—2009[a]		
Chemical	Quantity (1,000 m.t.)	Average annual growth rate, 2009–2014[a] (%)
Citric acid	1,500–2,000	4.7
Glutamic acid [b]	2,500–3,000	3.9
Lactic acid [c]	350–400	7.2
Lysine [d]	1,000 1,500	3.9
Polyhydroxyalkanoates (PHA)	1–2	>25[e]
Threonine	150–200	5.1

a. Volume basis
b. Calculated as monosodium salt because glutamic acid is mostly consumed as the flavor enhancer monosodium glutamate
c. As lactic acid, its salts and esters
d. As L-lysine hydrochloride
e. Conservative estimate; 2010 production capacity is sufficient to support an average annual growth rate of more than 100%.

Source: SRI Consulting.

The production of biotechnology-based chemicals, while still a niche operation in terms of global chemical production, is demonstrating double-digit growth, says a recent SRI Consulting report*. Enabled by rapid advances in industrial biotechnology and significant increases in the price of crude oil over recent years, the number of biotechnology-based chemicals within the sights of commercial producers is increasing.

The report provides detailed industry and market analysis for six biotechnology-based chemicals — citric acid, glutamic acid, lactic acid, lysine, polyhydroxyalkanoates and threonine. All these chemicals are produced by microorganisms without being challenged by synthetic production routes, have already achieved commercial status, and are considered important chemical building blocks.

The total market of the selected products amounted to 6-million metric tons (m.t.) in 2009 and was valued at about $10 billion, and the value is expected to reach over $12 billion in 2014. Of the six chemicals covered in the report above-average growth is expected for polyhydroxyalkanoates and lactic acid because of increasing demand for biopolymers (Figure 1). The uncertainty in these predictions centers around the familiar catch that current costs of these bio-based chemicals are higher than for their comparable petroleum-derived counterparts. In some applications, renewable and biodegradable properties might be enough to justify higher costs for these completely alternative chemical formulations. For bio-based chemicals that are designed for so-called drop-in applications, however, competitive production economics are far more critical (see box, p. 20–21).

Lactic acid and polylactic acid

The lactic acid business is characterized by a few major producers such as Purac (Gorinchem, the Netherlands; www.purac.com) and NatureWorks (Minnetonka, Minn.; www.natureworksllc.com) and many small-scale producers in Asia. The 2009 global market for lactic acid, its salts and esters is estimated at 376,000 m.t., valued at $823 million and is forecast to grow at an average annual rate of over 7% during 2009–2014. Demand for lactic acid is linked to various industries

* For more-detailed information, including all references see: "Biotechnology-based Chemicals", (December 2010) SRI Consulting's Specialty Chemicals Update Program (SCUP), which may be purchased by contacting Ralf Gubler in Zurich, Switzerland at +41-44-283-63-43 or rgubler@sric.ch. SRI Consulting is now part of IHS, Inc.

Technology Showcase

CRACKING THE COST

Up to now, the use of bio-based chemicals has largely fallen short on the economic side of the equation. In some cases the value of renewably sourced materials or biodegradable properties has taken up the slack. These materials typically have a completely different chemical formulation than the petroleum-based counterparts with which they compete. However, for high-volume chemical feedstocks, intermediates and fuels, the existing infrastructure favors so-called drop-in replacements. That is, of course, only if they can crack the cost advantage of traditional petroleum routes. Recent milestones prove that it is indeed possible (see also, p. 11).

Last month, OPX Biotechnologies Inc. (OPXBIO; Boulder, Colo.; www.opxbio.com) announced that it has demonstrated a manufacturing process for making performance-equivalent, bio-based glacial acrylic acid at a lower cost than the route for petroleum-based acrylic acid. Based on pilot-process results for its first product, known as BioAcrylic, OPXBIO calculates a commercial-scale manufacturing cost of $0.70/lb, with corn dextrose as feedstock, and $0.55/lb using cane sucrose as feedstock. With further process refinements and microbe optimization, OPXBIO president and CEO Chas Eggert says the company will lower production costs to $0.50/lb for corn sugar and $0.40/lb for cane sugar. Industry estimates put the production cost for petroleum-based acrylic acid at $0.75/lb. The global acrylic acid market tops $8 billion, with uses including diapers, paints, detergents and adhesives.

The process' fermentation step relies on a metabolically engineered bacterium to produce 3-hydroxypropionic acid (3HP), which, in a subsequent step, undergoes a dehydration reaction to yield acrylic acid. Key enabling technologies include the company's proprietary EDGE (Efficiency-Directed Genome Engineering) platform.

The company says its EDGE platform al-

and products, the most interesting of which is polylactic acid (PLA) plastics. However, high brittleness and the cost of PLA are the major issues determining the penetration rate of PLA in applications such as packaging.

For this particular application, Purac and Sulzer Chemtech (Winterthur, Switzerland; www.sulzerchemtech.com) have jointly developed a PLA polymer production technology, tai-

ADVANTAGE OF TRADITIONAL PETROLEUM ROUTES

lows OPXBIO to engineer high-performing microbes and develop bioprocesses faster and better than what is possible with conventional methods. After identifying metabolically significant genes, the EDGE platform introduces and evaluates the impact of genetic changes in a more comprehensive and rational way than other metabolic engineering techniques. Eggert explains that OPXBIO is able to correlate specific genetic mutations to metabolic performance, which allows a faster route to fully optimized microbe performance.

In its pilot studies at 1-, 10- and 250-L scale, OPXBIO achieved 79% production yield generating 70 g/L final product concentration in 26-h fermentations. Meanwhile, "OPXBIO completed this milestone with high speed and capital efficiency that is unprecedented in the bio-based chemical industry," notes Eggert. The company is moving toward demonstration-scale production, in 20,000 to 50,000 L reactors. Eggert says OPXBIO plans to begin commercial-scale production in 2014.

Meanwhile, Lanxess AG (Leverkusen, Germany; www.lanxess.com) is strengthening its commitment to produce premium synthetic rubber from bio-based raw materials. As part of this commitment, Lanxess has increased its minority shareholding in Gevo, Inc. (Englewood, Colo.; www.gevo.com), which focuses on renewable chemicals and advanced biofuels. Lanxess' increased equity stake reflects the good progress made by both companies in developing isobutene from renewable resources. Isobutene is a key raw material needed in the manufacture of butyl rubber. Isobutene is conventionally produced in steam crackers, which use various petrochemical-based materials as feedstock. Alternatively, Gevo is developing a fermentation process to produce the organic compound isobutanol from the fermentable sugars in biomass, starting with corn.

At the same time, Lanxess is developing a dehydration process to convert isobutanol into isobutene. Lanxess' dehydration process has not only proven to be successful in the laboratory but also in a small-scale reactor in Leverkusen, Germany, over a period of several months. Tests have shown that the process can deliver bio-based butyl rubber that meets the rigorous specifications of the tire industry, which represents roughly 25% of Lanxess' sales.

In addition to the share deal, both companies have signed an agreement that gives Lanxess certain exclusive rights to purchase bio-based isobutanol from Gevo, while Gevo receives an exclusive first right to supply Lanxess with specified quantities of bio-based isobutanol over a ten-year period. This arrangement is still subject to the parties' completion of a definitive off-take agreement, which is presently in negotiation.

Gevo's isobutanol can be used directly as a specialty chemical, as a gasoline blendstock, a jet feedstock and through conversion into plastics, fibers, rubber and other polymers. Gevo is currently retrofitting capacity of 22 million gallons per year (MGPY) at its first ethanol facility in Luverne, Minn., to produce 18 MGPY (50,000 m.t.) of isobutanol in the first half of 2012.

Bob Bernacki, Gevo's director of business development for chemicals, discussed opportunities for retrofitting ethanol plants at the 2nd Annual Bio-Based Chemicals Summit in San Diego last month. He says that the primary reason for retrofit is the fact that profit margins for isobutanol are approximately double that for ethanol. Other reasons for retrofit include potential for lower carbon footprint and feedstock flexibility. Bernacki says that the retrofit requires minimal downtime and ranges from $17 to 45 million depending on the capacity of an ethanol plant.

Gevo plans to expand its production capacity in the coming years through acquisitions and joint ventures and aims to have more than 350 MGPY of production capacity by 2015. ❏

Rebekkah Marshall, with Scott Jenkins

lored to Purac's specific lactide raw materials that could lower the cost of manufacturing performance-optimized PLA resins.

Polyhydroxyalkanoates

The market for polyhydroxyalkanoates (PHA) is nascent. In 2009, global consumption of the bio-based, compostable thermoplastic totaled 1,000–2,000 m.t. and had a value of $7–8 million. Consumption is expected to increase substantially in the next five years, thanks in part to a significant rise in production capacity. Telles, a joint venture of Archer Daniels Midland Co. (Decatur, Ill.; www.adm.com) and Metabolix (Cambridge, Mass.; www.metabolix.com), started up the world's largest PHA plant (capacity: 50,000 m.t.yr) in 2010. Other PHA producers include several in

China, Tianjin GreenBio Materials Co. (Tianjin; www.tjgreenbio.com/en/), Shenzhen Ecomann Biotechnology Co. (Shenzhen, Guangdong; ecomann.en.ecplaza.net/), and Ningbo Tianan Biologic Material Co. (Ningbo; www.tianan-enmat.com/).

PHAs are polyesters of various hydroxyalkanoates. The three most commercial PHAs are poly-3-hydroxybutyrate-co-3-hydroxyvalerate (PHBV) by Tianan, poly-3-hydroxybutyrate (PHB), and poly-3-hydroxybutryateco-3-hydroxyhexanoate (PHBH). Current end uses for PHA include various injection-molded products, such as bathroom accessories (soap dishes, pump dispensers) and pens. Thanks to the recent commercialization of new grades (including film and food-contact grades), formulations and blends, the bioplastic could see use in a broader range of applications in the future. Price could be a stumbling block, however. At present, PHA is substantially more expensive than conventional thermoplastics (such as polypropylene and polyethylene) and other bioplastics (such as polylactic acid and thermoplastic starch). Consequently, PHAs are at a disadvantage in many price-sensitive applications. Manufacturers are addressing this issue in three ways: by focusing on applications that will bear the higher cost of PHA resins because of their biodegradability, by blending PHA with less expensive polymers, and by developing technology that will lead to significantly lower production costs.

PHA research typically involves specialists in genetic engineering, metabolic engineering, chemical engineering and materials science. Research projects focus on improving the fermentation process; the separation, extraction, and purification stages of production; or the end product. For example, Metabolix, the co-owner (with ADM) of Telles, is responsible for the joint venture's research and development activities. Near-term research goals include lowering the cost and improving the yield of the microbial fermentation reaction that produces Mirel PHB copolymer from corn sugar. The company's ongoing strain development efforts target the development of microbes that can produce higher yields of Mirel at lower cost. In addition, Metabolix scientists are working to develop microbes that produce other, including second-generation, polymers suitable for new end uses.

Longterm goals include the development of "biomass biorefineries," genetically engineered plants that yield plastics as well as biomass for conversion to energy (such as steam, electricity or biofuels like ethanol or biodiesel). Current efforts focus on the coproduction of polymers, chemicals and energy in nonfood plants such as switchgrass, sugarcane and oilseed plants instead of in fermentation tanks. Metabolix has been working to develop bioplastic production in switchgrass (with support from the U.S. Dept. of Energy and the U.S. Dept. of Agriculture) since 2001. The company has proved that genetically modified switchgrass plants can produce biopolymers; in greenhouse trials, bioplastics accounted for more than 6 wt.% of switchgrass leaves and more than 3% of total plant weight. The yield, however, was well below the threshold of commercial viability, which Metabolix believes to be 7.5% of total plant weight.

Meanwhile, Ningbo Tianan Biologic Material Co. is developing cost-effective routes to PHBV copolymers with higher 3-hydroxyvalerate content; other projects focus on improving the efficiency of wastewater recycling and increasing PHBV's heat resistance and impact strength. Shandong Ecomann, Ningbo Tianan Biologic Material, and Tianjin GreenBio are also developing blends and formulations that offer improved processability and physical properties, thus broadening the range of potential applications for PHA. For example, Shandong Ecomann has developed biodegradable PHA/polybutylene succinate blends, PHA/montmorillonite nanocomposites, and plant fiber–reinforced PHA compounds. Ningbo Tianan Biologic recently developed PHBV/PLA blends that offer better heat resistance than neat PLA and a wider processing window than neat PHBV. Tianjin GreenBio has developed foamable PHA/PLA blends.

Japan's Kaneka (Osaka; www.kaneka.com), announced plans to start up a new 1,000 m.t.yr PHBH unit in late 2010; additional expansions will boost annual capacity to 10,000 m.t.yr in several years. Starting materials for PHBH include plant oils and other renewable resources.

Many of Kaneka's PHA-related patents emphasize the development of microbial strains that synthesize PHA at high production rates in industrial fermentation processes. Recent patents disclose genetically modified microorganisms that produce flexible, high-molecular-weight PHBH copolymers in good yield (up to 65 wt.% of the microorganism) from feedstocks such as glucose, butanol and butyric acid. The 3-hydroxyhexanoate units that are responsible for the copolymer's flexibility constitute at least 7 mol% of the PHBH copolymer. Other patents describe methods of collecting and purifying the bioplastic without reducing its molecular weight. ■

Edited by Rebekkah Marshall

Acknowledgement

The main body of this article and the sidebar on p. 20–21 have been excerpted by Rebekkah Marshall from a report by Hossein Janshekar, Kazuteru Yokose, Marifaith Hackett and Xiaomeng Ma, of SRI Consulting. For details on how to order the full report, see p. 19.

Circle 36 on p. 62 or go to adlinks.che.com/35063-36

PUMP IT UP

Increasing the efficiency and reliability of centrifugal pumps in process applications is indeed possible

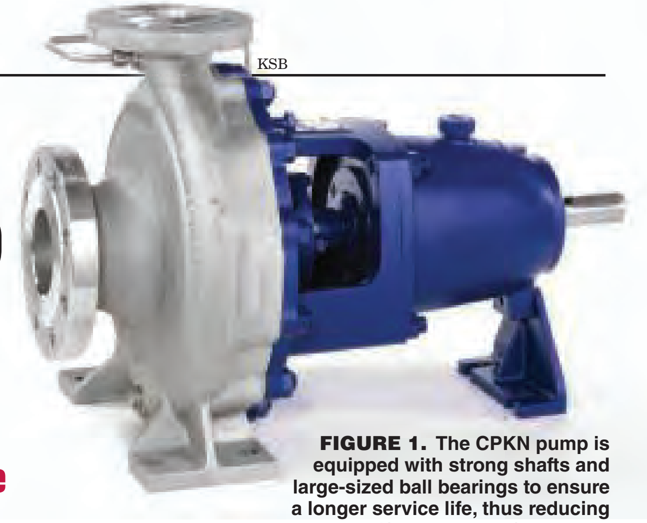


FIGURE 1. The CPKN pump is equipped with strong shafts and large-sized ball bearings to ensure a longer service life, thus reducing the lifecycle cost of the pump

Process plant operators continuously face the pressure of having to increase productivity by improving equipment reliability and plant availability, a goal seemingly at odds with the everyday realities of decreased operating budgets, rising energy costs and increasing operations costs.

And, when it comes to energy consumption and maintenance costs, chemical process pumps are possibly the most notorious problem child in the plant. Europump and the Hydraulic Institute estimate that pumps consume between 25 to 50% of the energy usage in process plant operations. And pump downtime represents a large share of process plant maintenance woes and costs, says Bill Newton, strategic marketing manager for the chemical industry with Flowserve (Irving, Tex.). With statistics like these, reducing the energy consumption of your pumps and increasing reliability may seem like fighting an uphill battle, however, pump experts stress that this is not necessarily the case.

The first step to improving both efficiency and reliability lies in selecting the proper pump for the application. This begins with a thorough analysis of the fluid to be pumped, including its major and minor constituents, concentration, acidity and alkalinity and suspended solids, says Newton. "A pump should be selected for the actual process conditions, flow requirements and corresponding head," he says. "The temptation to add margins must be resisted, as an incorrectly sized pump will operate at an undesirable point on the performance curve. This may lead to higher energy consumption, high vibration levels and other detrimental operating modes."

Beyond this, there are several steps, technologies and products that can be employed to improve both efficiency and reliability.

Efficiency improvements

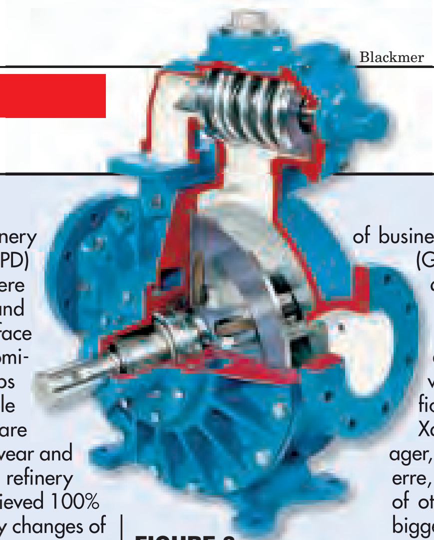
All pumping systems comprise a pump, driver and operating control system, and pump sizing is obviously critical when looking to improve efficiency. Correctly identifying the best efficiency point (BEP) and the preferred range minimizes losses in the impellers and casing, as well as the hydraulic loads on the bearings, says Newton. (For more on BEPs, see Process Pump Control, *CE*, November 2010, pp. 30–33). Driver selection will affect energy consumption, whether applied as a constant energy load or as a variable frequency. Operating control by throttling valve, pressure relief or flow bypass will reduce operating efficiency and increase energy consumption. Then there are the most basic factors of pump design, which are often overlooked when discussing energy usage — impeller running clearances, trim and mechanical seal drag, he says.

Christoph Pauly, mechanical engineer and press officer of KSB AG (Frankenthal, Germany), adds that processors should look beyond the pump itself to find further efficiency improvements. "With a comprehensive system analysis and specific recommendations we can achieve a notable increase in system efficiency, considerably reducing costs," he says. "So in the search for potential savings, we pursue a holistic system approach. This means we have not just the pump in our sights, but also all of its peripheral systems."

He says if a pump is examined in isolation, optimizing its components, such as the motor or the impeller, will achieve an efficiency increase of about 3.5%. Examining the entire module — electrical equipment, motor and pump — means that savings of as much as 10% can be obtained. However, by optimizing the entire system, which involves pump module, piping system, control strategy and operating mode, it is possible to save up to 60%, according to Pauly.

There are several ways to assist with such analysis. The first is a service-based offering, available from pump manufacturers like ITT Goulds, which provides a plant-wide pump-system energy audit. ITT's service identifies the pump candidates with the greatest potential payback, details a recommendation for these pumps and then provides an ROI calculation based on the recommendations. The second part of such a strategy would be execution, says Pat Prayne, product manager for ANSI pumps with ITT Goulds Pumps (Seneca Falls, N.Y.). "This includes the physical modifications such as trimming impellers and hydraulic re-rating the pump, but also optimizing the pump control strategy."

The company offers PumpSmart, an intelligent flow system that works with any pump, using a smart VFD (variable frequency drive) controller and proprietary control software to provide advanced process control, enhanced reliability through failure prevention, reduced lifecycle costs and up to 65% less energy costs. "With ITT's PumpSmart variable speed pump controller, we are maximizing the benefits of variable speed control by embedding pump-specific intelligence to inform operators


Blackmer

JUST YOUR TYPE

Since the 1970s, a major U.S. Gulf Coast area refinery had used reciprocating positive-displacement (PD) pumps for wash water service. The PD pumps were costly to operate, posed environmental complications and required frequent maintenance. Wood Group Surface Pumps (Houston) designed and engineered an economical Surface Pumping System to replace the PD pumps at the refinery. The new units feature easily replaceable multi-stage horizontal centrifugal pump elements and are designed for improved abrasion resistance, reduced wear and higher efficiency. After the units were installed, the refinery eliminated leakage and environmental issues and achieved 100% uptime with 24/7 reliability with no failures. Quarterly changes of the thrust chamber lubricant and routine vibration measurements are the only maintenance needed thus far.

Obviously, selecting the right pump for the application can make a big difference in reliability and efficiency. While in this case, centrifugal pumps were swapped in for an alternative type, this is not always the solution. Centrifugal pumps are the most widely used type in the chemical processing industry, but they may not always be the best choice for a given application.

"A lot of process engineers automatically select a centrifugal pump because it is what they know," says William Bohr, director of business development with Blackmer (Grand Rapids, Mich.). "But that doesn't make it the right pump for their application. Broadening your knowledge of different pump types can go a long way toward finding the most efficient pump for a process."

FIGURE 3. **The Blackmer ML Series pump offers self priming and run dry capabilities to extend its operational life**

Xavier Rasotto, market manager, chemical, with Mouvex (Auxerre, France), agrees. "Awareness of other pump types is one of the biggest challenges for chemical engineers. Some chemical engineers may not be familiar with the technology and benefits associated with other types of pumps," he says. "Since pumps are responsible for the second highest number of industrial equipment used after electrical motors, selecting the right kind of pump for any fluid transfer applications is a critical task."

And, once the choice for an alternative pumping technology has been made, users will often find there are advances within each of these pump types that can further boost energy efficiency. For example, Greg Duncan, director of engineering and technical support with Wilden Pump & Engineering (Grand Terrace, Calif.), says the company's ProFlow X air distribution system was designed to reduce energy consumption in its air-operated double diaphragm pumps. "It has an efficiency management system that allows the customer to select the optimization point he needs to find the perfect balance between efficiency and performance for a specific application."

Realizing that the most energy-efficient solution to the pump-shaft sealing challenge is a seal-less drive, Mouvex has developed the SLP Series of sliding vane pumps. The SLP Series is a rotary positive displacement pump that is not based on magnetic drives, but, rather, a seal-less, leak-free design that features no magnets, no mechanical seals and no packing. When compared to magnetic driven pumps, the SLP creates up to a 40% reduction in absorbed power and up to a 20% higher return in energy efficiency, says Rasotto.


Mouvex

FIGURE 2. **TheS LP Series is a rotary positive displacement pump that is not based on a magnetic drive. This seal-less sliding vane pump features no magnets, no mechanical seals and no packing, making it easier to maintain**

of flowrate, process upset conditions and overall pump performance," says Prayne. "It is typical to achieve a 30%, to as high as 70%, reduction in energy with our solutions."

Jeff Theisen, commercial project engineer, standard drives and motion control with Rockwell Automation (Milwaukee, Wis.), agrees that monitoring and control can go a long way toward reducing energy costs. "Power monitoring and control devices, such as energy-efficient motors, sophisticated controllers and software and variable speed drives — all of which can be networked together, provide more accurate information about actual production costs, allowing managers to make more intelligent business decisions," he says.

However, he adds that to enable such knowledge, an effective monitoring program is essential. Such a program should include a network of digital power-monitoring devices that capture and communicate power-consumption information. These devices are used to measure electrical parameters associated with a specific bus in a facility's electrical distribution system. This allows plant managers to gather detailed information on power consumption in different parts of their plants, on specific machines and even on individual product lines.

By metering consumption, small opportunities for improvement can be identified to provide a significant impact on energy usage, resulting in immediate financial gains. And, in addition to usage data, managers have access to power-quality information that can improve productivity and lengthen equipment life, further enhancing profits and efficiency.

Improving reliability

"The initial purchase price of a pump represents only about 10 to 15% of the total lifecycle cost of the pump, with energy usage being the largest cost," says Rich Whidden, applications engineer with Griswold Pump Co. (Grand Terrace, Calif.). "Maintenance, repair, labor and associated downtime costs make up the remainder."

For this reason, Whidden says, one

PUMP MANUFACTURERS AND SERVICE PROVIDERS

Blackmer	www.blackmer.com	KSB	www.ksb.com
Crane Chempump	www.chempump.com	Mouvex	www.mouvex.com
Dickow Pump	www.dickow.com	Moyno	www.moyno.com
Flowserve	www.flowserve.com	Rockwell Automation	www.rockwellautomation.com
Fluid Metering	www.fmipump.com	Viking Pump	www.vikingpump.com
ITT Goulds Pumps	www.gouldspumps.com	Wilden Pump & Engineering	www.wildenpump.com
Griswold Pump	www.griswoldpump.com	Wood Group Surface Pumps	www.woodgroupsurfacepumps.com

of the biggest responsibilities of his job is improving the reliability of chemical process pumps. "We try to help the end user choose optimal materials and sealing arrangements because these are the keys to ensuring long service life for a pump," he says.

Similar strides are being taken to increase reliability of pumps as well, especially when it comes to decreasing seal failure, which accounts for up to 70% of pump failures in process applications, according to Europump and the Hydraulic Institute.

"Sealing is one of the biggest areas for improvement, as a disproportionate percentage of pump downtime is caused by seal failures," acknowledges Jim Nelson, application engineer with Viking Pump (Cedar Falls, Iowa). For this reason the company has broadened its line of seal-less magnetic drive pump offerings to provide more options for customers to eliminate seal failures as a cause of maintenance issues. "The company's recently introduced Universal Magnetic Drive (UMD) pumps offer improved design over previous mag drive offerings and will interchange dimensionally with corresponding size pumps in our most popular heavy-duty pump line, the Universal Seal Pumps," he says. "This allows our customers to substitute a seal-less pump for a conventionally sealed pump in a difficult application without having to do significant modification to the pump unit or piping."

Along with the introduction of the UMD pumps, Viking offers a power monitor for positive pump and drive protection, in the event of an under-pressure situation, such as would occur with pump cavitation or running dry, and also an over pressure situation, due to an unanticipated increase in pressure or viscosity.

While proper selection of materials and sealing arrangements will go along way toward improving reliability, there is often no way of seeing how a pump is actually running. So, some manufacturers are working on technologies to improve that issue.

KSB recently designed a new unit called PumpMeter to make pumps "transparent." "Transparent operating conditions are important," says Pauly. "This is the only way for the operator to make sure the pump runs at its optimum operating point, thus increasing its service life."

With PumpMeter, measured and calculated values are shown in alternation on a user-friendly display. A typical pump-curve graph illustrates in which range the pump is currently operating, allowing the end user to see at a glance if the pump provides efficient and cost saving operation or if its availability is jeopardized.

Similarly, ITT offers ProSmart, a multi-patented, wireless predictive condition-monitoring system that provides continuous online machine monitoring, alerting operators to alarm conditions via email or telephone. "Any effective preventive or predictive monitoring program is limited in its ability to the consistency and quality of data that can be collected and analyzed," says Dan Kernan, manager, monitoring and control, with ITT Goulds Pumps. "The advancement in diagnostic technologies will not be in new techniques, but rather in lowering the cost of data acquisition. What we are seeing is a growing adoption of wireless sensor networks in industrial plants, which is lowering the data acquisition cost, but also enabling realtime monitoring, such as ProSmart."

Another option is Flowserve's Intelligent Process Solutions family of products, designed to help customers proactively manage plant assets to increase plant availability and reduce equipment lifecycle costs.

IPS APEX is a robust and extensive application of smart pump technology that can be applied in the chemical process industries. Onboard sensors and intelligent pumping algorithms make it possible for plant operators to predict system behavior before failure or disruption, protecting critical assets. It can also intelligently diagnose reliability and operational problems while providing outputs to adjust equipment and system parameters. In addition, process and equipment information can be shared through a Web-based portal, allowing plant and offsite technical experts, consultants and OEM engineers to diagnose problems and develop solutions.

"Much of this has been made possible by the practical application of low-cost wireless monitoring systems and plummeting hardware costs," says Newton. "But the real key to deployment is in the development of an integrated platform which combines realtime OEM pump expertise with sophisticated data acquisition, diagnostics and intelligent control." ■

Joy LePree

Griswold

FIGURE 4. Model 811 is an ANSI centrifugal pump, offering high performance, simplified maintenance and reduced cost of ownership

Fractionation Column

FRI's parallel projects

Considering that Fractionation Research, Inc. (FRI) has been performing distillation research since 1954, don't we have all the answers yet? Not according to the membership. The vendors of trays and packings have had very aggressive R&D programs. New and interesting products have appeared annually. In addition to the testing of such products in hydrocarbon service and at commercial diameters, the membership also sponsors a general development program. At present, picket-fence weir designs are under study.

Mike Resetarits is the technical director at FRI (Stillwater Okla.; www.fri.org), a distillation research consortium. Each month, Mike shares his first-hand experience with *CE* readers

All of the above projects comprise FRI's Mass Transfer Program. There also exists a Parallel Projects Program. The number one rule regarding the latter is that it must not interfere with the former. At the present time, the following four parallel projects are underway.

Professor Ken Bell is an Oklahoma State University (OSU; Stillwater, Okla.) faculty member and is a heat transfer "legend." With his guidance, FRI is about to put windows on one of its kettle reboilers. It is probable that this has never been done before, at least not on an industrial size kettle. With the windows, FRI's members will receive information regarding pool depths and entrainment.

FRI has employed a Yokogawa (Sugarland, Tex.; www.yokogawa.com) DCS for several years. Yokogawa is presently providing the technology and engineering to implement what Yokogawa calls modular procedural automation (MPA). FRI starts its unit and shuts it down about 20 times per year. When the unit is running, operating conditions are changed about six times per day. Steady state is a brief luxury at FRI. The MPA technology will enable FRI to automate startups, shutdowns and operating condition changes. In the near future, all operators will perform these operations identically — more safely. Changes will be effected more quickly; more data will be collected. Yokogawa engineers say, "It's like having your best operator in the control room all the time."

Zhejiang University of Technology (ZJUT) is located in Hangzhou, China. They have had a very active tray and packing development program since about 1970. On occasion, ZJUT performs contract research for FRI and its members. Zhejiang's Institute of Process Equipment and Control Engineering (IPECE) will soon be demonstrating a new control technology at FRI. The technology facilitates the steady operation of a distillation column very near, (97% of) the flood point.

Finally, FRI's very able technicians have shown an extreme interest in the new combustion-suppression technology Cold Fire from Cold Fire Southeast (Pelham, Ala.; www.coldfiresoutheast.com) and will be testing its capabilities in extinguishing structured packing fires. Cold Fire works in two ways to remove heat and fuel sources from the fire triangle. In a liquid fuel fire, it works first as a foaming agent to suppress vapors and smother the flames, and second as a surfactant to mix with the fuel and encapsulate it at the molecular level. At least 60 structured packing fires have been documented, and they are generally believed to be very difficult, and sometimes impossible, to put out. The FRI technicians will ignite some structured packing, in a cylindrical sleeve. Video footage will be collected as the fire is extinguished with cold fire

FRI is a busy place. Nevertheless, *CE* readers are invited to visit any time that their travels take them to Oklahoma. ■

Mike Resetarits
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CHEMICAL ENGINEERING
FACTS AT YOUR FINGERTIPS
Department Editor: Scott Jenkins

Infrared Temperature Measurement

Contact-based temperature sensors, such as thermocouples and resistance temperature detectors (RTDs), have demonstrated accurate and cost-effective operation throughout the chemical process industries (CPI). However, there are many applications and settings where they are simply not practical. In those cases, engineers can turn to a host of non-contact temperature measurement devices, many of which are based on measuring infrared (IR) radiation. IR thermometers can routinely perform measurements in situations where readings with contact thermometers would be virtually impossible. Situations where IR-based temperature measurement should be considered include the following:

- Rapid and frequent temperature readings are required
- Objects are moving
- Objects are within strong electromagnetic fields, such as in processes involving induction or microwave heating
- Rapid thermal changes are the norm
- Objects needing measurement are located in process chambers or behind windows
- The surface temperature of an object or equipment requires measurement
- Locations are inaccessible to contact thermometers
- Areas to be measured would be damaged or contaminated by contact measurement
- Varying surface-temperature distributions are present
- Objects are made from materials with low heat capacity and low thermal conductivity
- Materials to be measured are gaseous, such as combustion gases and flames

Within the CPI, IR thermometry is most effective and used most frequently in semiconductor and wafer processing, cement and lime processing, rotating kiln shells, waste incineration, glass processing, sintering and heat treating, metals processing and drying applications. While IR thermometers are generally more expensive than contact thermometers, they usually have longer lifetimes and require less maintenance.

A general knowledge of the key aspects of thermal radiation physics can help users apply and operate the devices more effectively.

Stefan-Boltzmann law

The energy radiated by an object per unit surface area per unit time is related to its temperature by the Stefan-Boltzmann law, which states that irradiance (in $J/s/m^2$) is proportional to the fourth power of the object's temperature multiplied by its emissivity. A constant of proportionality (the Stefan-Boltzmann constant) is required for calculations. In a perfect (theoretical) blackbody radiator, emissivity equals one.

Operation

Most IR thermometers operate according to the same basic operating principles (Figure 1). A bandwidth filter and optical lens are used to focus the IR energy emitted by an object onto a detector, which converts the IR radiation into an electrical signal. After compensating for emissivity (see below) and ambient temperature, an analog output is generated to provide temperature measurement. The analog signal can be converted to digital when fast acquisition rates are required.

Emissivity

The emission of thermal radiation is a surface phenomenon for most materials. The term emissivity refers to an object's ability to emit thermal radiation. Emissivity is defined as the ratio between the energy emitted by an object at a given temperature and a perfect radiator, or blackbody, at the same temperature. Emissivity values lie between zero and one. IR thermometers generally have the ability to compensate for the different emissivity values of materials. Materials with the highest emissivity values are the easiest to measure accurately with IR thermometers, while those with low emissivities are more difficult. For example, some polished, shiny metallic surfaces, such as aluminum, are so reflective in the infrared that accurate temperature measurement is not always possible.

Tables listing emissivity values for various materials have been published, and are available for reference (Table). Some IR thermometers allow users to change emissivity values according to the material being measured, while others have a pre-set emissivity value. When using IR thermometry, it is important to consider that materials can have different emissivity values at different wavelengths. To determine an emissivity value, you can heat a material to a known temperature, then adjust the emissivity value of the instrument until the IR thermometer matches the known temperature.

EMISSIVITY VALUES OF COMMON MATERIALS*

Material	Emissivity
Silver (polished)	0.01
Aluminum (unoxidized)	0.02
Gold (polished)	0.02
Aluminum (heavily oxidized)	0.20
Zinc (bright galvanized)	0.23
Steel (316 polished)	0.28
Soil (plowed field)	0.38
Iron (liquid)	0.43
Iron (rusted)	0.65
Water	0.67
Sand	0.76
Steel (cold rolled)	0.80
Wood (oak planed)	0.91
Brick (red, rough)	0.93
Carbon (Lampblack)	0.95
Ice	0.98

*Provided for illustrative purposes only.

Field of view (FOV)

The FOV is the angle of vision at which the instrument operates and is determined by the optics of the system. The optical system of the IR thermometer collects the IR energy from a circular measurement spot, and focuses the energy on the detector. The optical resolution of the instrument is determined by the ratio between the distance from instrument to object and the size of the spot being measured (distance-to-spot ratio). Higher ratios mean better resolution.

Ideally, the target being measured should fill the instrument's FOV. For the best performance, the target object area should exceed the FOV by a factor of about 1.5 (Figure 2).

Calibration

IR thermometers can be calibrated by aiming at blackbody radiators that are designed specifically for calibration and testing. By varying the source temperature of the blackbody, calibrators can tune the IR sensor's internal measurement signal to known temperatures.

Selection questions to consider

When selecting an IR thermometer for a CPI application, it is important to consider the following questions:

- What is the required proximity to the target?
- What is the size of object to be measured, and will it fit the instrument's FOV?
- Are there any physical obstructions between the object to be measured and the measuring device
- Are smoke, dust or other particulate matter likely to be in the measurement area?
- What are the measurement control frequency requirements?
- Does the object have a shiny surface?
- What are the output/interface requirements?

References

1. Young, A., IR Thermometry Finds CPI Niches, *Chem. Eng.*, Feb. 2002, pp. 56–60.
2. Omega Engineering Inc. [Internet]. c2003–2010. Stamford (CT). [cited Feb. 2011]. Available from: http://www.omega.com/.

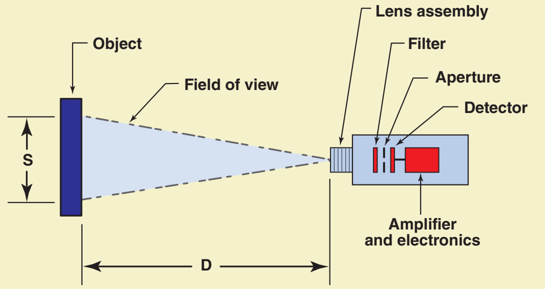


FIGURE 1. The optical system of an IR thermometer collects IR energy from a circular measurement spot, and focuses it on a detector

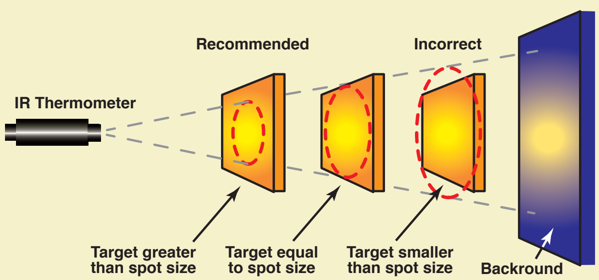


FIGURE 2. For accurate IR temperature measurement, the target area should be greater than the instrument's FOV by a factor of about 1.5

People


Haines


Guiot


Ramsey


Oakley


Marcotte

Peter Ferris becomes president and CEO of **Dur-A-Flex** (E. Hartford, Conn.), a manufacturer of epoxies, urethane, methyl methacrylate and colored aggregates.

Plasticolors, Inc. (Ashtabula, Ohio), a manufacturer of custom colorants and chemical dispersions, names *Larry Haines* strategic development manager.

Catherine (Kitty) H. Pilarz, senior director of Mattel/Fisher-Price product safety (East Aurora, N.Y.), is named 2011 chairman of the board of directors of **ASTM International** (W. Conshohocken, Pa.).

Olivier Guiot becomes general manager of **Milton Roy Europe SA** (Normandy, France).

Purafil (Doraville, Ga.) welcomes *Thomas Ramsey* as director of business development.

G. David Oakley, Jr. becomes president and CEO of **Strongwell Corp.** (Bristol, Va.), a pultruder of fiber-reinforced polymer composites. *John Tickle*, president and CEO since 1972, will remain chairman of the board of directors.

Precision Polymer Engineering Ltd. (Blackburn, U.K.), a unit of IDEX Corp., names *Paul Gillyon* managing director.

Eric Marcotte becomes regional sales manager for **Stedman** (Aurora, Ind.), a manufacturer of size-reduction equipment. ■

Suzanne Shelley

FOCUS ON

Compressors

Ingersoll Rand

Danfoss

This compressor matches output to demand

The Nirvana R190-225ne (photo) is a variable-speed-drive rotary-screw air compressor with an advanced motor design that allows users to match compressor output to required demand. In particular, the Nirvana R190-225ne features a patented modular drive, and a hybrid permanent-magnet motor design. Its variable-speed cooling system ensures consistent discharge temperature and matches energy consumption to thermal load. Its ability to match output to demand provides optimal operating efficiency. The company says the model contains the fewest components requiring servicing of any existing compressor, and has easily removable panels for improved service access. — *Ingersoll Rand, Davidson, N.C.*

www.ingersollrandproducts.com

Identify contamination areas with this service

A compressed-air-quality test program offered by this company can identify contaminated areas within a compressed air system that could affect facility operations. The program will analyze the quality of the compressed air system, determine contaminant levels at end-use points, and measure moisture content of compressed air in critical areas. The company also provides a summary report of the findings. The company says the testing program can reduce equipment downtime, lower excessive maintenance costs and make product contamination and component replacement less frequent. — *Parker Hannifin Corp., Filtration and Separations Div., Haverhill, Mass.*

www.balstonfilters.com

Detect compressor gas leaks with ultrasound

The Observer Ultrasonic Gas Detector responds to the airborne ultrasound generated when high-pressure systems release gas in open, well ventilated areas. Based on microphone technology, the detector provides a detection radius of up to 20 m at a leak rate of 0.1 kg/s. Because it is not based on concentration of the leaked gas, it is unaffected by changing wind directions, gas dilution and leak direction. The detector features the ability to self-test to verify the integrity of electronic circuitry and operation of the acoustic sensor. It is especially suited for natural-gas compressor stations. — *General Monitors, Lake Forest, Calif.*

www.generalmonitors.com

Reduce energy in compressor applications with this drive

The VLT Automation VT Drives (photo) are specifically engineered to reduce energy usage in compressor applications requiring variable torque. A combination of energy-optimizing features can lower energy use in variable-torque applications by 30%, the company says. The drives are available in sizes from 0.5 to 1,400 hp with a wide range of enclosure options. — *Danfoss VLT Drives, Loves Park, Ill.*

www.danfossdrives.com

Operate at cooler temperatures with this compressor

The GS Series of variable-speed-drive air compressors feature a unique cooling system that improves cooling of the main drive motor and other critical components, allowing the compressors to operate at lower temperatures and achieve greater volumetric and electrical efficiency. The lower operating temperature allows the intake of cooler, denser air, which increases the compression efficiency as well. The cooler airflow, along with heat-sensitive components provides up to 50% longer service life for motors and electrical components, the company says, and a 30–50% longer service life for bearings, seals and hoses. — *FS-Curtis, St. Louis, Mo.*

www.fscurtis.com

(Continues on p. 33)

Note: For more information, circle the 3-digit number on p. 62, or use the website designation.

INTERPHEX 2011 Conference & Exhibition


Vac-U-Max


Meissner Filtration Products


K-Tron America


Swagelok

North America's largest event for the pharmaceutical- and biopharmaceutical-manufacturing industries, Interphex 2011 (www.interphex.com) will be held at the Jacob Javits Convention Center in New York from March 29-31. The event will feature more than 650 exhibitors, including 100 vendors exhibiting for the first time at Interphex, as well as 30 technical sessions and several special events. Meeting organizers state the event's aim is to help pharmaceutical, biologic, generic and service-provider professionals improve manufacturing and supply chain performance.

These biocontainer standards are optimized for single-use

TepoFlex biocontainer standards (photo) have been optimized for single-use applications in the biopharmaceutical industry. Made of this company's polyethylene-based TepoFlex film, the containers are certified to be animal-component-free and are extruded and manufactured in a cleanroom that complies with ISO Class 7 standards. The biocontainers are available in a range of sizes, from 50 mL to 20 L. Booth 2611 — *Meissner Filtration Products Inc., Camarillo, Calif.*
www.meissner.com

A pelleter that integrates extrusion with sphere-making

This company designs and manufactures the Complete Drug Pelleting (CDP) System (photo, p. 32D-2), which fully integrates the extrusion and spheronization processes to continuously convert drug formulations into free-flowing spheres of a controlled size and shape. The CDP features a compact design that is ideal for current good manufacturing practice- (cGMP) compliant suites. It is constructed of stainless steel and is available in various production sizes. CDP systems are custom-designed and manufactured to client specifications. Booth 3937 — *LCI Corporation, Charlotte, N.C.*
www.lcicorp.com

Handle combustible dusts with this vacuum system

Designed for collecting and discharging powders in a safe, dust-free way, the Model 860/02 (photo) uses non-stick filtration that captures 99.9% of particles as small as 0.5 µm, as well as offering manual pulse-jet filter cleaning. When the vacuum is turned off, the collected powder automatically discharges into a static-conductive polybag. The affordably priced Model 860/02 has a fully grounded accessory kit, and an anti-sparking material inlet, so the unit can be used in OSHA Class II, Division 2 environments. Booth 2882 — *Vac-U-Max, Belleville, N.J.*
www.vac-u-max.com

These regulators have a variety of options

Through an acquisition, this company now provides RHPS Series high-flow, pressure-reducing and back-pressure regulators (photo). These regulators are constructed of 316L stainless steel, and are appropriate for applications in the biopharmaceutical industry, as well as oil and gas, petrochemicals, alternative energy and others. Both pressure-reducing and back-pressure regulators are available in spring-loaded and dome-loaded models. The RHPS Series is available for line sizes up to 4 in. Booth 3513 — *Swagelok Co., Solon, Ohio*
www.swagelok.com

Interchange feed screws with this feeder system

The KT20 is a twin-screw pharmaceutical feeder (photo, p. 32D-1) that offers interchangeable feed screws that are tailored to the properties of the material being fed. The ability to change screws allows gravimetric feeding of very hard-flowing powders, as well as free-flowing powders. The company also offers a non-product-contact vibratory drive designed specifically for the KT20 and related feeders. Booth 3637 — *K-Tron America, Pitman, N.J.*
www.ktron.com

Pump diaphragms that comply with FDA material requirements

Full Stroke PTFE (Teflon) Diaphragms (photo) from this company

Note: For more information, circle the 3-digit number on p. 62, or use the website designation.

Wilden Pump and Engineering

LCI

Scilog

MadgeTech

are fully compliant with FDA material-compatibility requirements. Designed to withstand common steam-sterilization temperatures, the PTFE diaphragms provide considerable suction capability along with increased flow and suction performance. They are for use on the company's air-operated double-diaphragm pumps. Booth 3173 — *Wilden Pump and Engineering Co., Grand Terrace, Calif.*
www.wildenpump.com

Automate column packing with this bio-chromatography unit
This company offers an automated column packing and unpacking station for use with its Prochrom-Bio chromatography columns that drastically reduces the time required to pack and unpack chromatography columns for biological separations. The specific procedure of the automated packing and unpacking station enables the fastest operation and most reproducible results in purification applications, such monoclonal antibodies, recombinant proteins, DNA, viruses, blood fractionation and more. The Prochrom-Bio columns feature a hydraulically actuated piston and specially designed packing and unpacking valves that provide consistent performance. Booth 2733 — *Novasep, Pompey, France*
www.novasep.com

This mass-flow controller interfaces with a balance
The ChemTec (photo) interfaces directly with an electronic balance to provide precise, automated mass-flow control of reactants, catalysts and additives. Feedrates can be pre-programmed, allowing precise control of reaction stoichiometry, and improving yields and molecular-weight distributions for polymer or biopolymer products. With a top-loading balance, the ChemTec offers mass-flow metering as low as 0.01 g/min. The ChemTec comes with software to enable unattended operation, and data archiving. Booth 3541 — *Scilog Inc., Middleton, Wisc.*
www.scilog.com

A diaphragm designed exclusively for passivation use
This company's Saunders Passivation Diaphragm (photo, p. 32D-4) is designed specifically for use during passivation of stainless steel in life-science-related applications, where seals and valve diaphragms are commonly replaced after passivation. Each of the company's passivation diaphragms is equipped with a high-visibility yellow tag that extends beyond the valve assembly indicating that the diaphragm is for passivation use only. The cautionary feature reminds end-users of the diaphragm's sole purpose, thus reducing the risk that it will be left in the system after exposure to passivation chemicals, and preventing

FlowTech

possible contamination from detritus or anodic components becoming embedded in the diaphragm face. Booth 3413 — *Crane ChemPharma Flow Solutions, Cincinnati, Ohio*
www.cranechempharma.com

This UV disinfection system is 3rd-party validated
The Pharmaline PQ ultraviolet (UV) disinfection system has been validated by a third party for use in manufacturing pharmaceutical and healthcare products, according to this company. The Pharmaline PQ has a dosage display that helps confirm that the device is generating the UV output necessary to kill microorganisms, including mold, algae and yeast. Water to be used in pharmaceutical product manufacturing is passed through the system, where it is exposed to UV light. Booth 1973 — *Aquionics, Erlanger, Ky.*
www.aquionics.com

Bend this temperature data logger probe into any angle
The HiTemp 150-PT (photo, p. 32D-2) is a submersible temperature data logger with a 24-in. stainless-steel probe that can be bent or angled in any direction. The flexibility and durability of the probe makes it easy to log temperatures inside bottles, vials and other hard-to-reach locations. The HiTemp150-PT can measure and record temperatures between –40 and 150°C, and can read at rates from once per second to once every 12 hours. The device comes precalibrated. Booth 2058 — *MadgeTech Inc., Contoocook, N.H.*
www.madgetech.com

These pumps have rotors for shear-sensitive products
The Unibloc-PD rotary lobe pumps (photo) use rotors specially designed for shear-sensitive products. The family of pumps is available in 17 different sizes, capable of accomodating flows from 0.1–250 gal/min. The pumps have fully machined stainless-steel pumps and pump gearboxes.The Unibloc pumps can be integrated into this company's LabTop "plug-in-the-wall" units for small-to-medium size capacity applications. Booth 2037 — *FlowTech Div, Marietta, Ga.*
www.flowtechdiv.com

An air duct system is for BSL-3 environments
The IPP Line of air duct systems can be used in biosafety level 3 containment environments, and complies with several common air-duct-leakage stan-

Show Preview

Crane ChemPharma Flow Solutions

Freeman Technology

dards. The duct systems are fabricated by a new welding method that the company says has had positive results. The IPP Line is available in diameters from 3–48 in. using a wide variety of stainless-steel gages. Booth 1578 — *Cheminée Lining.E, Inc., Terrebonne, Que., Canada*
www.chemineelining.com

This vacuum cleaner has a continuous collection system

The CFM S3 is a newly launched vacuum cleaner designed specifically for applications in the pharmaceutical industry. It features what the company calls an "endless bag" that can be dispensed as needed to the desired length. Once filled, the collection bag can be cut, sealed and disposed of, and restored for a new use. The CFM S3 vacuum also features the ability to monitor filter performance, as well as a modular design for easy maintenance and upgrades, and a range of hose and filter accessories to help meet industrial cleaning challenges. Booth 1658 — *Nilfisk Industrial Vacuums, Morgantown, Pa.*
www.pharmaceuticalvacuum.com

A new graphical user interface for this powder rheometer

This company has introduced software for the FT4 Powder Rheometer (photo) that allows a graphical user interface (GUI). Designed to be intuitive and flexible, the GUI comes standard with new units, and can be installed as a free upgrade on existing FT4 systems. The FT4 provides comprehensive powder characterization, including shear, bulk, dynamic and axial powder testing methodologies. Booth 2167 — *Freeman Technology, Welland, U.K.*
www.freemantech.co.uk

Optimize economy and reliability with this explosion protection

This company's pneumatically operated explosion-isolation pinch valve (EIPV) offers an economical and reliable method for preventing deflagration propagation through interconnecting pipes and conveying lines. The EIPV consists of a heavy-duty cast valve body with a rugged elastomeric sleeve. The virtually maintenance-free valve reacts to an explosion in milliseconds to block explosion pressures of 3 bars. Activation of the EIPV is achieved with a new solenoid output version of this company's explosion-protection control system. Booth 2238 — *Fike, Blue Springs, Mo.*
www.fike.com

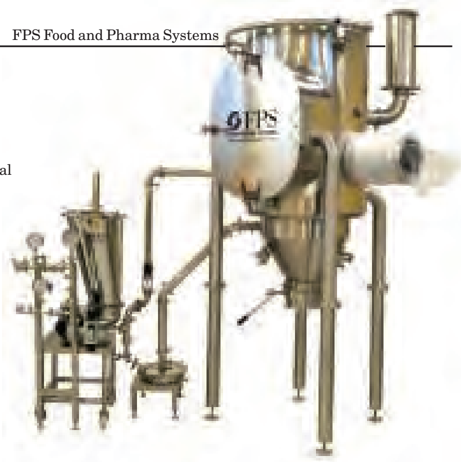
This dry-screw vacuum pump is easy to service

Featuring high durability and easy servicing, the KDS 425 is a dry-screw vacuum pump for industrial and process applications. Booth 2171 — *Tuthill Vacuum & Blower Systems, Springfield, Mo.*
vacuum.tuthill.com

Eliminate cap damage with this retorquing equipment

The Beltorque (photo, p. 32D-5) tightens caps after induction sealing for pharmaceutical, cosmetic, nutraceutical and personal care product containers. Using belts to tighten the caps, rather than discs or spindles, the Bel-

NJM/CLI Packaging Systems International



FPS Food and Pharma Systems

torque eliminates cap damage and achieves more consistent torque values. The high-speed machine increases bottling-line productivity by speeding changeover and reducing unplanned downtime. The Beltorque is suitable for round-, oval- and square-shaped containers from 2–12-in. height and from 0.5–7.0-in. dia., and can tighten up to 300 caps per minute. Booth 3543 — *NJM/CLI Packaging Systems International, Lebanon, N.H.*
www.njmcli.com

Non-destructive process analysis with this system

ProFoss is a process analysis system based on high-resolution diode-array technology. It provides non-destructive analysis of pharmaceutical and chemical products directly in the process line. No bypass is required. The system helps to optimize the use of raw materials and to consistently run production closer to target specifications. Booth 2163 — *Foss NIRSystems Inc., Laurel, Md.*
www.foss-nirsystems.com

Particle collisions reduce size in this system

The micronization system from this company (photo) uses spiral jetmill technology to accelerate particles into collisions to reduce particle size. Jet mills are available in a range of sizes to accommodate laboratory needs up to full-scale production requirements. The Jet mills are the result of an optimization study involving the milling chamber, nozzles and classifier, which allows high productivity at low gas-consumption rates. Booth 2662 — *FPS Food and Pharma Systems Srl, Como, Italy*
www.foodpharmasystems.com ■

Scott Jenkins


Hapman

MARCH
New Products


Goudsmit Magnetic Systems

Michell Instruments


Richter Chemie-Technik


Saint-Gobain Performance Plastics

Removing very fine metal particles from milk powder

Developed in collaboration with Friesland Campina Doma, this improved version of the rotating clean-flow magnet (photo) removes very fine metal particles from whey powder. And due to its renewed dynamic seal, the system is also dust-proof at an overpressure of up to 0.4 bar. The magnets move in a fully enclosed, rotating stainless-steel pipe and trap metal particles from 35 microns. The entire system is suitable for installation in ATEX Zone 1/2 D. — *Goudsmit Magnetic Systems B.V., Waalre, the Netherlands*
www.goudsmit-magnetics.nl

Magnetic drive pumps now available in ISO/DIN design

Following the launch of plastic-lined, magnetic drive process pump RMA in ASME/ANSI design two years ago, this manufacturer is now introducing the ISO/DIN version RMI (photo). This sealless magnetic-drive pump with fluoroplastic lining is available in eight sizes from 40-25-125 to 80-50-200 as a frame-mounted and close-coupled pump. The pump's pure PFA (perfluoroalkoxy) lining (3–5-mm thick) without carbon fillers offers very high chemical resistance, temperature resistance up to 150°C, full U.S. Food and Drug Administration conformity and inertness against pure fluids. Whereas the housing and impeller-magnet assembly are lined with pure PFA, pure polytetrafluoroethylene (PTFE) is used for the wetted part of the dual pump, which can also be made of carbon-fiber reinforced plastic. The pumps uses Safeglide Plus SiSiC bearings, which offer protection against dry running for 30 to 60 min. Flow capacities of up to 660 gal/min and delivery heads up to 360 ft are available. — *Richter Chemie-Technik GmbH, Kempen, Germany*
www.richter-ct.com

One analyzer now handles up to four measurement channels

The Promet I.S process moisture-in-gas analyzer (photo) is now available in a multi-channel format, with the introduction of the Multi-Channel Control Unit (MCU). This enables up to four measurement channels within a single 19-in. subrack unit. The Promet I.S channels can be combined with a sister product for moisture-in-liquid measure-

Note: For more information, circle the 3-digit number on p. 62, or use the website designation.

ment into the MCU to enable both gas and liquid sample measurements to be taken in a single analyzer. Four user-adjustable alarm points and two analog 4–20-mA outputs are provided as well as a digital RS485 RTU for connection to external devices. — *Michell Instruments Ltd., Ely, U.K.*
www.michell.co.uk

Confine products within production cycle with this bag dumper

This low-profile, bag dump station (photo, p. 32D-6) is an efficient way to minimize dust when introducing bagged products into a process. The unit incorporates a self-contained filtration system — featuring a low-maintenance, reverse-pulse cleaning system with an easily accessible single-cartridge filter — that provides 99.9% collection efficiency down to 1 micron. No external ducting or auxiliary fans are necessary. — *Hapman, Kalamazoo, Mich.*
www.hapman.com

A new hazmat suit gets NFPA certification

This company's first level-B chemical protective hazmat suit, OneSuit Shield, is certified to the National Fire Protection Agency (NFPA) 1994 Class 2 and 1992 standards. OneSuit Shield protects first responders from terrorism incidents involving the use of chemical or biological agents under NFPA 1994 Class 2, and under NFPA 1992, the new suit also offers certified protection against chemical liquid splash. OneSuit Shield features an open-face design with the self-contained breathing apparatus worn outside the suit, which allows the user to remain inside the suit until the mission is completed. Another feature is a unique mask interface (photo, p. 32D-6), engineered for seamless mask compatibility and optimal comfort and security. — *Saint-Gobain Performance Plastics, Merrimack, N.H.*
www.onesuittec.com

Stirred reactors for high-pressure chemistry research

The HPR Series reactors are designed for researchers interested in performing pressurized chemical reactions for synthesis or process development. The stirred reactors range in size from 50 mL to 4 L, and may be operated at up to 10,000 psi and 350°C. The reactors are equipped with a magnetically coupled impeller for optimal mixing. These benchtop models are ideal for studies on catalysis, polymerization, hydrogenation, oxidation, isomerization and dehydrogenation. Supplied as ready-to-use equipment, the reactors fit into a fume hood. — *Supercritical Fluid Technologies, Newark, Del.*
www.supercriticalfluids.com

Share data across systems with new modeling software

OpenPlant Modeler V8i 3-D plant modeling software enables realtime seamless sharing and data interoper-

ability across different organizations and systems using an internationally recognized standard (ISO 15926; Realtime Interoperable Network Grids) — the first commercially available software to do so, according to the developer. Designed to address workflow requirements of globally distributed-and-sourced plant projects, OpenPlant Modeler V8i and related products extend integration among multiple infrastructure disciplines and improve team collaboration. OpenPlant Modeler provides functionality for piping and equipment, and serves all other disciplines involved in real-world plant design projects, including civil, construction, environmental, HVAC, process design, electrical and others. — *Bentley Systems Inc., Exton, Pa.*
www.bentley.com

Avoid lumpy powder dispersion with this machine

The Megatron MT-VP powder dispersing/induction machine generates strong suction that prevents formation of lumps during the powder induction and wetting phase. The absence of lumps prevents plugging of the powder supply line, and improves the dispersing efficiency. Designed to be used both in pilot plant and production environments, the Megatron efficiently disperses powders into a flowing liquid regardless of density, and is appropriate for chemical, pharmaceutical and foodstuffs applications. — *Kinematica Inc., Bohemia, N.Y.*
www.kinematica-inc.com

Deliver gas pulses accurately with this instrument

The MicroPulse is a solid-state means of producing small pulses of various gases. It is intended as an alternative to mechanical syringes. The compact instrument contains a miniature heat exchanger and precision temperature controller that can be fitted into process-control circuits without adding volume. MicroPulse delivers up to 1.75 mL of gas at standard temperature and pressure. Advantages of the device include: no moving parts, no need for compressed-air source, and the application to which it is connected can initiate a flow pulse automatically at any interval. — *Intertech Development Co., Skokie, Ill.*
www.intertechdevelopment.com

Michael Smith Engineers

This series of centrifuge pumps is expanded

The Finish Thompson SP series of magnetic drive, self-priming centrifugal pumps has been extended with the addition of two new models. The SP10 and SP22 pumps (photo) deliver maximum flowrates of 12 and 45 m^3/h, respectively, and maximum discharge heads of 13 and 37 m. The pumps are available in a choice of polypropylene (PP) or polyvinylidene fluoride (PVDF), which results in a tough and durable, corrosion-resistant pump. Maximum operating temperatures are 82°C for the PP version, and 104°C for the PVDF version. The pumps are suitable for handling fluids with high specific gravities (up to 1.8), such as sulfuric and phosphoric acids, and sodium and potassium hydroxides. — *Michael Smith Engineers Ltd., Woking, U.K.*
www.michael-smith-engineers.co.uk

These pumps are ideal for oil, fuel, water and acid transfer

The UP Series of self-priming gear pumps is available in configurations that make them ideal for water processing, as well as oil, fuel or antifreeze transfer. The pumps also work well with seawater, acids and alkaline solutions. There are six models in the series, all with different flow and pressure capabilities. The pumps are available with nickel-plated bronze or PTFE gears, and stainless-steel or brass pump bodies. — *Clark Solutions Inc., Hudson, Mass.*
www.clarksol.com ■

Scott Jenkins and Gerald Ondrey

Focus

Gardner
Denver Nash

(Continued from p. 32)

Achieve large capacities with this compressor

Capable of capacities of 9,000 m^3/h, the Vectra XL 950 (photo) is the newest in a series of versatile and flexible compressors and vacuum pumps. The compressor can operate to 30 psig, and features single-point inlet and discharge connections to eliminate the need for manifolds. The compressor can be constructed from ductile iron or, starting in April 2011, 316L stainless steel. — *Gardner Denver Nash, Trumbull, Conn.*
www.gdnash.com

This compressed air dryer combines advantages

The Hybritec combination compressed-air dryer combines the energy savings of a refrigerated dryer with the very low dewpoints of a desiccant dryer. The air is first treated by a refrigerated dryer to remove most of the air's water vapor, then treated by a desiccant dryer to further reduce the dewpoint. The air is finally returned to a refrigerated dryer to be reheated and recycled to the air system. Hybritec dryers offer consistent outlet dewpoints, lower operating costs and longer desiccant life. — *Kaeser Compressor Inc., Fredericksburg, Va.*
www.kaeser.com

These compressors are designed for LPG

The LB Series of reciprocating gas compressors is designed specifically for liquefied petroleum gas (LPG) transfer and vapor recovery. LB Series compressors are oil-free reciprocating machines that handle a wide range of liquefied gases, and are especially well suited to unloading railcars, pressure vessels, transports and tanks that present poor suction conditions. The compressor operates over a temperature range of –10 to 100°C. — *Blackmer, Grand Rapids, Mich.*
www.blackmer.com ■

Scott Jenkins

Improving Information Management

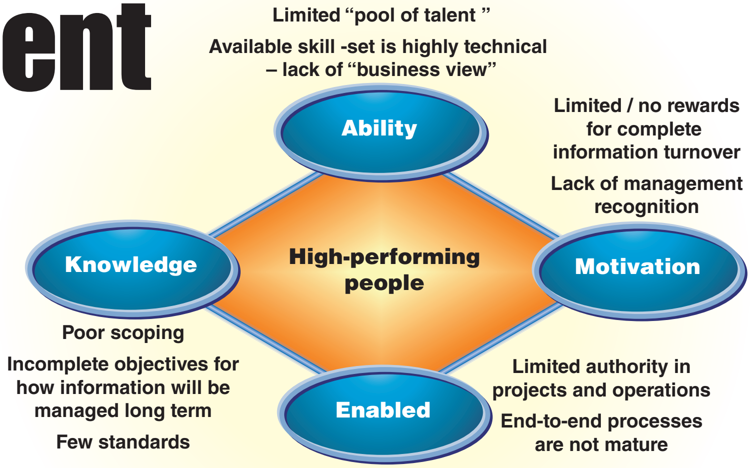


FIGURE 1. A number of job-scope issues, along with a shortage of qualified information management personnel affect the transfer of project information

Facility owners must take ownership of project information to reduce risk and improve quality when large-capital projects are handed over to project teams and facility operators

Graham Corsar
Saskatoon, Sask.

Maximizing quality, minimizing cost and meeting schedule milestones are ever-present challenges in large projects. While significant progress has been made in certain areas of facility construction, the management of project-related information continues to struggle. Information received by operators tends to be incomplete and inaccurate, while the cost of producing it remains high. Common reasons for suboptimal information management include: poor scoping, incomplete front-end-loading, high volumes of complex information, scarcity of expertise and a push toward faster project execution.

When information transfer is poorly managed, facilities face increased risks, including the following:

- Lower-safety environment, since inaccurate and incomplete information puts workers at risk — especially in highly automated systems and facilities
- Poor decision quality, resulting from inaccurate and incomplete data
- Project inefficiency, because poor-quality information results in poor-quality deliverables
- Regulatory non-compliance, as documentation regulations increase emphasis on auditable records

Companies will often accept these risks because of a mistaken belief that they have no other option. Companies think that they must sacrifice quality to achieve the desired cost and schedule. However, if facility owners take ownership of facility-related information from the earliest stages of a project, and if they actively manage its transfer to operations, they can maximize quality while meeting schedules and keeping costs down. Rather than treating information as a byproduct of a project, operators must approach information as a critical component of the facility. Information is as important as utilities, such as power, steam and natural gas.

The pathway to improving information transfer and decreasing risk begins with a better understanding of what factors cause today's information-management problems. It continues by applying a model that reduces risk by helping owner/operators take ownership of information early. The model consists of elements that allow facility operators to increase the quality of their information and reduce risk exposure. These elements mitigate or eliminate the factors working against effective information management during project turnover and handover.

For the purposes of this article, turnover — the process of transferring care, custody and control of the facility (including project information) from the project's contractors to the owner's project team or managing contractor — should be distinguished from handover, which refers to the transfer of control from the owner's project team to the facility's operators.

For example, turnover occurs when engineering firms submit final vendor's documentation to the managing contractor during construction, or when construction staff submits quality assurance records to the owner's construction management team

Recognizing the separateness of turnover and handover is critical to exerting control over information. In fact, distinguishing the turnover step as separate from the handover step provides an opportunity for quality management much earlier in the project.

CONTRIBUTING FACTORS

Several factors cause the elevated risk exposure that results from poor management of project information.

Personnel and job scope issues

A major challenge within the industrial capital-construction industry is

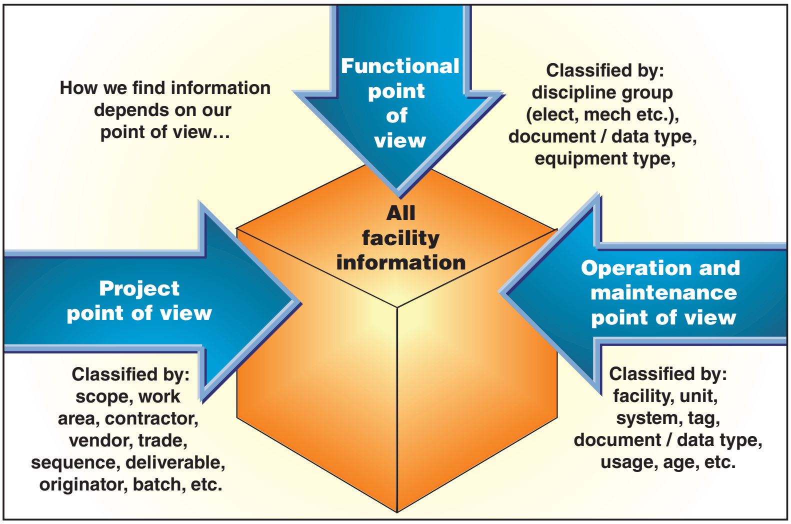


FIGURE 2. Different information-filing schemes can present problems for operators

a shortage of qualified information-management professionals. This occurs because historically, information management is not a career-building role. These positions have very narrow career tracks with few leadership opportunities, and the best candidates often move out of information management as soon as possible, seeking greater opportunity in information technology, design and project management.

In part, this narrow career progression probably arises from the relative newness of information management. Today, the role of "information manager" includes parts of the traditional roles of document control, computer-assisted design and drafting (CADD) coordination and engineering data management. At first glance, many positions in information management *look like* records management, engineering, or information services and technology roles. However, they don't fit neatly into any of those spaces. Rather, information management is a discipline that supports facility maintenance, operations and engineering; and is enabled by records management, information services and information technology.

Furthering the shortage of information-management personnel is a scarcity of high-performing people in the discipline. Information-management professionals don't get the experience and skills needed to rise to a high level. They tend to remain highly technical, but with limited "business vision" (Figure 1).

Also related to career path is the fact that document control roles are often viewed as "clerical" or "administrative," and recruited as such. Modern document control requires a much higher level of technical (especially engineering) knowledge, but people with that technical knowledge are not normally looking for clerical positions. They look for analyst and coordinator roles instead.

Personal motivation is unlocked by effective reward and recognition. But within engineering companies, there is rarely a reward for completing the last as-built, or turning over the last document to the operator. Also, decision-makers in operating and engineering companies are often unaware of the scale and criticality of information-management work, so many information-management professionals have the experience of being "forgotten until something goes wrong."

Information-management professionals are often three or more levels removed from project and facility management, and are often divided among two or more different functional areas. This limits their authority to make decisions and take the actions required to ensure complete and accurate information deliverables.

Poor scoping

Companies have adopted comprehensive project-delivery models to ensure adequate front-end loading, in terms of construction planning, procurement, engineering and the like. Despite these efforts, companies often still do a poor job of scoping information management deliverables at the beginning of a project. Why?

Poor (or non-existent) scoping in the area of information management is the norm. Most facilities lack clear expectations for how the information produced by a project will be managed over the long term, and standards are incomplete at best. With the lack of standards, expectations are vague and opportunities for individual success are limited.

Very few operating organizations have clear requirements for the final format, content and location of deliverables. When they do, those requirements often do not include the advanced databases and document formats used in modern engineering and project management. Finally, if advanced information formats are included, there is often a conflict between the configuration used by the operator and that used by the engineering firm.

Often, operations personnel do not have an opportunity to provide detailed input into the format and content of critical information deliverables. Then, by the time they do see them, hundreds of documents and hundreds of thousands of data points have been created, and it's too late to make structural changes to the deliverables.

Finally, documents and data are often not characterized as "deliverables" during front-end scoping. Rather, they are characterized as an outcome, or by-product, of the engineering and design. This leads to erroneous assumptions, such as "if the engineering is good, the drawings will be good," and "we only need the 3D model for the project."

Poor prioritization

The biggest impact on accuracy and completeness of deliverables can be made at the beginning of a project. Standards can be put in place and enforced, and deliverables can be developed in a manner consistent with future operational uses of the information.

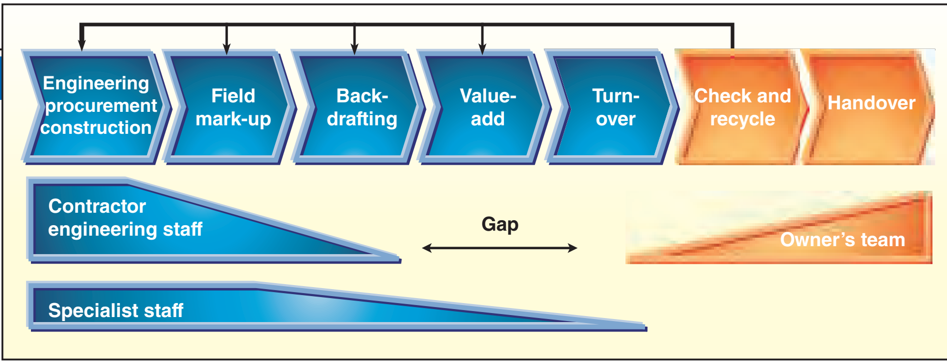


FIGURE 3. The traditional handover sequence detects errors too late in the process, after contractor engineers have left the project

But this can only happen if project teams treat information deliverables as high priorities, ensuring issues are resolved early — *before* they are too big to handle.

Partly as a result of poor scoping, projects typically experience significant unplanned costs when the true nature of the information deliverables is understood, and the effort required for achieving completeness and accuracy is realized. During the early days of a project, the format and content of information deliverables are low priorities, and are often never reported on or measured objectively.

In some cases, gaps are uncovered only when the project is ready to handover to the facility. If they are resolved, it is at a high cost, because gaps and inconsistencies are widespread. More often however, those gaps and inaccuracies are not resolved or not found at all. They are left for later, arising again when someone needs to use the information for operations or for a future project.

At that point they must be fixed, and the costs are high. Capital is expended in a reactionary way, to resolve issues as they arise. A better use of capital is to spend it up front, to put clear requirements and systems in place and monitor against those. The payoff from this investment is usually reached right away.

Industry challenges

A number of general developments in how large capital projects are carried out have had unintended consequences and have introduced unforeseen complications for information management. They include the following:

Higher information volume. The quantity of documents and data that a project engineer must handover to a facility at the end of a project has increased significantly. As more project work (especially engineering) is automated or aided by computer programs, more data are available. Facilities are increasingly using automation in reliability modeling, materials management and other business processes. Further, facility personnel are finding more re-use opportunities for project data after completion.

For example, 20 years ago, a paper-based spare-parts listing with a compressor was acceptable to a facility's material management group. They would take this list and enter it into their database manually. Today, there is an expectation that complete information on all spare parts be provided digitally, in a structure that is easily imported into the facility's system.

Furthermore, there has been a huge increase in the use of process automation in modern facilities. Each point in these systems requires extensive design documentation and data for maintenance. What was once a simple thermostatically controlled switch on an electric heat-tracer, is now a complex set of controls, for example. Facilities are also implementing mature management-of-change (MOC) processes. These require significant documentation as inputs, much of which would not have been maintained in the absence of an MOC process.

Quality management requirements, such as the ISO 9000 and 14000 standards, have also contributed to an increase in retained documentation. It is no longer acceptable to rely on fabricators or constructors to create and keep such documentation themselves. Now the same documentation is required by facility owners and retained by them for the life of the facility.

Faster project cycles and tasks. Fast-tracking is the new reality in capital projects. For many reasons, there is often simply no other way to execute. There is limited time to develop the information required to purchase, fabricate, construct and operate a facility. Because of these short timelines, imperfections in information are accepted or worked around. While the impact can be minimal, in a few of these cases, the impact can result in significant cost increase and schedule delays.

Also, as project schedules are compressed, huge volumes of project data are not "finalized" until close to the end of a project. In a system-based turnover model, approximately 75% of the systems reach completion within the last 10% of the schedule. As a result, sometimes 75–85% of all project information waits until the end of the project to be handed over, even though it has not changed much since earlier in the project.

Increased complexity. Perhaps the biggest challenge facing owners is the complexity of the information itself. Until the mid-1990s, document turnover was usually as simple as receiving a number of hardcopy (and sometimes electronic) data books. These included all information necessary to operate and maintain a facility. Quality assurance records were maintained by manufacturers and engineering companies, and the need for retrieval was rare. However, today's new and revamped facility is incredibly complex, and this complexity has translated into more information needed to effectively operate and maintain it.

Information-locating methods. On top of these complexities, the way projects file and classify information (by discipline, work package, system, vendor, construction area) doesn't work well for operations. If the data created by a project are to be of any value, they must be classified and organized in a way that makes sense to those looking for the information (Figure 2).

For example, project personnel create information and file it according to the phase of the project, scope of work, contractor, deliverable type and document number. However, operations and maintenance teams would look for that same deliverable according to the facility, unit, system, tag, document type and document number. A functional expert, such as a reliability engineer,

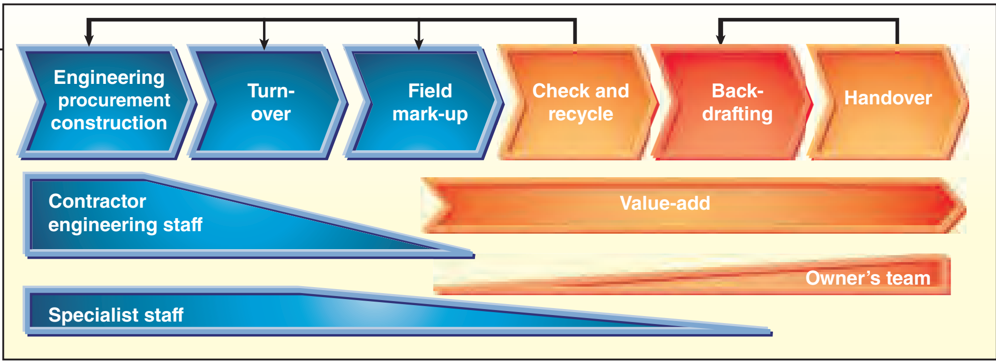


FIGURE 4. A re-sequenced process for turnover allows information deficiencies to be detected before contractor teams demobilize

would search by function, discipline, equipment type, location, document type and document number.

The detailed (or lower) classifications of each viewpoint are the same, but the paths to arrive there can be different. When these differences are applied to the thousands of documents a large operator may retain, the situation introduces major challenges to efficiency and risk management. Past approaches to filing information worked well for low volumes and paper-based information, but the methods are inefficient for modern facilities and digital tools.

Engineering and design tools. Design engineering systems are increasingly complex. Today's 3D models and process, instrumentation and electrical design tools contain massive volumes of information. While some return on this investment is gained when the deliverables are used during the project, even greater return is gained when the deliverables are re-used. Yet re-use requires that the data be maintained uncorrupted for the next project. This requires data warehouses to store and maintain the data collected from literally dozens of engineering tools.

With these tools, a given deliverable isn't just a document anymore. It is a representation of data from a number of tables in a particular format. So, while the information looks like a datasheet, it also includes the bits of data used to create the datasheet.

THE CONSEQUENCES

The effects of these information management challenges are both immediate and long-term, and can affect the viability of operating companies.

Immediate results

Poor scoping results in cost increase. If a scope is poorly defined, it will be poorly estimated, and will cost more in the end. High data volumes at the end of a project also increase costs — especially those resulting from field rework. Standard factored estimates for rework do not recognize the increased complexity or volume of information. So, even if re-work is inside of "normal" rates, those allowances do not allow sufficient amounts to make corrections in complex datasets, while ensuring that the data stay consistent. The factors used are based on no-longer-valid averages from past decades.

The shortage of qualified information-management professionals contributes to reduced efficiency, and therefore increased cost. When costs go up on a project, a decision must be made to either spend more or leave work undone. Often work is left incomplete, or transferred into operations. This is a major contributing factor in decreased quality.

In addition to incomplete work, vague and incomplete scoping leads to outright misses in scope. Examples include incomplete as-building, incomplete document turnover, lack of maintenance documentation, and others.

Decreased quality also results from shortages of qualified personnel. Where there is a lack of experience or competence, the quality of work is simply inferior, regardless of how many people are involved.

Longterm results

The immediate results pale in comparison to the longterm consequences. The safe, reliable and effective operation of industrial facilities depends on good decisions, and if people lack the tools for good decision-making, facilities' risk exposure increases.

Compliance management. Compliance management systems are becoming more common. This trend increases the need for up-to-date, accessible and auditable records. As discussed above, creating and maintaining records that meet these needs is becoming increasingly difficult for owner/operators. As the need for such records increases, and the ability to create and maintain them decreases, non-compliance events become more and more likely.

Safe work. Among the hundreds of factors that affect an individual's ability to work safely, accuracy of information is critical. Inaccurate information can create the conditions needed for critical risk exposure, such as in high-voltage equipment and process-control systems. These areas are increasingly complex and automated, so for an individual to work safely and effectively, updated records are necessary. Outdated records require that systems be de-energized or brought offline to facilitate safe work. Even then, when records are not up-to-date, workers are unable to rely as intended upon engineering controls, and therefore rely more heavily on protective equipment, increasing risk exposure.

THE MODEL

Clearly, increased cost in the shortterm and increased risk in the longterm are unacceptable to projects and owners. Yet the scenarios discussed here play out repeatedly on large projects. A change in the way owner-operators approach information is necessary; continuing the same information-management practices will only yield the same unacceptable results.

Based upon actual large-project experience, we have learned that there is a way to achieve acceptable quality while keeping schedule, cost and — most importantly — risk in line. This involves a fundamental change in the way owners approach their information.

Take ownership of information

The model for reducing risk by taking ownership is characterized by more active management of information on the part of facility owners, and incorporates a re-sequencing of tasks associated with turnover and handover, as well as a shift in focus toward factors that enable operators to make their systems work.

Re-sequence handover

Effective information management requires a re-sequencing in the cycle of as-building, turnover and handover. The handover step should be executed both before as-building is completed, and before contractor staff is demobilized from the job (Figures 3 and 4).

The challenge encountered with the conventional process is that deficiencies in information are not found until it is checked by the owner's team. However, by the time this occurs, the contractors' engineering and specialist (document management and others) teams are demobilized. The cost of remoblizing them to make corrections is prohibitive. The recommended model includes a new sequence.

The advantage of this new sequence is that it ensures deficiencies are identified and corrected before contractor teams are demobilized. Also, the value-added tasks are completed by owner's teams, in owner's systems, and in parallel with the process — reducing the need to transfer these data from contractors to owners.

This way, turnover is undertaken early, and documents requiring as-building are in effect "checked-out" for a short period of time to complete necessary updates. Turning this traditional process upside-down was not possible even 15 years ago. But today, information-management systems are much more mature, and information moves electronically. The effort of transferring documents for update is minimal compared with the benefits of higher-quality information.

Value-added activities

Value-added activities refer to those that transform information from project information into facility information. In other words, value-adds are the "stuff" that owners need to make their systems work, and that engineering companies don't necessarily need to make theirs work. Examples of this include document classification, filing and similar activities. Simply put, because an engineering company does not require an owner's filing system to be successful, they will likely do a poor job of placing documents into that filing system.

Active management

This model requires the owner to be more actively involved and to "run the show," especially in the areas of handover, turnover, as-building and value-added work. The work in these areas should not be blindly delegated to the engineering, procurement and construction (EPC) firm or construction contractor. Rather, facility-owners' personnel should take an active role in directly managing this work and ensuring it is completed.

Taking this approach requires that a new skillset be added to owners' project management teams. Staff should be assigned to managing the delivery of information, preferably as part of the project engineering and management group.

Shift focus

Using the model to reduce project costs also involves shifting focus to particular areas of critical importance, including "as-building." As-building is a critical step in making sure that information is up-to-date. There are two areas in as-building in which an owner should exert influence: First; ensuring that accurate as-built mark-ups are received from construction and fabrication groups; Second; directly managing the updating of engineering documentation to reflect those mark-ups.

Why should the owner care? The simple answer is: What gets measured and managed, gets done. As-building is the last opportunity an owner has to make a positive impact on the cost and quality of information. As-building leverages core competencies that owners have in maintaining operations information. Engineering companies' core competencies lie in the *creation* of information, not in the longterm *maintenance and use* of that information.

A more pointed focus should also be directed at the turnover of information from creators to the project team. Much information is "finished" early in the project, and with a formal turnover, can be evaluated and then accepted or rejected early in the project — thus reducing the massive volume of information at the end of the job.

Traditionally, information turnover is left until the end of the project. Doing so creates such a huge volume to be processed that effective assessment and acceptance is impossible. At that point, there is not sufficient time or money to ensure information quality. However, if efforts are made to turnover information when complete, the quality will naturally increase as a result of increased attention.

Get digital

In order to effectively reduce costs, improve quality and reduce risk, owners must get rid of the paper. Since all deliverables are created with electronic tools, the owner must manage the information with electronic tools.

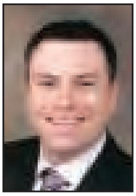
However, a note of caution is warranted. An ultra-mature, seamlessly integrated, end-to-end information-management application that is all things to all people is not required. In fact, such a thing does not exist. Owner organizations need strong processes to manage the digital deliverables, with a focus on quality and completeness. Only once a critical mass of owners with strong processes is built will the software companies be able to build strong end-to-end enabling products.

Outsource and off-shore

At the present time, owners need to look to India and other low-cost centers for a labor force with the ability, motivation, knowledge and enablement to fully realize the opportunities of the model. The work required to deliver accurate and complete information is generally not affordable at current engineering rates (approaching $100 per hour). India offers a highly trained and malleable workforce that is exceptionally strong in detail-oriented assignments where quality at a low cost is crucial. ■

Edited by Scott Jenkins

Author



Graham Corsar (E-mail: graham.corsar@yourlink.ca) is the document control manager for the Vault Program at Agrium's Vanscoy Potash Operations, near Saskatoon, Sask., Canada. Prior to joining Agrium last year, Corsar held information-management positions at Suncor Energy and Petro-Canada, as well as consulting organizations in Calgary, Alberta. He specializes in information management, with a particular focus on large capital projects and document-management systems.

SOLVING COMMON BATCH PROBLEMS: Controller-Based Systems

Chris Morse
Honeywell Process Solutions

Eliminating the server from the equation can lead to fewer problems, shorter cycle times and other factors that affect the bottom line

Agility, reliability, reporting and sharing of business information are among the key ingredients that have been dictated to modern-day control systems by the competitive pressures facing today's manufacturers. In short, production must be faster, more efficient and provide actionable data for operators. And the last thing anybody in this situation needs is a server failure. Where does that leave the traditional server-based batch systems and the manufacturers who use them?

Legacy systems

Server-based batch execution (Figure 1, left) has been around since the early days of the ISA S88 standard for batch processes. Server-based architectures met their expectations in the past and provided adequate control that lived up to original standards. Unfortunately, those standards for production have evolved, while these servers by and large have not. In fact, servers frankly, have become communication bottlenecks between the controllers that carry out the process actions and the operator who must interface with them.

What happens, for instance, when the server must go offline for maintenance or it inevitably crashes? This leads to loss of view and production, and in a worst case scenario, results in hazardous conditions that lead to a safety incident. Quite simply, legacy batch-control systems can no longer meet corporate objectives.

Over the last few years, the trend of moving from the centralized, server approach to controller-based batch (Figure 1, right) has gained traction as a viable alterative. In order to calculate the benefits and advantage of a controller-based approach, though, one must first consider the typical small batch plant (Figure 2).

The typical scenario

Such an operation might consist of a pre mixer, two reactors and two blenders with a number of raw materials and a flexible path through the plant. Let us assume that this hypothetical plant can produce 22 different products, and the valid paths through the plant may look like this:

Pre Mixer → Reactor 1 → Blender 1
Pre Mixer → Reactor 1 → Blender 2
Pre Mixer → Reactor 2 → Blender 1
Pre Mixer → Reactor 2 → Blender 2

To keep recipe maintenance at a manageable level, the batch system supports any valid route through the plant from a single recipe.

A recipe can be thought of in two parts: First, the procedural element of Procedure/Unit Procedure/Operation

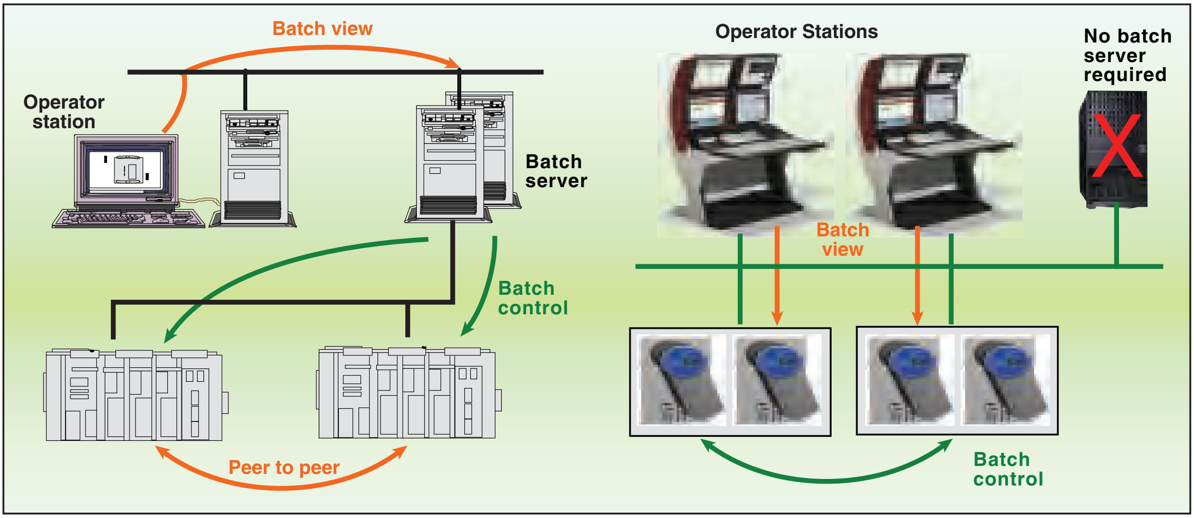


FIGURE 1. Server-based architecture (left) has lagged behind the evolution of batch standards. As a result, there is a trend to move toward controller-based batch execution (right)

and second, the formula values (times, temperatures and raw material quantities). The procedural elements may differ little between products. For example, if Material 4 is not used in Product 14 but is used in all others, then a formula value of 0 is entered and the Material 4 phase does not execute when Product 14 is being produced. The same procedure may, therefore, be used for multiple products. For the purposes of this example, assume Products 1 to 18 require procedure A and Products 19–22 required Procedure B.

All products, therefore, can be accommodated by building and maintaining 2 procedures and 22 formula sets. The procedure, formula and route through the plant are selected at run time. Equipment can be selected at any point during recipe execution before the unit procedure requiring that equipment executes.

The plant includes shared equipment that must be acquired and released by a batch. For example if Material 4 is being delivered to B1, and R2 reaches a point in the batch where Material 4 is required, the request from R2 for Material 4 is queued. If B2 also requires Material 4 before the addition to B1 is complete, this request is also queued. The requestors are allocated on a first-in, first-out basis.

Any equipment element, not necessarily an equipment module, can be declared as a shared resource. For example, only certain concurrent reactor discharge routes are valid. R1 to B1 concurrent with R2 to B2 are valid but not R1 to B2 concurrent with R2 to B1. The horizontal line between R1 and R2 is effectively a shared item of equipment and can be tagged and declared as such. If R1 is discharging to B2, the shared pipe must be acquired. If R2 reaches a discharge point to B1, the batch requests the pipe and queues until it is released by R1.

With all of this in mind, it's time to examine probably the most-obvious disadvantage of a server-based approach: system availability.

System availability

System availability of a batch plant is not typically scrutinized the same way as it may be in a continuous processing facility, as interruptions to production in a batch plant are generally perceived to be easier to handle than a continuous plant, where startup time is considerably longer. Considering the potential for negative impact, though, perhaps system availability in batch plants should receive more attention.

Taking into account the model above, for example, what is the estimated impact of an 8-h outage due to server failure? In the model, plant Material 2 has a short storage life and is part of the production of an upstream plant, which runs continuously. Only 6 h of storage capacity is available for Material 2.

Thus, the financial impact could look like this:

- Lost product with a sales value of 8 batches: $48,000
- Cost of shutting down upstream plant, which produces other products: $90,000
- Disposal of off spec production from incomplete batches: $ 5,000

That's a total of $143,000 for a single failure. Such a failure does not only hamper the production of salable product; it results in real business disruption and thus hamstrings overall competitiveness and profitability.

Further complicating matters, that scenario doesn't even take into account the potential non-financial impacts of safety or environmental incidents resulting from the unexpected process disruption, and the disruption to customer deliveries.

By contrast, how then does a controller-based system improve on these results? A controller-based system can improve overall availability because the batches are executed on a platform that lacks a single point of failure. This approach can drastically reduce the number of process interruptions that are caused by hardware failures.

But the benefits of controller-based batch can extend far beyond a reduction in failures. Moving batch execution into the controller level can actually streamline the process itself and thus improve actual business results.

Controller-based architecture

In general, a single controller-based platform on which all levels of the ISA S88 procedural model execute is a far more robust solution (Figure 3).

For starters, removing the server from the equation removes associated costs, security and maintenance

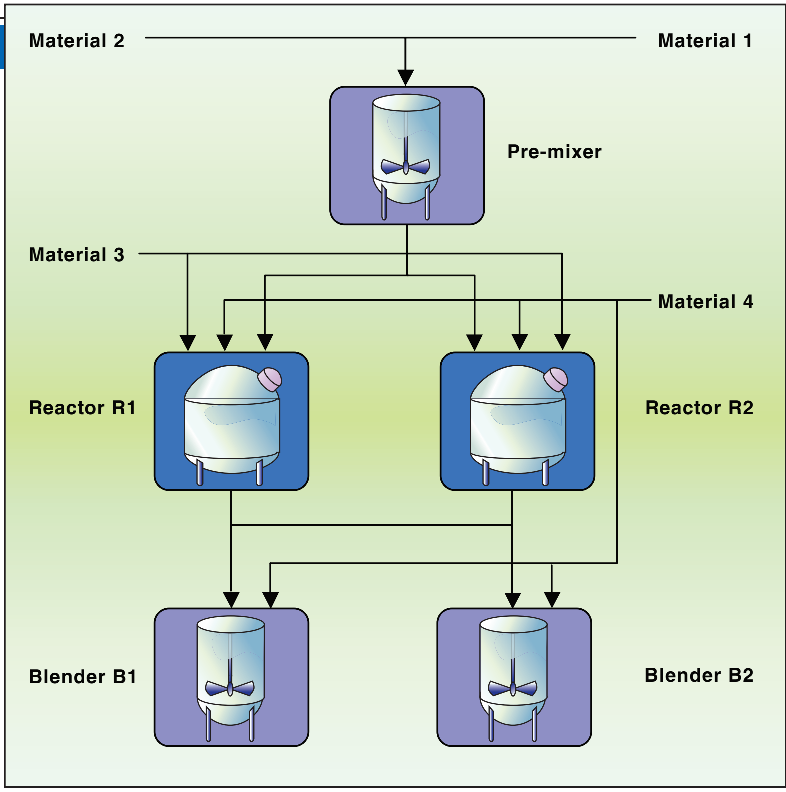


FIGURE 2. A typical batch scenario is shown here, as discussed in the text

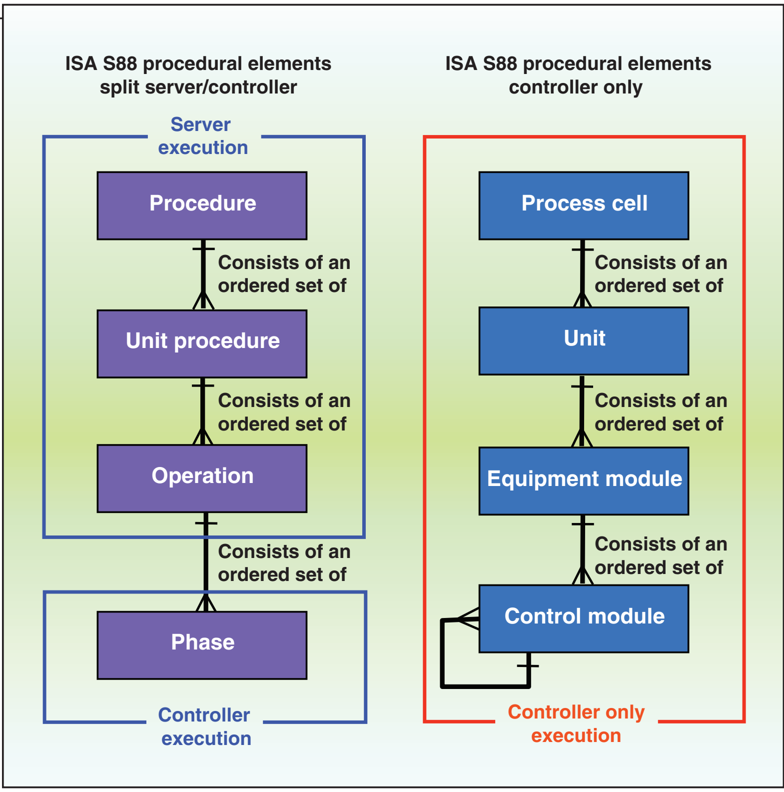


FIGURE 3. A controller-based platform removes the server with the associated costs, security and maintenance issues

issues, as well as communication latency. Because the batch functions are embedded into the system, plants are not forced to purchase — not to mention install or maintain — additional batch hardware or software packages. Standard displays are provided for all batch functions and can be customized to display data in the context of actual plant layouts. Multiple controllers also can behave as a single virtual controller of sorts, where any point can reference any other point without additional configuration for peer-to-peer communication, further reducing configuration efforts if plants elect to create redundancy using a well-proven, bumpless changeover mechanism. This enables the redundant controller to provide the view of the batch directly to the operator, as opposed to the operator having to rely on a batch server or any single point of failure.

A batch system may consist of multiple redundant controllers with transparent peer-to-peer connections. This allows plants to migrate controllers between releases without needing to completely shut down the system to change batches of control configuration. Removing the batch server also reduces batch cycle times, and communication "dead time" during phase transitions is significantly reduced because the transitions can take place in the same controller without the need for a separate server.

Eliminating the single point of failure has already been addressed, but let's take a more-detailed look at the host of other benefits.

Cycle time reduction

Product-sales values and market conditions can be volatile factors in determining a plant's profitability. Because the plant's overall control system is crucial in responding to these factors, the ability for communication exchange between the controller and a server is highly critical. This makes communication dead time a far greater hinderance when it comes to plant throughput.

Taking again into consideration our model plant, let us assume that batches are executed on a server:

- Additional production can be sold profitably
- Sale value of a batch is $3,000/ton
- A finished batch is 2 tons of saleable product
- Reactor is the throughput bottleneck in the 2 Reactor/Blender streams
- Average batch cycle time is 6 h for reactor and blender
- There are 340 plant operating days per year at 24 h/d
- Batches per year = ((340 x 24)/6) x 2) = 2,720 batches
- Number of recipe steps is 70

By moving batch execution from a server to the controller:

- The solution reduces step delay times from 12 s to 2 s
- Reduced batch cycle time to 5 h 48 min (70 x 10 s)
- Batches per year = ((340 x 24)/5.8) x 2 = 2,814 batches (3% increase)
- 94 additional batches per year = addition revenue of $564,000

Customer experience is that the flexibility of controller-based batch enables many other improvements including: reducing batch cycle time by up to 8%, raw material usage reductions and improving user productivity.

Ease of routine maintenance

All batch systems — server or controller based — require regular changes to accommodate things, such as equipment modifications, product specification changes and process improvements. Under the legacy, server-based approach, these changes could be quite complicated. These first-generation systems required plants to shut down the server or controller (or both) for configuration changes (both plant and network) and patch installation. Accordingly, making these changes required a window when there were no batches running in the plant. Because batch processes involve long residence times, this naturally resulted in required changes happening only once per year or in any process only with extensive planning and period of reduced production. Ultimately, this approach results in delayed improvements and other important changes that can't occur until a planned server shutdown.

One advantage that controller-based batch presents, though, is that plants are not required to shut down any elements to make these changes, so as to leave production largely unaffected. Tasks such as software migration, equipment and recipe configuration, and controller and hardware additions can all take place on process.

Another benefit of embedding batch into the system is that appropriately skilled DCS (distributed control system) engineers can maintain an entire system comprised of DCS configuration and maintenance functions. That is because these functions are managed by the same engineering tools and user environments. Legacy batch systems, though, required specialized skills and additional training due to involved add-on software packages. Further diminishing legacy systems' appeal is the fact that they are maintained in a different engineering and operating environment.

Our model plant could potentially save up to $155,000/yr through these increased efficiencies:

- Reduced support costs for server and batch application: $25,000
- Reduced training costs: $10,000
- Benefits from timely process improvements versus waiting for shutdown window: $30,000
- Lost production avoided through online changes versus planned shutdown: $90,000

Reporting and analysis

A common industry problem can be summed up by saying plants are drowning in data but starving for information. Batch processes certainly fall into this category.

This is largely because while plants must pay careful attention to creating and checking recipes, they aren't necessarily able to close the loop by analyzing the results of a batch or series of batches. For this reason, the chemistry of batch processes is often less understood than that of well-developed continuous processes. This is important because converting data into actionable information enables plants to improve process quality, consistency, yield, safety and the overall environment. And this, of course, contributes the bigger overall picture of improving plant performance and profitability. Thus, being able to gather historical data on batches and convert that data into actionable knowledge is another key demand placed on today's batch manufacturers.

Basic reporting requirements were previously met by legacy batch systems in the form of a database or process historian, and the outcome was a text file or printed report following the end of a batch. It goes without saying, though, that this method falls short of today's standard of instant, easy-to-use information. Pulling the information from a database or historian can be quite daunting.

Going back to our model plant, a user may want to investigate a quality problem with a batch produced four weeks ago. The user suspects a crystallization problem in the cooling phase, but the only reference point is the batch identifier. To manually view data on the batch, the user must know which reactor ran the batch, the date and time of the batch's start and finish and the tag names for temperature and pressure on the reactor. Finding this information requires an extensive search through multiple records, and then viewing a batch report and configuring a trend of pressure and temperature for the batch.

This can be one of the more tedious tasks facing a batch plant operator. Like in other industries, however, integrating control systems with automated reporting solutions significantly increases overall efficiency. In a controller-based batch solution, an automated reporting system uses the batch identifier as the only reference.

The first step involves reviewing a batch report showing data relevant to that batch. If this appears in order, a user can select the batch identifier and display a preconfigured trend for that batch. The reporting tools also use the concept of a "Golden Batch" (known to be within specifications, with which other batch trends may be displayed on the same axis for analysis.

Figure 4 shows the batch of interest (red) trended with other batches, and a difference in cooling profile can be seen. Having identified that this may be the source of the quality problem, the user can then quickly configure a batch query, which interrogates all the batch and continuous data for batches where the cooling time has been as long as the batch of interest and compiles relevant reports and trends. As a result, the user can initiate some process improvement activities after finding that other batches with long cooling times exhibited similar quality problems.

Common batch challenges

In general, controller-based batch systems are well-equipped to solve many of the common challenges to batch production that plants today see. The main advantages are detailed as follows:

Availability.

Challenge: "My process really needs a fully redundant platform to execute batches. Material 3 must be added to R1 or R2 as soon as conditions of temperature and pressure are reached. If a batch stops mid-execution, the process consequences can be hazardous or equipment can be damaged. Server-based batch platforms do not give the level of redundancy I need."

Solution: Controller-based batch runs on a fully redundant controller and requires no other hardware to be available for phase transitions to take place.

Modularity.

Challenge: "I see the benefits of S88, but I do need to execute parts of a recipe in some circumstances and not the whole recipe. The batch system I have today only executes complete recipes so if the operator wants to wash out a blender he has to run a complete recipe."

Solution: An operator can manually operate any element on the S88 hierarchy. In this example he or she can run a water addition phase, fill the blender, start then stop the agitator manually and run a discharge phase when complete.

Minimum batch cycle times.

Challenge: "My plant is fully sold at present so I am looking to reduce batch cycle times. I notice some really long dead time between consecutive batch steps. I would like to reduce those times to reduce my batch cycle time."

Solution: The communication dead time between server and controllers can result in two minutes of dead time between one phase completing and the next starting. This is unproductive time for the plant. Controller-based batch systems run in the much faster environment of the controller, and this time can be reduced to six seconds. Reducing this time alone can translate into increased plant throughput of up to 2%.

Operator acceptance.
Challenge: "Display ergonomics improve our operator's performance. They want to see batch information as part of a process display and to navigate away as little as possible"

Solution: Controller-based batch solutions with toolkits of display objects that can be embedded in user displays to show the operator what is happening to a batch in the context of familiar plant representation without navigating away to another display. Navigation to more detailed information is achieved with a minimum number of clicks.

Out of the box functionality.
Challenge: "Having a batch package added onto our DCS has cost more than we would like. There is additional training, support and expertise required. I want to see the batch functions built into the system and available out of the box."

Solution: When batch is embedded in control, there is no additional software package or hardware to purchase and learn about. Batch configuration and user interface is based on the same visual conventions and uses the same tools as the rest of the DCS. As a result, operators and other personnel experienced with the DCS find the batch functions straightforward and intuitive to use.

Flexibility.
Challenge: "Expectations from our customers and our own process chemists are that our batch plant produces a wider range of products in smaller quantities than we have in the past. To do this, the number of routine changes we have to make to our system is increasing. We want any changes to be made quickly without the need for a window of equipment downtime."

Solution: This reflects a challenge in flexibility seen across the chemicals industry. As with the rest of DCS, all changes to batch configuration can take place online without impacting production — no exceptions. Batch equipment configuration can be changed on process. Any hardware addition or removal including a complete controller can be achieved on process. Even a software release migration can be carried out with batches running.

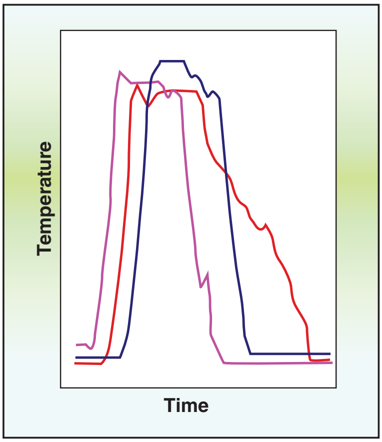


FIGURE 4. Trending of batch runs can be used to identify problems, such as poor crystallization due to slow cooling

Cross system communication.
Challenge: "We have a large batch system and need controller level peer-to-peer connections from any part of the plant to any part of the plant. With our current system, this involves a lot of setup particularly for shared material feeds and has to be thought about very carefully if we change anything. Making this easier would reduce our costs."

Solution: All controllers configured in a DCS server behave as a single virtual controller. The engineer, formulator or operator requires no knowledge of where any one element executes. Peer-to-peer communication between controllers is transparent to all users. This reduces the engineering effort to design and configure a batch system, can reduce the hardware cost and makes routine changes easier and quicker to implement.

Scalability.
Challenge: "We are building a new plant for a new product. If the product is successful we will expand it with additional units and increase the level of automation. In the past, this has involved moving I/O connections, moving blocks of code and a large reconfiguration and compiling activity. We do not want a costly, risky and disruptive modification like this to do when we expand."

Solution: With a DCS server behaving as a single virtual controller, expansion is easy. Controllers and I/O can be added on line with no disruption to the process. If it becomes necessary to move things around, this is simply an export and import without cutting and pasting of code. This enables an expanded plant to run sooner and cuts the cost of that expansion.

Concluding remarks

Today's competitive environment demands automation solutions that increase plant efficiency and profitability. Most batch plants face common challenges such as the following:

- Maximizing productivity from assets in use to meet demand
- Producing an increasing number of different products
- Maintaining the complex sequencing software in batch execution often on mature control platforms
- Reducing production costs to remain competitive

Control system performance can significantly impact a plant's bottom line, which means legacy server-based systems are quite simply not enough to meet these demands. Nor can they provide sophisticated control capabilities that enable increased throughput, lower costs and improve regulatory compliance while responding to customer demands for better product quality and faster delivery cycles.

Technology, however, now available for batch automation can help with these challenges to improve business results. Leveraging automation capabilities through simplified, cost-effective new technology while optimizing current investments is key to success — and this is the key value proposition that will make controller-based batch a valuable asset in improving plants' overall profitablility and competitiveness. ■

Edited by Gerald Ondrey

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E&C PROJECTS

Clarifying the Role of the Lead Process Engineer

The LPE can make or break a project, depending on how well he or she clarifies the project scope and produces thorough PFDs and P&IDs

John Lagace, LeadProcessEngineer.com

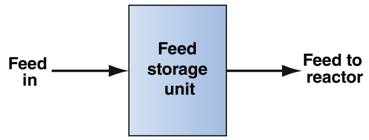


FIGURE 1. A simple block flow diagram is needed at the start of any capital-intensive E&C project

For any capital-intensive and labor-intensive engineering and construction (E&C) project, the lead process engineer (LPE) plays a pivotal role. To maximize the success of these complex projects, companies that hire E&C companies should be aware of the role that the E&C process engineering team plays in terms of helping to execute these projects. In a nutshell, the LPE is responsible for developing the project scope and managing the process team's costs and schedule.

When the LPE does this properly, the scope of the project is well-developed, the schedule is reality-based, and successful project execution can save a lot of time and money for the client. Conversely, when the LPE is not well-trained, or is forced to accept a poorly developed project scope and an inadequate or incomplete schedule for the front-end activities, the project can falter and decisions will be made late, when the resulting rework imposes a penalty on both project costs and schedule. This article discusses the basics of getting a project started successfully.

The LPE's first task is to understand the project's starting point so that he or she can estimate the hours that will be needed, build a schedule, and get the right team assembled to execute the job.

The questions listed below should be answered early in a project to avoid higher costs and delays. Answers to these questions provide the building blocks required for appropriate development of project scope. Typical questions are as follows:

- Which technology will be used?
- What standards and specifications will be used?
- What is the expected operating life of the facility?
- Can parts of the facility be reused (if the project is a revamp)?
- Can the process be simplified?
- Are existing utilities and infrastructure adequate to support the new project?
- Are exotic alloys needed, and if so, can lower-cost alternatives be used instead?
- What are the long lead items?
- Who are the client contacts to answer questions, make decisions and issue approvals?

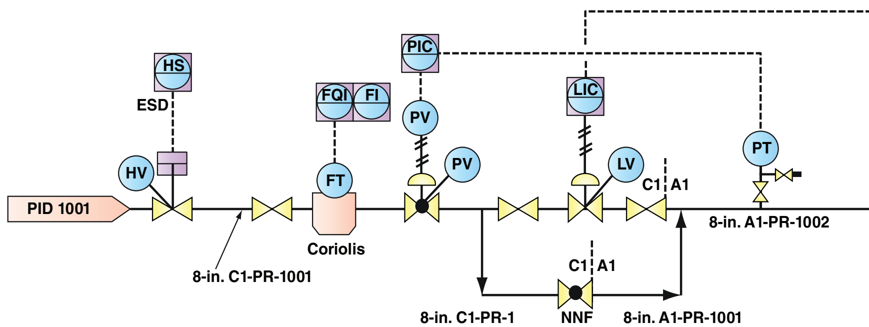
These questions should be pursued as soon as the project gets underway, irrespective of when the engineering team joins the project. For instance, a client can engage an E&C company to take on a specific engineering project at any point from the initial concept to the detailed design phase. No matter when the E&C company joins the project, the team members should seek solid answers to the questions listed above before making any commitments on proposed schedule and budget.

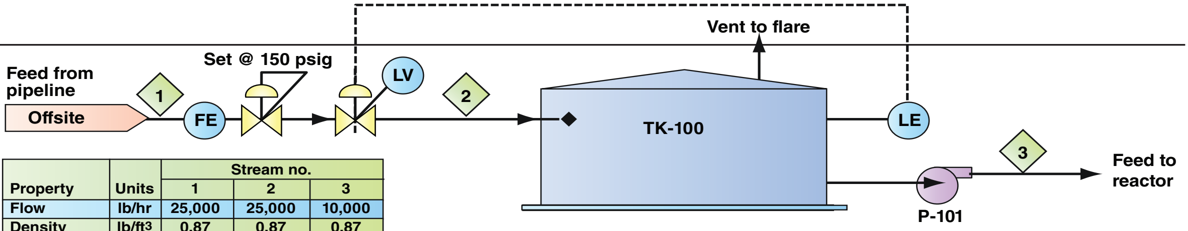
The role of the LPE

The major responsibilities of the LPE in any E&C project include:

- Determining and documenting the process scope of the facility
- Developing a process schedule
- Developing a cost estimate that is appropriate to the scope
- Determining manpower requirements to execute the process activities according to the schedule and budget
- Managing assigned personnel to execute the scope of work
- Reporting progress to managers and owners, and articulating ongoing expectations and oversight to the process team

Specifically, the LPE must:





Property	Units	Stream no. 1	Stream no. 2	Stream no. 3
Flow	lb/hr	25,000	25,000	10,000
Density	lb/ft^3	0.87	0.87	0.87
Pressure	psig	1,200	150	250
Temperature	°F	Ambient	Ambient	Ambient
Enthalpy	Btu/lb	120	-12	16

FIGURE 2. Shown here is a simple process flow diagram. Ideally, a PFD should be able to be sketched out on a single page, to summarize the key elements of the process or facility

- Plan the job
- Manage the schedule
- Manage the budget
- Manage client expectations
- Communicate with the project manager, project engineer and department head
- Manage the process design
- Manage the piping and instrumentation diagrams (P&IDs)
- Manage the process engineering team
- Manage interactions with the other discipline leads involved in the project

The importance of planning and maintaining schedule must be underscored — the LPE must make a realistic schedule and keep all participants on schedule. With so much responsibility, the LPE is often criticized by participants in other disciplines for being behind schedule because those related disciplines rely on the LPE's work to begin their own work. If the LPE plans the job well, documents everything adequately and executes according to the project needs, the negative comments won't stick.

Developing project scope

Reference [*1*] provides sound guidance for developing a comprehensive project scope. Although it was written for an owner company, the questions presented there and the resources provided for answering the questions have broad merit. In general, a good project scope includes:

- Details about throughput, chemistry and the technologies selected
- New or revised plot plans, process flow diagrams (PFDs; Figure 2) and piping and instrumentation diagrams (P&IDs; Figure 3) to show proposed project requirements (Note: Both PFDs and P&IDs are discussed in detail below)
- Colors can be used to indicate new, moved, modified, retired in place or demolished equipment and piping on the plot plan
- A preliminary equipment list with estimated sizing broken down by new, modified, moved and retired equipment
- A preliminary instrumentation list
- A preliminary tie-in list
- A list of required piping specifications by service
- Definition of the role and responsibilities of your company versus those of the other contractors and the owner
- Location where the engineering work will be done
- Known milestones that must be met and plans to meet them (For instance, what fixed dates, such as client turnarounds, must be met?)
- A summary of engineering standards, specifications and tools that must be used
- Description of all deliverables and activities, in as much detail as possible (here you should attempt to list them individually, based on what you know). Such information will provide a basis for sound schedule development and a great foundation for requesting additional time and budget once more is known. Table 1 provides a useful list to follow
- Studies that must be carried out, with individual schedules and cost estimates for each
- Plans for plant walk-throughs and plant data required, and the anticipated number of trips and hours that will be required

The information gathered as a result of this effort will provide a solid basis for your developing the project schedule and time budget.

KEY FOR FIGURES 2 AND 3

A1	150-lb pipe spec carbon steel	FV	Flow-control valve	PI	Local pressure indicator
C1	600-lb pipe spec carbon steel	HV	Hand valve, motorized	PT	Pressure transmitter
ESD	Emergency shutdown	LE	Level element	PV	Pressure-control valve
FE	Flow element	LI	Local level indicator	RO	Restriction orifice
FQI	Flow totalizer indicator	LIC	Level-indicator controller	TE	Temperature element
FT	Flow transmitter	LT	Level Transmitter	TI	Local temperature indicator
		LV	Level-control valve	TT	Temperature transmitter
		PE	Pressure element		

Note 1: Notations such as [8"-C1-PR-1] are line numbers that show line size, pipe specification, process service and line number

Note 2: Small squares with letters inside of the tank are the tank nozzle designations, which reference the equipment specification sheet

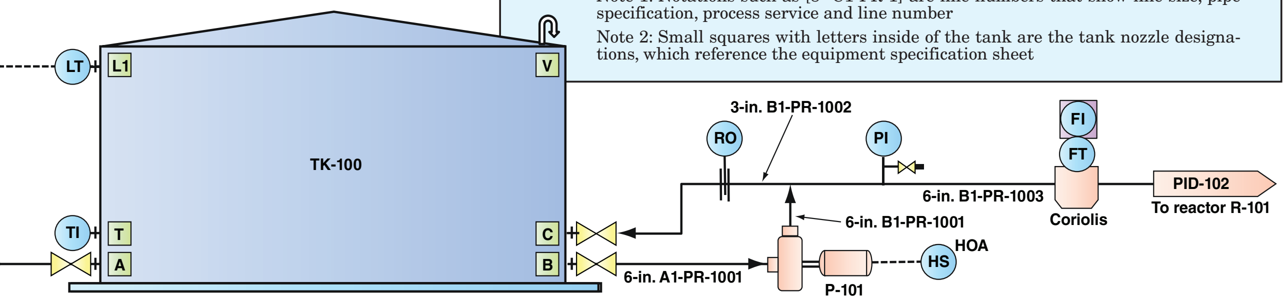


FIGURE 3. In a process and instrumentation diagram, specific details of the process are captured, to support the design and procurement process

TABLE 1. PROCESS WORK BREAKDOWN

Project phase*	Process activity	Project phase*	Process activity
Planning	• Pre-kickoff meeting organzation • Kickoff meeting agenda • Kickoff meeting travel planning • Kickoff meeting • Conference notes • Action-item list from kickoff meeting (becomes the project action-item list)	Process flow diagram (PFD) development	• PFD list • Development • Modification • Internal review • Review with client • Issue PFDs
Scope development	• Initial written scope • Internal scope review • Client scope review • Issue for approval • Issue to disciplines	Heat & material balance (H&MB) development	• H&MB development from simulation results • H&MB modification • H&MB review internal • H&MB review with client • Issue H&MB
		Metallurgy	• Metallurgical diagram or guide
Studies	• List of studies • Study deliverables list • Study estimate • Study schedule • Study execution • Client review and approval of study	Plot plan input	• Plot plan development • Squad check • Client review
Data collection	• Basis for engineering design document (BEDD) • Develop list of required data and documents • Obtain required data and documents from client or other resources • Receive and log data and documents • Set up transmittal log of receipts and sends or project controls	Piping and instrumentation diagram (P&ID) development	• P&ID list • P&ID development to Issue for Client Comments (IFCC) level • P&ID Modification • P&ID squad check IFCC • P&ID review with client (IFCC) • Update P&IDs • Squad check Issue for Approval (IFA) • P&ID review with client (IFA) • Update P&IDs • Squad check Issue for Design (IFD) • P&ID review with client • Update P&IDs • Squad check Issue for Construction (IFC) • P&ID review with client (IFC) • Update P&IDs
Meetings	• Weekly meeting note preparation • Weekly schedule update • Weekly budget update • Weekly update of project variances from plan and any change notices • Weekly update of required data and documents		
Process simulation	• Process simulation list • Process simulations • Process simultion client review and approval • Simulation design cases	Value-improvement process (VIP) reviews	• VIP meeting 1 • VIP meeting 2
		Constructability	• Attend constructability review meeting 1 • Attend constructability review meeting 2

*Note: The order of these items may change, and you may add or delete items as you wish. The goal is to develop a comprehensive checklist to guide your projects.

Developing project hours

Each activity and deliverable in a complex E&C project takes time to accomplish. Factors that influence the time required for each activity include the work complexity, the prior work experience of the team, the overall team capabilities, and whether the deliverable requires new documentation or modification of existing ones.

Process engineers are notorious for insisting that they cannot estimate time for their creativity. This is not correct. A trained LPE can estimate the time required for everything from simulation modeling to P&ID completion. The estimate may not be precise, but will provide the means to reconcile changes and ask for additional time later, if required. The goal is to document the preliminary assumptions and have the client and project manager accept your basis and your proposed schedule and time estimate.

LPEs should use a reasonable, consistent basis for estimating the number of hours required per document and per activity (Discussion of techniques for carrying out such an estimation is beyond the scope of this article). Table 1 provides a list of activities that are commonly required for complex E&C projects.

Scheduling your project

Your company scheduler can sit down with you once you have assembled your deliverable documents and have developed reasonable hour estimates and help you put together a schedule that shows your activities linked to those of other disciplines on the project. For maximum utility, have the scheduler put together the schedule in two forms:

1. Based on client dates, indicating milestones that must be met. This is the most aggressive schedule.
2. Based on the maximum-sized team you can reasonably expect on the project. This is the achievable schedule.

The estimate developed using the actual team size defines whether the milestones can be met, or whether adjustments are required. If the schedule cannot be met, this is the time to find out so that appropriate corrective measures can be taken. This can include adding team members, reducing the scope, or relaxing certain milestones.

PFDs with H&MB

As noted earlier, the PFD is a major document that is produced and managed by the LPE as part of any capital-intensive E&C project, and it represents the first step in virtually all chemical process and petroleum-refinery projects.

Process engineers routinely communicate complex ideas using illustrations. The PFD provides an easy means to convey a complex process design to other people following the natural flow of feeds and raw materials through the equipment and process.

There is no de facto standard for guiding the development of a PFD. Every E&C company has an internal standard of sorts, but it is always subject to a client's own wishes and standards. The discussion that follows is distilled from 35 years of professional experience. Several useful references are also presented (although none were consulted, studied, paraphrased or quoted during the development of this article).

Project phase*	Process activity
Process Safety Management (PSM) and Management of Change (MOC) reviews	• PSM/HAZOP preliminary • PSM/HAZOP final • List of action items • MOC process set up • MOC process activities
Piping line list input	• Obtain line list from Piping Dept. or develop one from the P&IDs • Size primary lines • Size minor lines • Update process information on line list • Internal review of line list • Update line list (line list is owned by the piping dept.)
Equipment design	• Equipment sizing calculations • Equipment sizing files • Equipment sizing calculation, internal review • Equipment sizing, client review • Sized equipment list • Metallurgical considerations • Equipment data sheets, Revision A (this is the process dept. information issued to the mechanical dept. for its input) • Equipment Engineering Design Summary (EDS) (explains the sources of data used and assumptions behind the equipment sizing) • Equipment data sheets, Revision A (client review) • Equipment data sheets, Rev. B • Transmittal to the mechanical dept. for its input to data sheets • Update for vendor comments and clarifications • Process review of the mechanical dept. EDS, Rev. D, for inquiry and purchase order

Project phase*	Process activity
Equipment design (cont.)	• Equipment technical bid evaluation • Process sign-off for purchase order (While this is not always practiced, it is important for highly engineered equipment such as towers, compressors, and so on)
Environmental	• Environmental review of process • Fugitive-emissions estimate • Flare-emissions estimate • Pump-seal requirements (per leak detection and repair, LDAR, requirements) • Wastewater considerations • Solid-waste considerations • Waste stream alternate disposition • Air and water permit data
Study report format	• Style (These formats are best saved as company styles and developed only once) • Writing • Assembly • Transmittal (hard copy and electronic)
Front End Loading (FEL) package format	• Style • Writing • Tables • Figures • Assembly • Internal review • Revision • Transmittal (hard copy and electronic)
Front end engineering development (FEED) package format	• Style • Writing • Tables • Figures • Assembly • Internal review • Revision • Transmittal (hard copy and electronic)
Archiving	• Archive list • Archive procedures • Archiving

In general, a PFD shows the following details:

- All process piping including major bypass or recirculation lines
- Flow direction
- A preliminary line size based on heat and material balance (H&MB) conditions
- Interconnecting lines to other units
- Major equipment and item numbers
- Primary control instruments

By comparison, PFDs typically do not show:

- Pipe specifications or line numbers
- Piping or mechanical specialty items
- Process control instrumentation beyond the primary element and related control valve
- Minor process lines
- Vents and drains, double blocks and bleeds
- Process safety valves (PSVs)
- Other piping and process details of a minor nature

In general, PFDs typically follow this familiar format:

- Streams enter at the top left of the first page and streams leave on the right side of each sheet
- All equipment components are represented in sequence and connected by lines representing the piping
- Major utilities are indicated in terms of where they are used in the process
- Lines are called streams and each one carries a unique number for reference. A diamond shape is typically used
- The stream numbers correspond to the stream summary in the H&MB in conjunction with the PFD
- A H&MB usually accompanies a PFD giving the stream composition, flowrate, physical properties and thermodynamic properties
- Each equipment item on the PFD has a unique equipment item number, and a corresponding equipment block summarizing such parameters as dimensions, capacity, horsepower, material of construction, design pressure and design temperature
- The equipment symbols identify the piece of equipment within reason and are typically understood by all process engineers
- The PFD has a revision number and date to indicate its current status
- Normal, minimum and maximum stream values are given for defined cases
- Each H&MB represents a "case," whether it is normal operation, start-of-run conditions, end-of-run conditions, or a particular product run

Most, but not all of these characteristics are usually found on a PFD. A typical PFD is shown in Figure 2 with all of these attributes.

Developing the PFD

PFDs can be developed using paper and a pencil, or they can be developed using a process simulator. All major simulators have PFD screens where the simulation is pieced together in a PFD format. How a PFD is developed isn't critical, but using a simulator can save the engineering team a lot of time.

A PFD is used to quickly understand a process, so it makes sense to minimize the sheets required to define the process. As a first pass, try to use a single sheet to show the entire process. Fifteen to twenty equipment items can occupy a single sheet. However, a complex tower with furnace, pump-arounds and a preheat and cooling train may be easier to understand if broken down onto a few sheets. Try it and see. There is no single answer.

I find it easy to use Microsoft Excel or Visio to develop a quick PFD. I do this whether a simulation will be used or not. It provides a useful template for piecing the process together.

Developing the H&MB is a critical aspect of PFD development. Some engineers may argue that the H&MB is separate from the PFD, but I believe that a PFD without an H&MB is an incomplete document and of little utility for further process development.

The H&MB must enable the process engineer to design the equipment and piping indicated. As such, it must go beyond the normal compositions, flows, temperatures and pressures, and provide useful information for extreme conditions that may be possible. To develop a H&MB, map out the possible scenarios to be considered, such as the following:

- Normal case
- Startup case
- Shutdown case
- Startup run case
- End run case
- Product A, B through *n* cases
- Runaway case

A typical H&MB is shown on the PFD (Figure 2). The HMB typically is located on the PFD or as a table following the PFD drawings.

These scenarios are required to identify materials of construction, extreme design conditions for equipment, stress conditions for piping and safety scenarios for PSV sizing. From these cases, the worst-case coincident conditions can be identified that drive the design. Following the principles in this article will give you the knowledge required to quickly develop a PFD.

The workhorse P&ID

The P&ID is a ubiquitous document in all E&C projects, although the acronym is defined in several ways. Some define P&ID as the process and instrumentation diagram, others define it as the piping and instrumentation diagram, and the word drawing can be substituted for diagram. At the end of the day, the P&ID is a pivotal document for any E&C project.

There is ongoing debate over whether a P&ID or a PFD is the best document to use, and in general, the particular phase of the project will dictate which is best. Both PFDs and P&IDs are required, each serving a particular need at a particular time.

In general, a P&ID is more involved than a PFD and represents a more mature level of project development — therefore it will be more costly to develop. A PFD, with its attendant heat and material balance (H&MB), provides the relevant details about process flows and compositions to support economic decisions made in the early front-end loading (FEL) phases.

The P&ID provides a summary of every plant component in sequential order. It contains the information and references necessary to define every engineered piping item, equipment item or specialty item on the P&ID drawing. Ref. 2 provides an excellent summary on how to develop P&IDs. Because it is so complete, this document has become widely used and is considered the gold standard for P&ID development.

As shown in Table 2, the project phases are designed to limit the capital commitment until a decision is made to proceed with or to cancel a project. The initial phases (Phases 1 and 2, called FEL 1 and FEL 2 in the table) are driven by process engineers because these are development stages where the question "what if?" is useful. In the first two phases, creative brainstorming is used to get all of the ideas out on the table.

In Phase 3 (FEL 3), consideration of options is complete and the project must close in on a final solution and nail down the scope to minimize future rework. At this point, other disciplines, such as piping, mechanical and instrument and electrical have input to the P&IDs to better define their discipline scope of work. The LPE's role must change from development of scope to maintaining the integrity of the approved scope.

Each subsequent phase of an E&C project commits more capital, so comprehensive information must be gathered as inexpensively as possible. This is the key to using P&IDs most effectively. Once the process has been defined in the P&ID, it is time to fill in the details required to make it workable in practice, and to identify all components that must be purchased.

Unlike PFDs, the P&ID also has a legal basis. Specifically, OSHA 1910.119(e)(6) requires updating and revalidation of process hazard analysis (PHA). Up-to-date P&IDs are a requirement of a PHA.

P&IDs are continually upgraded, with more details added, as a project proceeds. Each issue is worth some discussion with key stakeholders. The issue should always contain all of the details known and available, but each issue should have at least a minimum level of detail for it to have value at that point.

As noted, Table 2 defines the P&ID revision name at each project phase. The various issues are explained below.

The first issue is usually called "Issue for Comment" or "Issue for Information." It generally reflects the information that is known to the process engineer, with only minimal input from other disciplines. Input from other disciplines will come later, after the client has approved the basic process concept that is illustrated by the P&IDs.

Once the client comments are incorporated, further detail is added to provide all major information to the P&ID. These will be signed off by the client and are typically called "Issued for Approval PIDs".

This is the formal template for the final process push. Process hydraulics calculations are used to size lines, pumps and valves. Much more detail is now available, and this set of P&IDs is ready for process to issue to the other disciplines for detailed engineering to begin. They are called "Issue for Design P&IDs (IFD)."

P&IDs developed for the IFD contain all of the information possible that does not require detailed engineering input, such as actual tie point details, and vendor-supplied equipment details because the equipment is defined but not yet ordered. Piping runs are not yet determined, so decisions related to pumps and control valves are not final. Vendor information on most equipment is not yet known either.

TABLE 2. PROJECT PHASES						
Phase	**Business opportunity selection**	**Front-end loading 1**	**Front-end loading 2**	**Front-end engineering development**	**Detailed engineering**	**Construction**
Major documents	Block flow diagrams	Process flow diagrams	PFD preliminary P&ID	P&IDs issued for approval	P&IDs issued for construction	P&ID as built
Engineers involved	Process engineers	Process engineers	Process engineers, Some input by Piping, Instrument, Mechanical	All disciplines		
P&ID	Owned by process dept.	Owned by process dept.	Owned by process dept.	Owned by project or piping dept.	Owned by project or piping dept.	Owned by the client
Project % complete	Project % complete = 0.5	Project % complete = 1.5	Project % complete = 5.0	Project % complete = 10	Project % complete = 25	Project % complete = 100
Major activities	Planning	Planning	Planning	Executing	Executing	Executing
Capital committed	Capital commitment very small	Capital commitment very small	Capital commitment small	Capital commitment significant	Capital commitment large	Capital commitment huge

Source: Ref. [*1*] Piping and Instrumentation Diagram Documentation Criteria, PIP PIC001, Process Industry Practices, April 2008.

These "holds" will be filled in when the project staffs up for detailed engineering.

The P&IDs now are ready for process safety management (PSM) review. Some companies call these "Issue for Hazop." Updating the P&IDs with the PSM items will produce the "Issue for Design 2" or Hazop set of P&IDs for use during detailed engineering.

In many E&C organizations, custody of the P&IDS moves from process to the project engineer or piping coordinator after the PSM stage.

While there is some debate on this point, my recommendation is that process engineers should remain owners of the P&ID for optimal Management of Change (MOC) results.

The amount of information contained in a given P&ID differs for different client companies. Some P&IDs show a single equipment item and peripherals, while other P&IDs are more cluttered, showing, for instance ten to twelve equipment items. Between these two extremes is a wide array of P&ID formats. As noted earlier, Ref. 2 provides realistic guidelines for developing P&IDs with an appropriate amount of detail.

Several items can help to make P&IDs more manageable. For instance, every P&ID is made up of multiple drawing layers, each with a purpose.

These typically appear as different colors on a CAD computer screen, but print as black so that they appear to be a single layer.

The drawing can also include a hidden "CAD design intent layer" that does not print. This hidden layer can be used to explain the process intent of the P&ID and clarify any non-obvious design details. By way of example, I once designed a forced-feed reboiler. A particular butterfly valve (where the reboiler line entered the column bottom) was deleted during detailed engineering to save money. The intent was to delay vaporization until after the valve, to prevent fouling of the reboiler. When the design concept did not work during startup, I was called by the client and I explained the process necessity of the butterfly valve. A hidden CAD layer could have been used to convey the importance and intended use of the valve to the start up team.

I am a firm believer in the LPE approving all additions to P&IDs after the IFD issue, in order to control and centralize all revisions. Establishing the LPE as the central gatekeeper for all changes will ensure that consistency is maintained for all marks made, and will prevent potentially conflicting and inappropriate design changes from being implemented by other project participants. It also provides an audit trail to document who made what mark and for what reason.

A log book should also accompany the P&IDs to capture who made a change to the drawing, and to describe when and why it was made. Before the PSM stage, the log book is a simple log book. After the Hazop stage, this document becomes the MOC log. ■

Edited by Suzanne Shelley

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DuPont

Chemical Protective Clothing

ISO 16602 offers a much-needed, common global language for expressing protective clothing performance

Susan Lovasic, DuPont

Chemical protective garments are available in a wide variety of fabrics and designs that provide varying levels of protection for chemical process industries (CPI) workers, who may be exposed to chemicals in the form of vapors, liquids and particles. While other forms of personal protective equipment — such as safety glasses and hard hats — are highly regulated in the U.S. and Canada, the performance of chemical protective clothing is not. An international standard for classifying chemical-protective-clothing performance, however, is available in ISO 16602. The ISO 16602 Standard ("Protective clothing for protection against chemicals — Classification, labelling and performance requirements") provides an objective system to appropriately test, classify and label chemical-protective-apparel products. This article shows how ISO 16602 can be used as a tool to help with the selection of appropriate chemical protective clothing by providing an objective means of defining the performance of chemical protective apparel in situations involving potential exposure to chemical hazards.

Since, in North America, chemical protective clothing is not assessed by a comprehensive standard that quantifies the performance of garments, safety and health professionals selecting chemical protective clothing can only rely upon manufacturers' claims to choose the appropriate garments. Unfortunately, the performance of chemical protective clothing can vary by manufacturer and there is no established means to compare the performance of the various garments on the market. There is also no standard language in place that describes either the overall performance of the protective ensemble or the performance of the individual components against types of different chemical hazards. While some standards do exist for hazardous materials (Hazmat) emergencies, little regulation exists regarding routine industrial workplace applications. This void in recognized standards for everyday, industrial-use chemical protective clothing can lead to confusion and uncertainty for the safety professionals who must select the appropriate apparel for a given hazard or application.

Established by the International Organization for Standardization (ISO), the requirements outlined in ISO 16602 provide a common language for the performance of chemical protective clothing. While ISO 16602 was introduced fairly recently (in 2007), it is already recognized and accepted internationally, and is poised to become the global language for expressing chemical-protective-clothing performance.

By offering a common, global classification system and a standard presentation of the performance data, ISO 16602 can simplify the selection of chemical protective apparel by safety and occupational health professionals. Standardizing the protective clothing performance data allows objective evaluation and comparison of the various garments available in the marketplace, rather than relying solely upon vendors' claims. Although ISO 16602 permits a range of performance levels for a series of key properties, it also establishes a minimum level of performance for each major type of hazard. ISO 16602 defines performance requirements based on results obtained from existing test-method standards.

Many companies are multinational and do not have access to the same chemical protective apparel in each location even though they may be engaged in the same work tasks and therefore have the same needs for protective clothing. The ISO 16602 description of chemical-protective-clothing performance is vital to these businesses as it provides a common description that can be used to select the appropriate, locally available products. In addition, ISO 16602's objective performance levels allow safety professionals a means of identifying and selecting higher performing garments if a specific selection of chemical protective clothing fails to perform as intended in the work environment for which it was chosen.

Clothing selection

The first, and most critical, step to selecting appropriate chemical protective clothing is the completion of an accurate hazard assessment. By identifying the task, the surroundings, the chemical(s) and any hazards beyond chemical exposure, a hazard assessment provides a basis for understanding what chemical protective clothing and other personal protective equipment (PPE) are necessary to protect the workers operating in specific situations. The environment, chemical hazard and work activity must be considered in order to be able to select the most appropriate protective clothing — including the fabric, seam type and garment design — most suitable. Without adequate protection from chemical protective apparel and proper work practices, the likelihood of a worker being exposed to potentially harmful chemicals increases. Conversely, overprotecting a worker with unnecessary clothing can be burdensome and result in heat stress, reduced field of vision, restricted mobility and increased physical exertion for the wearer, as well as possibly higher purchasing costs for the employer.

Every work situation is unique, and the ISO 16602 Standard does not consider all specific hazards that may be present in the work environment. Safety and occupational health professionals need to consider hazards that are specific to their work conditions and then look to ISO 16602 to find the minimum requirements for chemical protective garments for that type of situation. ISO 16602 focuses exclusively on typical chemical hazards and protective clothing requirements for such hazards so the work situation may also require additional forms of PPE, such as footwear, gloves, face protection, fall protection and respirators. When evaluating protective clothing performance under ISO 16602, gloves, footwear and respirators must be included in the whole-garment ensemble testing. It is important to validate that any additional PPE components will work properly with the chemical protective clothing selected for use.

Types of clothing

The ISO 16602 standard is based upon a series of *types* and *classes*. ISO 16602 designates minimum performance levels for six types of chemical hazards. The type is the overarching system, with chemical protective clothing fitting into one of the six different types. The garment type designation is based upon the physical state of the hazard, for example vapors, liquids, aerosols or particles (Figure 1).

When setting the requirements for each type in ISO 16602, the entire garment is tested as well as the individual components. During the whole-garment tests, a "human subject" wears the test garment and accompanying PPE, such as gloves, boots and respirator. The human subject is exposed to non-hazardous test chemicals while in an enclosed chamber performing a series of movements meant to simulate actual work activities. This whole-garment testing is used to validate the barrier performance of the entire ensemble against a specific type of chemical threat (gas, liquid or particle). Whole-garment testing is conducted for each ISO 16602 type, and the exposure conditions for the tests vary according to the hazard defined by that type. Note again that the test chemicals are non-hazardous and are used to essentially determine how much of a similar phase chemical will leak into the suit. The whole-garment tests do not evaluate the chemical permeation properties of the garments. This is assessed in the class testing portion of ISO 16602.

For example, the Type 3 whole-garment test is conducted by having the test subject march in place with exaggerated arm-pumping movements, while slowly turning, in front of a high-pressure, high-volume liquid spray nozzle. This liquid is tinted with a dark color to be visible if it penetrates the test garment. Once the high-pressure liquid exposure portion of the test is completed, the outer test garment is carefully removed and an inner "indicator" garment is checked for evidence of liquid penetration, which is evident by staining from the dark liquid. Beyond the whole-garment tests, additional tests are conducted on the garment's fabric(s) and components to qualify the class performance level for the garment against specific chemical challenges and the physical demands of the task and work surroundings. ISO 16602 defines different class levels of performance for each type of protection as described below.

Classes of clothing

Within each of the six garment types, there are also requirements directed at the mechanical, barrier and basic flammability properties of the fabrics and components used to make chemical protective clothing. Laboratory tests are used to determine the mechanical durability, the barrier against specific chemical hazards, and ease of ignition of the garment materials. The results of these tests will fall into a unique performance class. Each type within ISO 16602 specifies a combination of barrier and durability tests levels, establishing a minimum performance class for each of the tests to meet the specific type requirements. A higher class rating denotes a higher level of performance for that property.

The flammability requirements outlined in ISO 16602 establish a minimum performance level of flame spread once the material is ignited; it does not qualify an ensemble as suitable for protection against heat and flame hazards. Specific evaluation of chemical protective clothing for heat and flame protection is not in the purview of ISO 16602. In North America, relevant standards specifically related to protective clothing for use near fire and electric-arc hazards are NFPA 2112 (Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire) and NFPA 70E (Standard for Electrical Safety in the Workplace).

The class tests are as important as the whole-garment tests described earlier. Both are integral to evaluating the overall integrity and expected performance of chemical protective clothing. This integrated rating system aids the selection of the most appropriate chemical protective apparel for specific work tasks. Testing the whole garment and the individual components separately ensures the sum of the parts is able to provide the appropriate protection.

Applying ISO 16602

While understanding ISO 16602 is critical for safety and occupational health professionals, it must also be applied consistently and correctly in the workplace. Consider the task of opening a flange in a process pipe containing a hazardous liquid under pressure. Even though the pipe should be depressurized and drained as much as possible before the flange is removed, this activity would likely require an ISO 16602 Type 3 garment for protection against the possibility that pressurized liquid exposure might occur. The Type 3 whole-garment jet test would have demonstrated the liquid-penetration resistance of the ensemble and the performance of the connections between the garment and other items of PPE, such as gloves, boots and respirator. The chemical barrier performance of the suit material and components should have been determined with permeation tests using

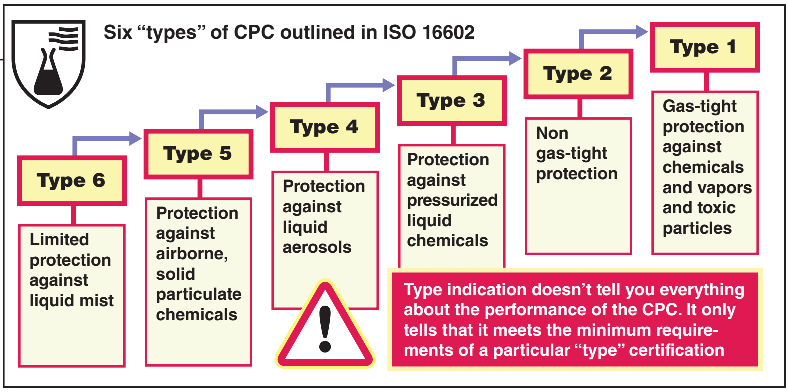


FIGURE 1. Do not assume that the terms "gas-tight" and "liquid-tight" refer to absolute barrier performance in chemical protective clothing (CPC). They can oversimplify the level of barrier provided by such garments. Instead, these terms should be considered as "vapor-protective" and "liquid-protective," respectively

the specific chemical that is in the process piping. The mechanical durability of the suit against the rigors of the job would have been assessed with the mechanical-strength laboratory tests outlined in ISO 16602. The hazard assessment and experience of the safety and occupational health professional would lead to the selection of a garment with a specific performance class in each of the barrier and mechanical tests, plus the type requirement.

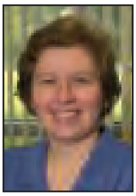
Another example can be found in work situations where exposure to hazardous particles might be likely to occur, such as sanding lead-based paints or mold-abatement work. For protection against airborne hazardous particles, a Type 5 ensemble would be the obvious choice, barring any other hazard or complications. Most likely, the garment would be a one-piece coverall with an attached hood, but nothing in ISO 16602 precludes a multiple-piece ensemble, such as a separate jacket, hood and pants. ISO 16602 does not specify the design of the ensemble; it specifies the level of performance. As with the previous case, the nature of the work task will determine the class of mechanical durability required for the work activity and environment. Note that the use of a respirator might also be required when working near airborne particles.

Labeling

In addition to delineating performance standards for chemical protective clothing, ISO 16602 also sets minimum requirements for the labeling and documentation for such garments. Chemical-protective-clothing labels complying with ISO 16602 must be permanently attached to the garment and should include the manufacturer's contact information, the garment style and model number, the ISO 16602 type, the date of manufacture, size and care instructions. With each garment, the manufacturer should provide complete instructions that include safety considerations and limitations, user instructions and all inspection, warranty, and maintenance information. Since ISO 16602 does not require third-party certification to claim compliance, the safety and occupational health professional should request and examine validation reports provided by the garment manufacturer that support all performance claims made for the chemical protective clothing. Use of ISO 16602 by garment manufacturers can provide objective information that enables safety and occupational health professionals to select the most-appropriate chemical-protective clothing for their employees. ■

Edited by Dorothy Lozowski

Author



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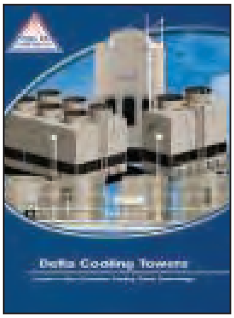

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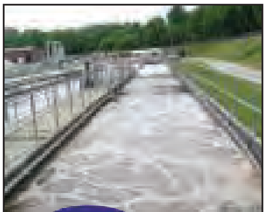

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16. Publication of Statement of Ownership
Publication is required and will be printed in the March 2011 issue of this publication.
17. Signature of Owner: Don Pazour Date: 2/10/11

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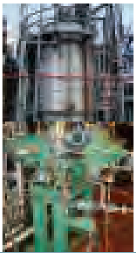

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BUSINESS NEWS

PLANT WATCH

Genzyme to build additional biologics manufacturing plant in Belgium

January 22, 2011 — Genzyme Corp. (Cambridge, Mass.; www.genzyme.com) plans to build an additional manufacturing plant in Geel, Belgium, to support the longterm growth of Alglucosidase alfa, known as Lumizyme in the U.S. and as Myozyme in the rest of the world, for Pompe disease. The new €250-million plant will include 8,000 L of production capacity, a complete purification installation, and ample room for additional future capacity expansions. Commercial approvals for the new site are expected to start in late 2014.

Samsung Engineering wins EPC contract for Dow/Mitsui plant in Texas

January 11, 2011 — Samsung Engineering (Seoul, Korea; www.samsungengineering.co.kr) has signed a $411-million contract for a chlor-alkali plant with Dow-Mitsui Chlor-Alkali LLC, a joint venture (JV) comprised of The Dow Chemical Co. and Mitsui & Co., Ltd. (Tokyo, Japan; www.mitsui.co.jp/en). The chlor-alkali plant will be located in Freeport, Tex. and will produce 816,000 ton/yr of chlorine. The contract is for engineering, procurement and construction services (EPC) and is scheduled for mechanical completion by January 2013.

Linde and Air Products form a JV to supply hydrogen chloride

January 13, 2011 — Linde Gas North America (Murray Hill, N.J.; www.lindeus.com) and Air Products (Lehigh Valley, Pa.; www.airproducts.com) have formed Hydrochlor, a 50-50 JV to supply high-purity anhydrous hydrochloric acid to the electronics and other industries. As part of the agreement, Hydrochlor will build a facility to process and package HCl supplied via pipeline from The Dow Chemical Co. (Midland, Mich.; www.dow.com). The new facility will be located on Dow's Freeport, Tex., site and is scheduled to be commissioned in the 2nd Q of 2012.

Evonik and GACL sign an MoU for multi-million Euro HPPO project in India

January 12, 2011 — Evonik Industries AG (Essen, Germany; www.evonik.com) and the Indian chemical company Gujarat Alkalies and Chemicals Ltd. (GACL) have signed a memorandum of understanding (MoU) on a proposed, multi-million-euro project for Dahej, India. The plans include a new hydrogen peroxide production plant by Evonik and a propylene oxide facility by GACL. The aim is to produce propylene oxide using the environmentally friendly HPPO (hydrogen peroxide to propylene oxide) process developed jointly by Evonik and Uhde GmbH (Dortmund, Germany; www.uhde.eu). The project is contingent upon the approval of the executive board and supervisory board of Evonik Industries AG.

Siemens to supply I&C system and turbines for solar-thermal power

January 11, 2011 — Siemens Energy (Orlando, Fla.; www.siemens.com/energy) will supply an instrumentation & controls (I&C) system and two steam-turbine generators for the Ivanpah solar-thermal power plant located in California's Mojave desert. The purchaser is BrightSource Energy Inc. (Oakland, Calif.). The three units for the Ivanpah project will have a combined installed capacity of approximately 400 megawatts (MW). The start of commercial operation of the Ivanpah Units 2 and 3 is scheduled for 2013. The plant's capacity will be sufficient to supply approximately 140,000 households with clean power and is expected to reduce annual CO_2 emissions by more than 400,000 tons.

MERGERS AND ACQUISITIONS

Clariant plans €2-billion acquisition of Süd-Chemie AG

February 16, 2011 — Clariant AG (Muttenz, Switzerland; www.clariant.com) is planning to acquire the controlling majority in Süd-Chemie AG. As part of the planned transaction, Clariant has come to agreements with the majority shareholder One Equity Partners (50.4%) and the family shareholders (approximately 46%). Clariant will acquire slightly above 95% of the outstanding shares. The total value of the transaction is €2.0 billion (CHF 2.5 billion). After all necessary regulatory approvals, including anti-trust, are obtained, Clariant expects the transaction will be completed in the first half of 2011.

GE completes $3-billion acquisition of Dresser, Inc.

February 1 2011 — GE (Atlanta, Ga.; www.ge.com) has successfully closed its $3-billion acquisition of Dresser, Inc., an energy infrastructure technology and service provider, based in Addison, Tex. The Dresser businesses will be integrated into GE's Energy Services and Power & Water business units.

Boehringer to sell Resomer business to Evonik

January 14, 2011 — Evonik Industries AG (Essen; www.evonik.com) and Boehringer Ingelheim Pharma GmbH & Co. KG (Ingelheim, both Germany; www.boehringer-ingelheim.com) have an agreement on the sale of the Resomer business (biodegradable polymers based on lactic and glycolic acids) to Evonik. The completion of the transaction is subject to various conditions and closing is expected early March 2011. Both companies agreed not to disclose information on the sale price.

SNC-Lavalin acquires engineering firm in Columbia

January 12, 2011 — SNC-Lavalin Inc. (Montreal; Canada; www.snclavalin.com) has acquired Itansuca Proyectos de Ingenieria S.A., an engineering firm based in Bogota, Colombia.

Lanxess makes its first acquisition in Argentina

January 12, 2011 — Lanxess AG's (Leverkusen, Germany; www.lanxess.com) wholly owned subsidiary Rhein Chemie (Mannheim, Germany), has acquired Argentina-based Darmex S.A. (Buenos Aires) — a leading manufacturer of release agents and curing bladders for the tire industry. Both parties have agreed not to disclose the purchase price. The transaction will close with immediate effect and does not require prior approval by any authority

Stamicarbon acquires Italian engineering company, Noy Engineering

January 6, 2011 — Stamicarbon B.V. (Sittard, the Netherlands; www.stamicarbon.com), the licensing and IP Center of Maire Tecnimont S.p.A. (www.mairetecnimont.it) has acquired Noy Engineering from Tecnimont.

BASF completes acquisition of CRI/Criterion's styrene catalysts business

January 4, 2011 — BASF SE (Ludwigshafen, Germany; www.basf.com) has successfully completed its acquisition of CRI/Criterion's global, styrene catalysts business. As part of this agreement, BASF has acquired CRI/Criterion's customer list, contracts and exclusive and non-exclusive licenses for intellectual property, including applicable patents and know-how in the field of styrene catalysts, as well as CRI/Criterion's styrene catalysts inventory. There were no plant assets associated with the deal. ■

Dorothy Lozowski

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March 2011; VOL. 118; NO. 3

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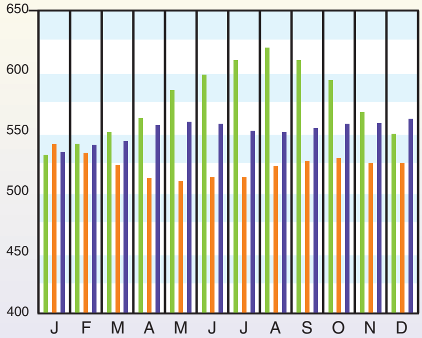
Equipment	674.7	669.0	618.4
Heat exchangers & tanks	627.2	618.3	554.2
Process machinery	627.6	627.0	597.9
Pipe, valves & fittings	854.3	847.0	776.3
Process instruments	426.2	426.1	417.5
Pumps & compressors	903.6	904.0	895.2
Electrical equipment	488.4	487.1	467.2
Structural supports & misc	696.3	688.2	620.0
Construction labor	328.5	328.8	331.2
Buildings	503.4	501.4	494.6
Engineering & supervision	335.6	336.1	343.2

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

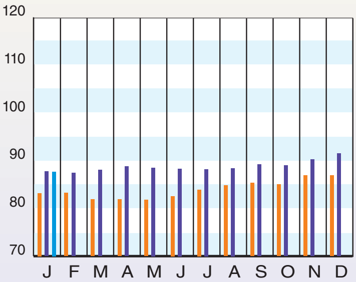


Starting with the April 2007 Final numbers, several of the data series for labor and compressors have been converted to accommodate series IDs that were discontinued by the U.S. Bureau of Labor Statistics

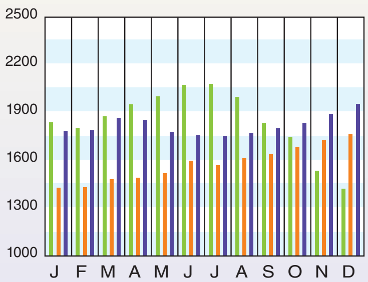
CURRENT BUSINESS INDICATORS

	LATEST	PREVIOUS		YEAR AGO
CPI output index (2007 = 100)	Jan.'11 = 91.4	Dec.'10 = 91.5	Nov.'10 = 90.2	Jan.'10 = 87.7
CPI value of output, $ billions	Dec.'10 = 1,956.6	Nov.'10 = 1,893.4	Oct.'10 = 1,836.7	Dec.'09 = 1,765.7
CPI operating rate, %	Jan.'11 = 74.0	Dec.'10 = 74.1	Nov.'10 = 72.9	Jan.'10 = 70.3
Producer prices, industrial chemicals (1982 = 100)	Jan.'11 = 291.4	Dec.'10 = 282.8	Nov.'10 = 276.0	Jan.'10 = 261.7
Industrial Production in Manufacturing (2007=100)	Jan.'11 = 92.6	Dec.'10 = 92.3	Nov.'10 = 91.6	Jan.'10 = 87.8
Hourly earnings index, chemical & allied products (1992 = 100)	Jan.'11 = 156.1	Dec.'10 = 154.6	Nov.'10 = 154.9	Jan.'10 = 150.4
Productivity index, chemicals & allied products (1992 = 100)	Jan.'11 = 124.9	Dec.'10 = 125.4	Nov.'10 = 123.3	Jan.'10 = 117.8

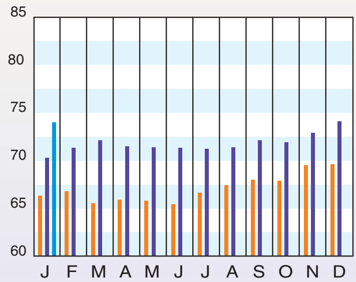
CPI OUTPUT INDEX (2007 = 100)



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



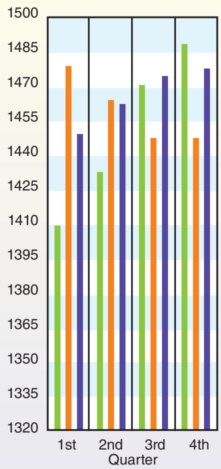
Current Business Indicators provided by Global Insight, Inc., Lexington, Mass.

MARSHALL & SWIFT EQUIPMENT COST INDEX

(1926 = 100)	4th Q 2010	3rd Q 2010	2nd Q 2010	1st Q 2010	4th Q 2009
M & S INDEX	1,476.7	1,473.3	1,461.3	1,448.3	1,446.5
Process industries, average	1,537.0	1,534.4	1,522.1	1,510.3	1,511.9
Cement	1,532.5	1,530.0	1,519.2	1,508.1	1,508.2
Chemicals	1,507.3	1,505.2	1,493.5	1,481.8	1,483.1
Clay products	1,521.4	1,518.3	1,505.6	1,496.0	1,494.3
Glass	1,432.7	1,428.5	1,416.4	1,403.0	1,400.1
Paint	1,545.8	1,542.1	1,527.6	1,515.1	1,514.1
Paper	1,447.6	1,444.5	1,430.1	1,416.4	1,415.8
Petroleum products	1,640.4	1,637.0	1,625.9	1,615.6	1,617.6
Rubber	1,581.5	1,579.3	1,564.2	1,551.0	1,560.5
Related industries					
Electrical power	1,434.9	1,419.2	1,414.0	1,389.6	1,377.3
Mining, milling	1,579.4	1,576.7	1,569.1	1,552.1	1,548.1
Refrigeration	1,809.3	1,804.8	1,786.9	1,772.2	1,769.5
Steam power	1,506.4	1,502.3	1,488.0	1,475.0	1,470.8

Annual Index:

2003 = 1,123.6	2004 = 1,178.5	2005 = 1,244.5	2006 = 1,302.3
2007 = 1,373.3	2008 = 1,449.3	2009 = 1,468.6	2010 = 1,457.4



CURRENT TRENDS

Capital equipment prices (as reflected in the *CE* Plant Cost Index) increased from November to December. Meanwhile, Global Insight's CPI operating rate and output index were relatively flat.

According to the American Chemistry Council's (Arlington, Va.; www.americanchemistry.com) most-recent weekly economic report at *CE* press time, inflation in the U.S. at the consumer level "remains tame," but inflation pressures are building in China, Europe and many emerging markets. Also, industrial production gains in overseas markets seem to be moderating, the report adds.

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


WHERE DO THE
KEY PLAYERS IN PHARMA,
BIOTECH AND MANUFACTURING
COME TOGETHER?