CHEMICAL ENGINEERING

April
2009

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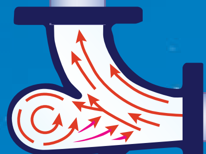


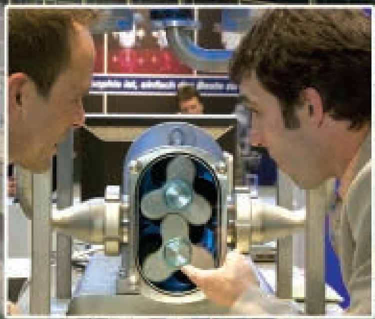
PNEUMATIC
CONVEYING
PAGE 53

ACHEMA Attracts The CPI

Achema
Show Preview

Optimizing
Pumping Systems

Recycling
Cathode Ray Tubes



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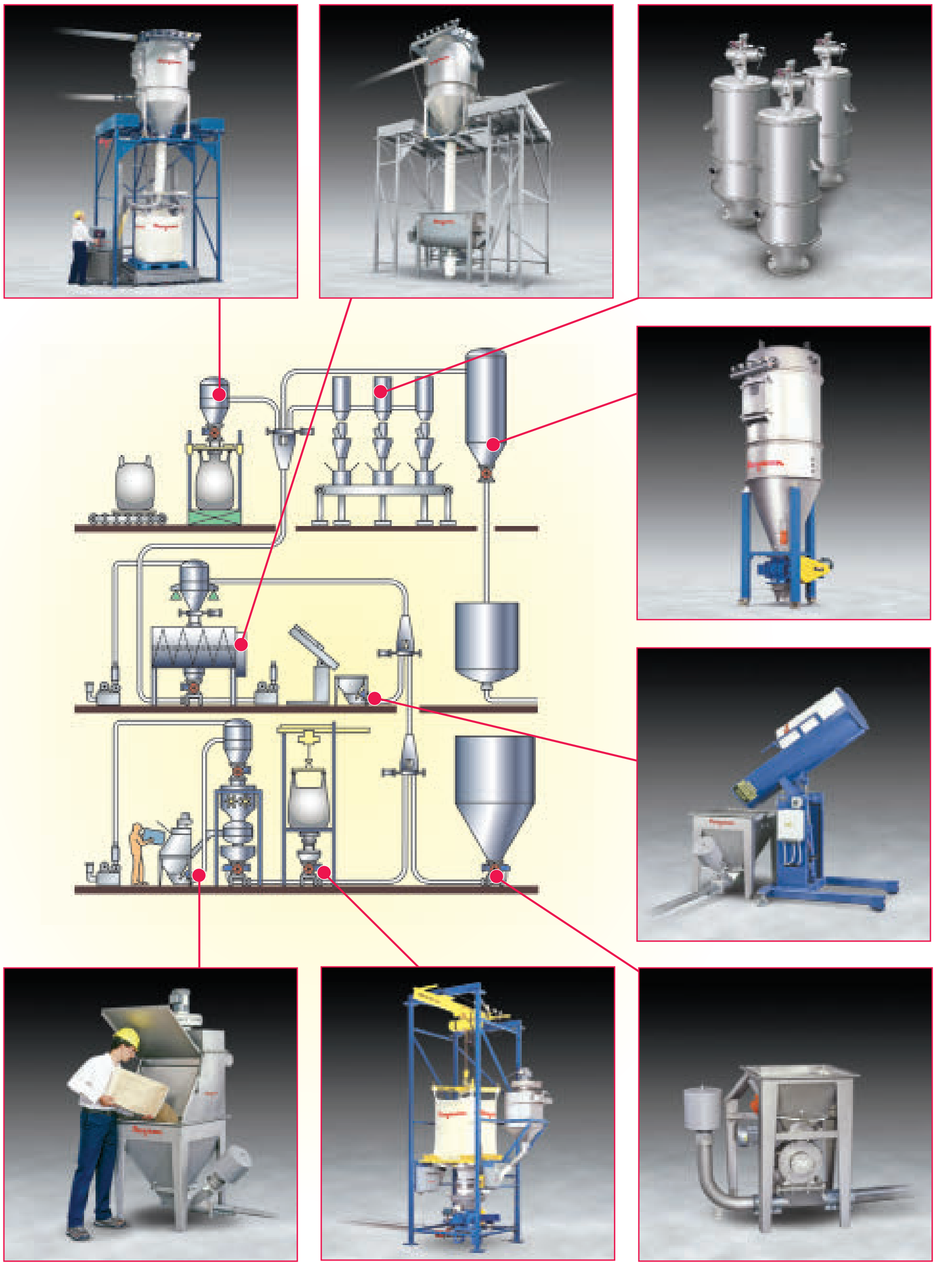

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This month's cover is composed of pictures from Achema 2006. Photos: Dechema / Helmut Stettin

Editor's Page

Achema maintains influence

Longtime readers of this magazine may notice that this month's cover theme marks an exception to a rule that has been fairly well established for awhile now. Topics on the cover of *Chemical Engineering* typically reflect one of the practical, how-to articles that we are known for — or at least point readers to an especially timely and lengthy news roundup article. This time, however, instead of focusing on a single comprehensive story or even a two-part series, we highlight an important thread that weaves throughout the issue.

That thread is Achema 2009, the 29th International Exhibition-Congress on chemical engineering, environmental protection and biotechnology, which will take place next month (May 11–15) at the colossal fairgrounds in Frankfurt, Germany. Notably contrary to what one would expect for a trade show in this economy, Achema does not show signs of unraveling.

Chemical Engineering's cover policies aside, Achema is in no way a new phenomenon to this magazine or to the global chemical process industries (CPI) that it serves. The first Achema was held in 1920 in Hanover, with 75 exhibitors. Initially touring different German cities for a short period, Achema has long been staged in Frankfurt on a frequency of once every three years.

Over time, Achema has grown substantially and is on course to attract 180,000 visitors this year — slightly more than the previous Achema did in 2006 under much better economic circumstances. The size of the event is truly remarkable. Dechema e.V., the show's organizer, expects around 4,000 exhibitors to fill 140,000 m^2 of net exhibition space — that is equivalent to more than half of the combined floor area of the Empire State Building here in New York. Meanwhile, Achema continues its trend toward becoming increasingly global, with around 46% of exhibitors coming from outside Germany, compared to 44% in the year 2006.

That said, it is easy to wonder what is holding Achema together when the CPI's travel budgets and other expenditures are reportedly being cut. That anomaly is the subject of our Newsfront on p. 34, which points out — among other things — that Achema has a reputation for being "the place" to showcase new technologies. See our Achema Show Preview (p. 40) for a brief crossection of the products to be unveiled there (also see March, p. 40, for Part I).

Even as prevalent as the Achema theme is in this issue, it is only the tip of the iceberg when it comes to our coverage of the event. *Chemical Engineering* delivers Achema-related news across our print and online platforms leading up to, during and after the show. The central clearinghouse for this content is our Achema Microsite (www.che.com/achema), which has been live since February. A comprehensive collection of Achema show news, new product summaries, exhibitor information and useful visitor links, this online show guide is a convenient resource not only for Achema visitors but for all chemical engineers who are simply curious about the important trends that are emerging in the CPI.

Of course, during the show, *Chemical Engineering* editors will once again be onsite to produce the official *Achema Daily*, in cooperation with Vogel Business Media GmbH. And, our Achema review in the July issue will round up the highlights of the show and summarize the many innovations that we witness there.

The point is, Achema's front and center status in this magazine might indeed be rare, but its influence is ongoing. For the connections that we make there, ourselves, go a long way toward achieving two chief, longterm goals: cultivating good sources for practical, how-to articles and keeping you informed of what is happening in and affecting the CPI. ■

Rebekkah Marshall

Letters

Solar plant construction

Thank you for your recent article, Solar's Second Coming, in *March* (pp. 18–21). I completely enjoyed it. Your information was relevant and quite well presented.

Perhaps you might consider a follow-up story on how the components and their materials of construction are affecting solar plant efficiency and construction costs. The chemistry and metallurgy that are being used in struts, frames, and storage devices are, in many ways, as interesting as the plants themselves.

Again, congratulations on a terrific article.

Brian Courtney, Senior PR Executive
Schubert Communications, Inc., Downingtown, Pa.

Hydraulic Institute seeks input on ANSI pump standards

The Hydraulic Institute (HI; Parsippany, N.J.; www.pumps.org), under the approval of the American National Standards Institute (ANSI; Washington, D.C.; www.ansi.org), is seeking qualified individuals in North America to participate in the review process for the draft of two updated standards:

1. Standard ANSI/HI 4.1-4.6, Sealless Rotary Pumps for Nomenclature, Definitions, Application, Operation and Test. This standard covers the unique features of sealless rotary pumps and includes sections on types and nomenclature; definitions; design and applications; installation, operation, and maintenance; and test. Because of the variety of rotary pump configurations available and the broad range of applications, familiarization with Hydraulic Institute Standards ANSI/HI 3.1–3.5 Rotary Pumps for Nomenclature, Definitions, Application and Operation and ANSI/HI 3.6 Rotary Pump Tests is recommended.

2. ANSI/HI 5.1-5.6, Sealless Rotodynamic (Centrifugal) Pumps for Nomenclature, Definitions, Application, Operation and Test. This standard applies to canned motor pumps and magnetic drive pumps. Excluded from the scope of products are submersible wastewater pumps. The standard includes types and nomenclature; design and application; installation, operation and maintenance; and test.

Individuals and organizations directly and materially affected by either standard are asked to contact HI. These parties include pump users and specifiers, producers, standards developers, government agencies, and general interest groups. HI is currently assembling a canvass list of all parties interested in reviewing the drafts. These lists will be submitted to ANSI in order to meet its open canvass requirements.

To participate in the ANSI/HI canvass, contact Karen Anderson, administrator, Technical Affairs, at kanderson@pumps.org or (973) 267-9700 x 23.

Circle 07 on p. 70 or go to adlinks.che.com/23013-07

Calendar

NORTH AMERICA

Residuals and Biosolids 2009. Water Environment Federation Specialty Conferences (Alexandria, Va.). Phone: 703-684-2400, ext. 7739; Web: wef.org
Portland, Ore. **May 3–6**

22nd Annual Technical Conference & Exhibition. American Filtration and Separations Society (Richfield, Minn.). Phone: 612-861-1277; Fax: 612-861-7959; Web: afssociety.org/spring2009/
Bloomington, Minn. **May 4–7**

World Innovation Forum. HSM Group (New York, N.Y.). Phone: 866-711-4476; Web: hsmglobal.com/us
New York, N.Y. **May 5–6**

Plastics in Underground Pipes 2009. Applied Market Information (AMI) LLC (Reading, Pa.). Phone: 610-478-0800; Web: amiplastics-na.com/events/
Orlando, Fla. **May 6–7**

19th Annual Joint ISA POWID/EPRI Controls and Instrumentation Conference, and 52nd Annual POWID Division Sympostium. ISA (Research Triangle Park, N.C.). Phone: 919-549-8411; Web: isa.org/powersymp
Chicago, Ill. **May 12–14**

11th Annual Electric Power Conference & Exhibition. Trade Fair Group (Houston, Tex.). Phone: 832-242-1969, ext. 306); Web: electricpowerexpo.com
Rosemont, Ill. **May 12–14**

IETC 2009: 31st Industrial Energy Technology Conference. Texas A&M University, Energy Systems Laboratory (College Station, Tex.); Phone: 979-847-8950; Web: http://ietc.tamu.edu
New Orleans, La. **May 12–15**

2009 BIO International Convention. BIO International (Washington, D.C.). Phone: 202-962-6655; Web: convention.bio.org
Atlanta, Ga. **May 18–21**

19th Annual Fugitive Emissions/Leak Detection and Repair (LDAR) Training and Symposium. The International Society of Automation (Research Triangle Park, N.C.). Phone: 919-549-8411; Web: isa.org/ldar
Austin, Tex. **May 19–22**

55th International Instrumentation Symposium. The International Society of Automation (ISA; Research Triangle Park. N.C.). Phone: 919-549-9418; Web: isa.org/iis
League City, Tex. **June 1–5**

Human Error Prevention (a) and Root Cause Analysis (b) Seminars. High Technology Seminars (Cold Spring, N.Y.). Phone: 845-265-0123; Web: hightechnologyseminars.com

Calendar

Albuquerque, N.M. **June 9–10 (a), and June 11–12 (b)**

Atlantic Design & Manufacturing Show. Canon Communications LLC (Los Angeles, Calif.). Phone: 310-445-4200; Web: atldesignshow.com
New York, N.Y. **June 9–11**

AWWA Annual Conference and Exposition 2009. American Waterworks Assn. (Denver, Colo.). Phone: 303-347-6140; Web: awwa.org

San Diego, Calif. **June 14–18**

Honeywell Users Group Americas Symposium. Honeywell Automation & Control Solutions (Phoenix, Ariz.). Phone: 877-466-3993; Web: honeywell.com
Phoenix, Ariz. **June14–19**

13th IACIS International Conference on Surface and Colloids, and 83rd ACS Colloid and Surface Symposium. International Assn. of Colloid and Interface Scientists (Delft, Netherlands), American Chemical Society — Division of Colloid and Surface Chemistry, and NSF Industry/University Center for Surfactants at Columbia University (New York, N.Y.); Phone: 203-569-7909; Web: innoresearch.net
New York, N.Y. **June 14–19**

Recycling Metals from Industrials Waste. Colorado School of Mines (Golden, Colo).; Phone: 303-273-3321; Web: mines.edu/outreach
Golden, Colo. **June 23–25**

EUROPE

Nanofair 2009. VDI Wissensforum GmbH (Düsseldorf, Germany). Phone: +49 (0) 211 62 14 201; Web: nanofair.com
Dresden, Germany **May 26–27**

Electronics & Battery Recycling 2009. ICM AG (Birrwil, Switzerland). Phone: + 41 (0) 62 785 1000; Fax: + 41 (0) 62 785 1005; Web: icm.ch
Toronto, Ont. **June 24–26**

17th European Biomass Conference & Exhibition. ETA-Renewable Energies (Florence, Italy) and WIP-Renewable Energies (Munich, Germany); Phone: +39 055 500 2280; Fax: +39 055 573 425; Web: conference-biomass.com
Hamburg, Germany **June 29–July 2**

ASIA & ELSEWHERE

23rd International Activated Carbon Conference and Courses. PACS Testing and Consulting (Coraopolis, Pa.). Phone: 724-457-6676; Fax: 724-457-1214; Web: pacslabs.com
Johannesburg, South Africa **May 26–27** ■

Suzanne Shelley

Chementator

Edited by Gerald Ondrey April 2009

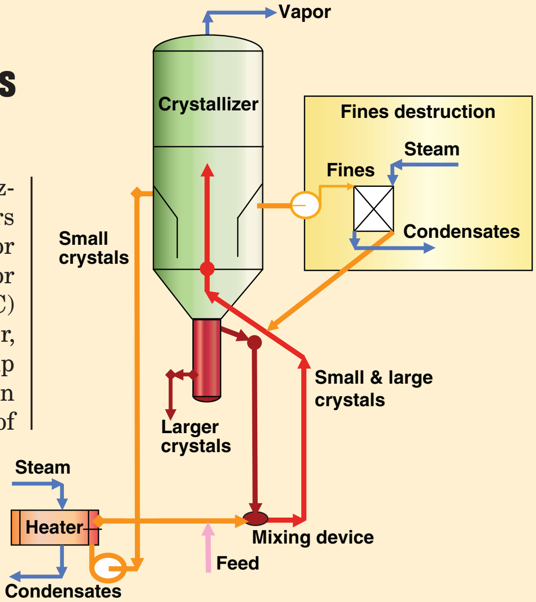
This new crystallizer reduces damage to larger crystals

With the exception of Oslo-type crystallizers, the main commercial crystallizers are agitated systems that use an agitator [agitated tank or draft-tube baffle (DTB)] or a circulation pump [forced circulation (FC) crystallizers]. In such systems, however, large crystals become damaged by the pump or impeller, which leads to the generation of fines, says Michel Malfand, president of Crystal Evap consult (Draveil, France). As a result, FC units typically have an elutriating leg, and most DTBs have some type of "fines killer", he says.

Malfand has patented a new crystallizer (diagram) that is based on a different hydraulic concept, whereby only the medium-sized crystals are in contact with the agitating device; the larger crystals are indirectly circulated without contact. To increase the particle size, the system is also equipped with a leg and, if necessary, a fines killer.

A pilot crystallizer has been constructed capable of producing 20–40 kg/h of crystals with a water evaporation rate of 40–120 kg/h. The hydraulic concept has been validated, achieving improved crystal size distribution and lower coefficient of variation (CV). In tests performed with product "A", the crystallizer produced homogeneous crystals with a d_{50} of 500 microns, compared to dispersed crystals with a d_{50} of 200–250 microns produced in conventional crystallizers, says Malfand. Because fewer fines are produced, there is less recycled material from the dryer, the air treatment and the screen. As a result, the new crystallizer is expected to save energy and capital costs, he says. And because there is no pump or agitator, scaleup is very easy, adds Malfand.

Last month, the firm started tests for a potential customer; the results of the test could lead to the construction of a crystallizer with a 40,000 metric ton per year (m.t./yr) capacty.



Calibration-free pH

The world's first continuously self-calibrating pH measurement system was previewed at the Interphex show in New York last month by Sensorin (Burlingame, Calif; www.sensorin.com). According to the manufacturer, all currently available pH sensors including glass, optical and ion-selective field effect transistors (ISFET) require calibration, whereas Sensorin's approach, which is internally referenced and based upon amperometric pH sensing, does not. This is a plus for online monitoring of pH-sensitive applications.

The Sensorin solid-state design combines two electrodes onto a proprietary substrate on the same probe's surface. Both electrodes, therefore, contact the aqueous solution to be analyzed. The reference electrode is a pH-insensitive redox couple and its potential is a constant signal at a constant potential in solution. The measurement electrode is a pH-sensitive redox couple and its potential varies as a function of hydronium ion concentration. The sensing is performed by measuring

(*Continues on p. 14*)

Sonopolymerization as a means to manufacture composite nanoparticles

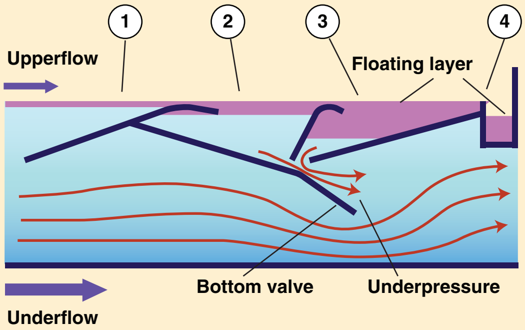
Many methods have been developed for the encapsulation of "active" materials within a carrier nanoparticle, such as a polymer. These composite structures can be used in many biomedical, cosmetics, and food processing applications for the controlled release of pharmaceuticals, neutraceuticals, and flavors. However, most of the proposed encapsulation methods developed so far involve multiple steps or complex preparation. Now a team from the School of Chemistry, University of Melbourne (Australia; www.unimelb.edu.au) and the Dept. of Chemical Engineering, Massachusetts Institute of Technology (MIT; Cambridge, Mass.; www.mit.edu), has developed a "one-pot" sonochemical process using ultrasound at 20 kHz for the nanoencapsulation of magnetite nanoparticles within host latex particles.

The team says sonochemical free-radical-polymerization reactions can be achieved without chemical initiators, and that fast polymerization rates are obtained with a relatively high percentage of monomer-to-polymer conversion. The particles exhibit excellent colloidal stability and strong magnetic properties, and are of the desired size to be technologically relevant, according to the researchers. The composite beads prepared by the team "will retain the superparamagnetic properties of their small constituent Fe_3O_4 nanoparticles, yet have sufficient magnetic content that they will respond to magnetic field gradients to overcome counteracting diffusional forces in ways that individual nanoparticles will not." This is an important factor in chemical processes using high-gradient magnetic separations.

The process starts with magnetite particles dispersed in the monomer phase. Water and sodium dodecyl sulfate (SDS) is added to the phase. The liquid mixture is sonicated (20 kHz, 8 W/cm^2) for 20 s, which leads to the formation of SDS-stabilized monomer droplets containing magnetite particles. Further sonication for 50 min leads to SDS stabilized polymer particles containing magnetite particles. The researchers believe this technique can be applied to a range of polymers, and are currently investigating the synthesis of polymers sensitive to temperature and pH.

Note: For more information, circle the 3-digit number on p. 70, or use the website designation.

Reduce process consumables with this new separator



Aqueous Recovery Resources, Inc. (ARR; Bedford Hill, NY; www.suparator.com), has developed the Suparator, an oil/water separation system that involves no moving parts or media, for low operational costs and minimal maintenance. The separator (diagram) is based on the Bernoulli effect, whereby increased stream velocity in a fluid results in internal pressure reduction, which enables liquids of different specific gravities to be separated. A number of valves are mounted across the fluid channel such that the major part of the flow passes underneath and a smaller portion passes overhead. Several wings are used to progressively shear off more oil and reduce water content. Dirt and other unwanted foreign objects also get removed before they settle into the water.

In the first step, water and oil enter a compartment (1), from which only water gets sucked out (2). The remaining oil becomes concentrated into a thick floating layer, but still contains some water and chemicals. The oil becomes further concentrated as water and chemicals re-enter the water flow (3). Finally, the upper fraction of the floating layer gets skimmed off, isolating pure oil for refining or storage (4).

This technology enables desired chemicals to stay in the aqueous medium and not get separated with the oil, making it ideal for removing thin oil films from valuable mixtures and solutions. By reusing the resulting process fluids and allowing oils to be recovered and reused, process consumables are potentially reduced by 50%, compared to conventional separators, says ARR.

Since the system was commercialized a few months ago, several large-scale units have been sold. ARR is next looking to use the Suparator in the extraction of oil from Canadian oil sands, which are very thick and difficult to separate.

A less expensive way to make conductive coatings

Cambrios Technologies Corp. (Sunnyvale, Calif.; www.cambrios.com) has formed a strategic partnership with Chisso Corp. (www.chisso.co.jp) and Sumitomo Corp. (both Tokyo; www.sumitomocorp.co.jp) for commercialization of Cambrios' first product, ClearOhm coating material. Targeted for the liquid crystal display (LCD) market, ClearOhm is seen as a solution to some of the problems with the currently available transparent conductive coatings that are made from Indium tin oxide (ITO) and other conductive oxides.

Transparent conductive materials are widely used for displays, touch panels, solar cells and other applications. Coatings of these materials, such as ITO, are deposited using expensive, energy-consuming vacuum-sputtering processes. The market has been interested in finding a replacement for ITO to eliminate the high cost of processing involved.

Cambrios' technology consists of a dispersion of metallic nanowires in a solvent, which is typically water, that has a viscosity and surface tension suitable for most wet-processing coating equipment and substrates. The coating can be formed at room temperature using standard coating process equipment, such as slot die, gravure and spin coaters, instead of sputtering. The coated film is then soft baked at a low temperature for a short time to achieve best performance characteristics.

ClearOhm coatings have been found to perform better than standard transparent conductors in many applications. For example, this novel coating has better transmission than standard transparent conductive oxides (TCO) in a wide range of conductivities. ClearOhm coated films are also more flexible and far less prone to cracking.

Another consideration is that in most applications, transparent conductive layers are patterned and so require additional processing steps. ClearOhm can be printed directly, eliminating the need for costly patterning equipment and additional acids and other chemicals used in the patterning process.

Cambrios expects commercial sales of ClearOhm coatings in the touch-panel market starting in 2009, with future plans for commercialization in the LCD and thin-film solar markets.

(*Continued from p. 13*)

the potential difference between the current peaks for the two reagents. Since the peak potential of both electrodes is used with every measurement, the sensor is inherently self-calibrating. This Continuously Self-Calibrating Sensor (CSC Sensor) design is independent of temperature, pressure and other variables that can interfere with other pH systems.

Sonocrystallization

Syrris Ltd. (Royston; www.syrris.com) has launched the Atlas SonoLab System in collaboration with Prosonix Ltd., (Oxford, both U.K.; www.prosonix.co.uk). The automated system combines the Atlas jacketed-reactor platform with Prosonix's SonoLab ultrasound technology, enabling the reproducible control of crystallizations, and allows selectivity of parameters such as particle size, shape, crystallinity and polymorphism. The system can also be used for sonomilling and sonochemistry.

Energy-saving burner

Last month, Dürr Environmental and Energy Systems (Stuttgart, Germany; www.durr.com) launched the Tarcom V gas burner, which is said to reduce energy consumption in thermal air oxidizer (TAR) systems. The burner can be retrofitted into existing TAR oxidizers.

Tarcom V is the product of a series of burner developments, which started with the so-called cone burner, and further refined into the swirl burner, and has now culminated in a swirl burner with a hollow cylindrical flame. This flame geometry — similar to a rotating hollow cylinder — achieves a high mixing efficiency, resulting in a better temperature distribution in the combustion chamber, which in turn leads to "significant" energy savings and improved emissions, says the company.

Slow-release pesticides

Scientists at the Institute of Natural Resources and Agrobiology of the Spanish National Research Council (Madrid; www.csis.es) have developed

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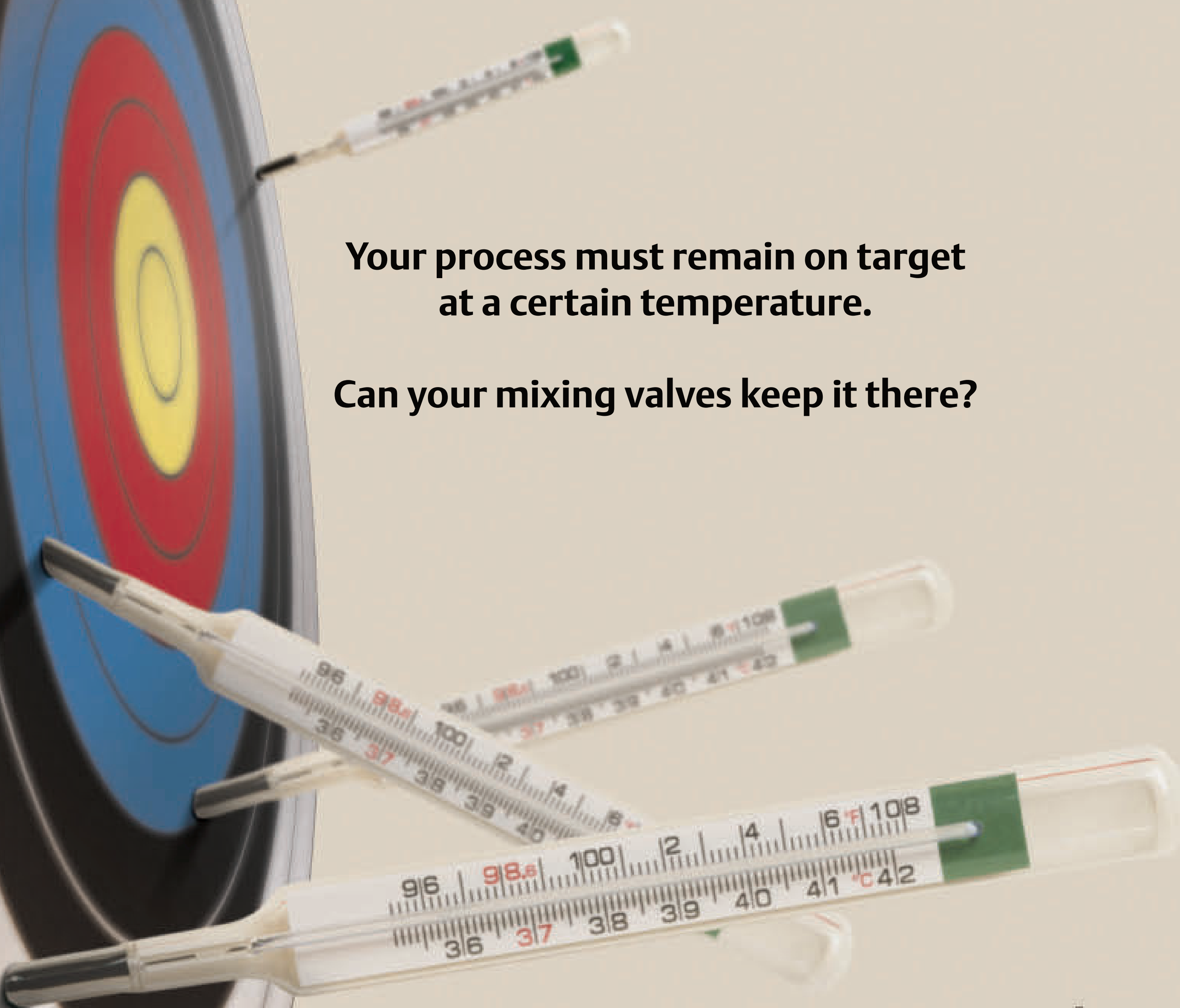
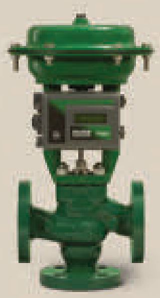


Your process must remain on target at a certain temperature.

Can your mixing valves keep it there?



For worry-free heat exchanger control, choose the Fisher® GX 3-way valve from Emerson. It provides accurate, constant control of temperature for either mixing or splitting service. And its robust, low-profile design fits tight spaces. There's no better way to stop temperature fluctuations than the Fisher GX 3-way valve. Learn more at **www.Fisher.com/gxCE** or contact an Emerson sales office.

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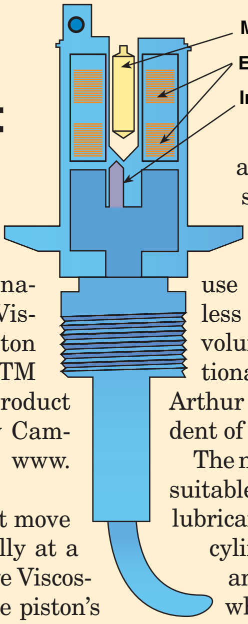
A new standard for viscosity measurement



The American Society of Testing Materials (Conshohocken, Pa.; www.astm.org) has developed a new standard for measuring viscosity: ASTM D 7483-08, Determination of Dynamic and Kinematic Viscosity of Liquids by Oscillating Piston Viscometer (OPV). The new ASTM method is part of a brand new product line to be launched this month by Cambridge Viscosity (Medford, Mass.; www.cambridgeviscosity.com).

OPVs are driven by two coils that move a piston back and forth magnetically at a constant force (diagram). Cambridge Viscosity's patented circuitry analyzes the piston's two-way travel time to measure and control absolute viscosity. OPVs allow viscosity measurement and control of a broad range of fluids including those that are transparent, translucent and opaque. The measurement function of the viscometer is fully automatic and maintains a continuous fresh sample while under test. Oscillating pistons are capable of taking viscosity measurements of fluids much more frequently than older capillary-tube viscometers. They also use a smaller sample size (volume of less than 5 mL with a typical solvent volume of less than 10 mL) than rotational or vibrational viscometers, says Arthur Hindman, executive vice-president of Cambridge Viscosity.

The new test method can be particularly suitable for many petroleum products and lubricants for bearings, gears, compressor cylinders, hydraulic equipment, fine and general chemicals and coatings, where proper viscosity is important for product performance. It covers the measurement of dynamic viscosity and derivation of kinematic viscosity of liquids, such as new and in-service lubricating oils. The test method is applicable to Newtonian and non-Newtonian liquids, covering dynamic viscosities of 0.2 to 20,000 cP at temperatures of –40 to 190°C.

(Continued from p. 14)

a method to encapsulate and slowly release pesticides as a means to prevent leaching and volatization of the substances into the environment. The pesticide is encapsulated in lecithin liposomes or vesicles, which in turn are fixed onto the surface of clay. The final product is a powder that can be dispersed in water. Adsorption to the clay prevents the active compound from being washed away, yet enables the slow release of the pesticide as needed. The researchers believe the method can be applied in other areas, such as mosquito repellents.

PFOA alternative

Cerealus Holdings, LLC (Waterville, Maine; www.cerealus.com) has developed a non-toxic, bio-based chemical replacement for fluorinated compounds, such as perfluorooctcanoic acid (PFOA), used in food packaging and food-

(Continues on p. 20)

High-throughput screening accelerates glycerol-to-chemicals research

Arkema (Colomes, France; www.arkema.com) and hte (Heidelberg, Germany; www.hte-company.de) have successfully concluded a research collaboration aimed at identifying new catalysts for the conversion of glycerol — a byproduct of biodiesel production — to acrolein (2-propenal) and acrylic acid. The collaboration, which started last year, utilized hte's proprietary parallel testing technology to explore and evaluate suitable catalysts by means of high-throughput experimentation. "By using this approach, we have produced results in a matter of months; this normally would have taken over two years using conventional testing equipment," says Jean-Luc Dubois, scientific director at Arkema.

Arkema already has a number of patents covering this glycerol-to-chemicals technology. In the process, glycerol first undergoes an intramolecular dehydration to acrolein using a solid acid catalyst. Acrolein is then further oxidized to acrylic acid with the same catalyst, or in a separate reactor. The reaction takes place in the gas phase at 300°C and near atmospheric pressure. Although glycerol dehydration does not require another reagent, a major innovation (patented by Arkema) has been to add oxygen during the first step; this not only extends the life of the catalyst, but also significantly reduces the production of some byproducts, says Dubois.

Glycerol conversions of 100% are easy to achieve, and several families of catalysts can lead to selectivities of at least 70%, says Dubois. The acid strength of the catalyst is one of the key parameters, he adds. Arkema may build a demonstration plant within two to four years. This will only make sense if the product can be made at the same cost as current technology, but with a lower carbon footprint — something Arkema is now investigating, says Dubois.

A palladium catalyst makes primary amines in aqueous NH_3

Primary amines are made in high yield by a palladium-catalyzed allylic amination reaction developed by Shu Kobayashi, a chemistry professor at the University of Tokyo (Japan; www.chem.s.u-tokyo.ac.jp.). The reaction uses aqueous ammonia as the nitrogen source — the first time this has ever been achieved, disproving a 30-year old theory that allylic amination using aqueous ammonia was impossible.

Kobayashi discovered the method when trying to perform allylic amination of 1,3-diphenyl allyl acetate in tetrahydrofuran (THF) solvent. No reaction occurred when using NH_3 gas as the nitrogen source; but when switching to aqueous NH_3, the researchers obtained 71% secondary amine and 14% primary amine. Kobayashi speculates that the pri-

(*Continues on p. 20*)

Optical fiber sensing gets an NSF boost

Last January, Chiral Photonics, Inc. (Pine Brook, N.J.; www.chiralphotonics.com) was awarded $500,000 in a Small Business Technology Transfer Phase II grant from the National Science Foundation (NSF; Washington, D.C.). The grant will be used to develop a new optical-fiber-sensor platform capable of measuring temperature, pressure, strain axial twist, liquid levels and other variables. The company has already started commercializing a temperature sensor — based on the patented chiral grating technology — that is capable of measuring temperatures up to 1,000°C with ±1% accuracy, says business development manager Saul Felman. Since then, the device has found applications in petroleum refining (fractional distillation processing and combustion), oil borehole monitoring, industrial furnaces (such as smelters) and concentrated solar power.

Sensor gratings are fabricated by twisting a glass fiber into a helix as it is passed through a microheating zone. The resulting optical fiber, tradenamed Helica, has unique optical properties. For example, characteristic dips in the grating's optical transmission spectrum shift to the red by about 1.3 nm as the temperature increases by 100°C — the property that is exploited for high-temperature sensing.

Fiber optic sensors are immune to electromagnetic interference, have fast response times, can be remotely operated and pose no electrical ignition hazard. Because the gratings can be implemented in any fiber, radiation and chemically resistant fibers are being developed.

PALLADIUM CATALYST (Cont. from p. 18)

mary amines form first, which subsequently undergo a further amination to form the secondary amine. This secondary reaction can be suppressed by using dioxane instead of THF as solvent, producing 71% primary amine.

Primary amine yields of 71–85% have also been achieved with other allyl substrates. In addition, asymmetric synthesis of optically active allyl-amine have been performed with 71% yield and stereo-selectivity of 87% using a palladium catalyst with BINAP [2,2'-bis(diphenylphosphino)-1,1'-binaphthyl] ligand.

(Continued from p. 16)

grade paper. The patented coating additive, called Hold-out, is made from a byproduct of corn, and is a water-based formulation that is grease and oil-resistant, making is suitable for food packaging in the fast-food industries. PFOA, which is used in similar applications, has come under increased scrutiny over its potential toxicity, and was classified as a "likely human carcinogen" in 2006 by EPA, which has commenced programs to eliminate PFOA production by 2015.

Making H_2 from H_2O

Scientists at the Max Planck Institute of Colloids and Interfaces (Potsdam-Golm, Germany; www.mpikg-golm.de) have discovered that carbon nitride acts as a photocatalyst for splitting water into H_2. Besides being less expensive than alternatives (such as inorganic semiconductors doped with Pt), the carbon nitride is stable over a wide pH range. The next step is to improve the efficiency. ❏

Cut installation costs in half with this orifice flowmeter

ABB Instrumentation (Warminster, Pa.; www.abb.com/instrumentation) has cut the cost of installing orifice-plate flowmeters by up to half with the launch of its OriMaster compact orifice DP flowmeter. The latest in the company's FlowMaster range, the OriMaster comes fully factory configured and pressure tested, solving many of the problems associated with sizing, selection, installation and operation of conventional orifice-plate installations, says ABB.

OriMaster installation is simplified by its wafer-design, orifice-carrier assembly, enabling it to be fitted into an existing space between standard pipe flanges. Because incorrect centralizing of orifice devices can cause additional metering errors of 3%, the OriMaster comes with a centering tool to ensure correct placement in the pipeline.

The flowmeter is suitable for clean liquids, gases and steam applications in line sizes from 1 to 8 in. (DN25 to DN200) and pressures up to 1,450 psi (100 bars). The OriMaster combines all major components needed for installation in one assembly, thereby eliminating the need for users to source and install a separate manifold, transmitter and impulse piping, typically cutting the cost to install and commission by up to 50%, says ABB.

EPA proposes national reporting system for greenhouse gases

The U.S. Environmental Protection Agency (EPA, Washington D.C.) plans to set up the first U.S. national system for reporting emissions of CO_2 and other greenhouse gases. The proposal marks the first step toward a program for climate control. "Through this new reporting we will have comprehensive and accurate data about the production of greenhouse gases . . . a critical step toward helping us better protect our health and environment," says Administrator Lisa Jackson.

Under the initial proposal, the reporting requirements would apply to suppliers of fossil fuel and industrial chemicals, manufacturers of motor vehicles and engines, and facilities that have greenhouse gas emissions of 25,000 m.t./yr or more. Most (except for vehicle and engine manufacturers) would submit their first annual reports in 2011, for calendar year 2010.

The proposed rule will be published shortly in the Federal Register, after which there will be a 60-day comment period, including two public hearings, before the rule is finalized. The reporting requirements will cost industry \$160 million in 2011 and \$127 million in subsequent years, estimates the EPA. ■

RECYCLING CATHODE RAY TUBES

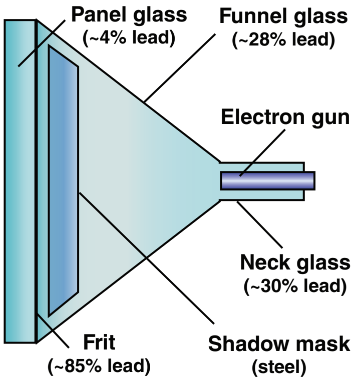


FIGURE 1. The glass components of a CRT contain varying levels of lead, making them difficult to process

As CRTs become an obsolete form of video display technology, recycling their lead-filled glass is increasingly important

Earlier this decade, liquid crystal display (LCD) and plasma screens surpassed cathode ray tubes (CRTs) as the visual display of choice in computers and televisions. While the production of CRTs has dwindled to nearly nothing, we will still deal with end-of-life (EoL) units for years to come. CRTs are being disposed of at an alarming rate, overwhelming landfills with toxic amounts of lead. The implementation of proper processing methods for lead-containing glass is critical to the environmentally safe and economically viable recycling of EoL CRTs.

A study conducted by the National Safety Council (Itasca, Ill.; www.nsc.org) estimates that 20.6 million computers became obsolete in 1998, of which only 11% were recycled. The problem has potential to get worse, as Chris Harris of the International Association of Electronics Recyclers (ISRI; Washington, D.C.; www.isri.org) shows in a September 2008 report on electronic scrap management. For the rest of this decade, it is predicted that the number of outdated computers will increase by 100 million annually as a result of increased consumption and decreasing product lifespans.

Recycling technologies

CRTs pose the greatest problems to the electronics recycling industry for both their environmental risk and processing difficulty. Hazardous levels of lead, mercury and hexavalent chromium are found in CRTs, making proper recycling imperative. As shown in Figure 1, the panel glass of a CRT only contains 4% lead, but the funnel and neck glasses contain up to 28% and 30%, respectively. Meanwhile, the solder glass connecting the panel and funnel glasses, referred to as the frit, contains a huge lead level of 85%.

CRTs are recycled by initially either shredding the entire unit (with or without casings), or separating the glass components (panel, funnel, neck and frit). Shredding results in a mix of glass and lead that is subsequently separated by electro-magnetic or density methods. The resulting glass, which contains varying levels of lead, is often smelted in a furnace to convert the lead ore in a reaction with carbon-based fuel to elemental lead. Separating the glass components first requires manual separation of the CRT from its housing and other exterior parts. Then, separating the glass before shredding allows the individual glass streams to be sent to either glass-to-glass (GtG) processors or smelters.

Federico Magalini, a member of the Secretariat of Solving the E-waste Problem (StEP) Initiative of the United Nations University (Bonn, Germany; www.step-initiative.org). explains that choosing one method over another is not a clear-cut decision. "Simply comparing the two approaches (shredding versus disassembly and separation) under different boundary conditions," he says, "you could find totally different solutions."

Harris of ISRI agrees that the processing method really depends on a specific recycler's business model. "Technology is moving toward handling old monitors in a mechanical way," he says, explaining that, for large recyclers that process thousands of CRTs every day, the slow process of breaking down every monitor isn't feasible. Shredding, he says, "is adequate, and can be efficient for handling massive quantities."

SSI Shredding (Wilsonville, Ore.; www.ssiworld.com) is a top provider of shredders to the electronics recycling industry, offering the four-shaft Quad unit for high control of particle size in this demanding application.

Crushing is an alternative to shredding for size reduction of CRT glass. An example of a whole-unit crushing technology has recently been implemented by HMR USA, Inc. (Brisbane, Calif.; www.hmrusa.com), which utilizes a rotating hammer mill to implode the CRT glass, followed by separation of metal-containing glass with a magnet.

While shredding an entire CRT is less labor intensive than disassembly, sorting the resulting fragments calls for advanced separation equipment. Optical sorting technologies have been a mainstay in the recycling industry, but they are relatively new to the recycling of electronic scrap, allowing recyclers to separate incoming material by lead content. Typically, the sorting is performed on a slide or conveyor belt, with one or more arrays of air ejectors separating the material. For CRTs, optical sorters are often based on X-ray transmission, like the MSS Inc. (Nashville, Tenn.; www.magsep.com) X-Sort, for the separation of leaded glass from non-leaded glass. The X-Sort technology separates shredded glass based on X-ray absorption levels.

Crushing the entire CRT before separating limits the reusability of CRT glass. Chris Harris explains that "CRTs don't have a positive value after putting them through a shredder — this lead-containing glass actu-

ally has a negative value." Emerging recycling technologies are working to make largely valueless CRT glass reusable. E-World Recyclers LLC (Vista, Calif.; www.eworldrecyclers.com) developed the patented glass hot-wire separator in November of 2007, which separates non-hazardous CRT panel glass from lead-filled funnel glass. The processes creates a chemical change in the glass, which causes it to fracture at the weakest point of the CRT (around the frit lines), cleanly separating the panel from the funnel. Such careful separation methods create exit streams of clean, reusable glass.

One of the major issues hampering CRT recycling, as Magalini points out, is downstream markets for lead-containing glass, considering the decrease in demand for new CRT production. "This means that new applications for the arising factions should be investigated or developed to ensure a proper valorization of factions in the near future," he says. Though the GtG options for used CRT glass are quite limited, they are worth investigation, he adds, as they are an economical alternative to sending all glass to cost-intensive smelters.

Current uses for EoL CRT glass include heavy clay construction products (brick, pavement, roofing tile and piping), as well as ceramic products. A report published by the Waste & Resources Action Programme (Oxon, U.K.; www.wrap.org.uk) found that using CRT glass in these applications is as feasible as using any clean, recycled container glass.

Dlubak Glass (Upper Sandusky, Ohio; www.dlubak.com) is a recycler that produces ceramic beads from CRT glass. Herb Schall, director of Dlubak, says that their products are finding a place in an emerging domestic market for building materials. "Mixing the beads in cement yields artificial blocks for blockhouses," says Schall. The ceramic beads create unique physical characteristics in the blocks, including insulating capabilities and compatibility with nail and screw guns. Upcoming plans for Dlubak include the use of the relatively lead-free CRT panel glass for producing beads that will be used in road striping.

GtG processing of CRTs is quite limited, but the market for their recycled lead is extremely limited as well, according to ISRI's Harris. "There are few places to send lead, and they are very expensive," he explains. "Most sustainable markets are cost-prohibitive, and there will be time before they will become viable options." The most common destination for recycled lead is the battery industry, which makes up 85% of the lead market. Doe Run Co. (St. Louis, Mo.; www.doerun.com) is a major CRT glass recycler that extracts lead from glass through a smelting process. Ground CRT glass is fed to a blast furnace, where the glass acts as a silica-replacement flux in the smelting process. The resulting metal is recycled into refined lead for batteries.

Regulating end-of-life CRTs

Generally, there is a lack of regulation of electronics recycling, but the U.S. Environmental Protection Agency (EPA) has set forth CRT waste-management requirements that aim to increase the number of EoL CRTs being recycled. The EPA provides conditional exclusions from federal hazardous-waste-management standards for CRTs based upon their condition, time in storage, and storage and transportation conditions. Additionally, exporters shipping CRTs to another country must notify the EPA and wait for written consent, which prevents the shipment of CRTs to developing countries that would not recycle the units safely.

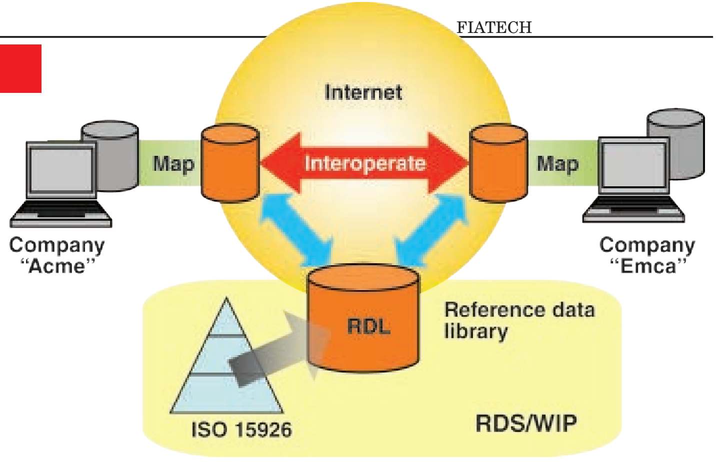
U.S. federal requirements for CRT recycling may be rather lax, but regulation on the state level is generally much tougher. Currently, nineteen states have laws in place for the responsible recycling of electronics. Most of these regulations require electronics manufacturers to implement recycling or recovery programs, or pay an advanced fee or a fee per unit for the cost of processing their products. Many of these laws specifically control the disposal of TV and computer monitors, or specifically CRTs. For example, since April 2000, Massachusetts law prevents the disposal, incineration or transfer for disposal of CRTs at a solid waste disposal facility. More recently, CRTs have been banned from disposal in landfills and incinerators in Minnesota since July 2006, and in New Hampshire since July 2007.

Increasing stringency on the state level is a step in the right direction, but most electronics recycling initiatives agree that national systems should be put in place. The Basel Action Network (BAN; Seattle, Wash.; www.ban.org) developed a certification program for electronics recyclers to ensure responsible practices. BAN's e-Stewards program provides strict standards to electronics recyclers, forbidding the exporting of toxic electronics scrap to developing countries and disposal in local landfills and incinerators, as well as the release of private data stored on computers.

The e-Stewards program, among other U.S. initiatives, hopes to spur national requirements at least as strict as those provided by the European Union. The Waste Electrical and Electronic Equipment (WEEE) Directive became European Law in February 2003, restricting the use of hazardous substances in electronic equipment, while promoting the collection, recovery, and recycling of such equipment. Such a system puts the responsibility to create an efficient and responsible electronics-recycling infrastructure on the shoulders of electronics manufacturers. ■

Kate Torzewski

DIGITAL HANDOVER HEADACHES



Fiatech hopes the ISO 15926 standard will provide much needed interoperability to project management

Electronic project handover has helped but standardization issues with data and system compatibility remain

Project management can be a messy, complex issue for all involved parties and, likely, the most hair-raising aspect of all is project handover from the EPC (engineering, procurement, construction) contractor to the chemical processor. In the past, this literally involved a truck pulling up with cartons and boxes chock full of engineering documents, drawings, operations manuals and catalogs. From there, the project owner usually took the load into a room somewhere in the facility where operations and maintenance staff would later spend countless hours searching for the particular drawing or manual they needed for a repair or other task.

In recent years though, both parties have become more sophisticated and made the process a digital one. However, the electronic handover has not eliminated issues such as poor-quality information and missing documents, drawings and manuals. In fact, the digital handover has created several new challenges associated with incompatible data formats. But, both EPCs and owner operators are working on the challenge with the help of software gurus and Fiatech (Potomac, Md.), an organization determined to bring standards and interoperability to the table.

General challenges

In all handover situations, incomplete data provided by the EPC, cloudy specifications from the project owner and poor planning by both parties can create headaches.

"No matter how early in the project the parties start to discuss the handover requirements, the work always seems to get left to the end when budgets are running out and people are mobilizing," says Adrian Park, global technical director for owner operator solutions with Intergraph (Huntsville, Ala.). This, he says, results in incomplete and incorrect information. "Clearly the challenges here are partly due to the size, volume and complexity of the data to be delivered, but also the challenge is how people manage the whole process."

To remedy the situation, Park says Intergraph directs its clients to start the process early with handover requirement specifications that are very detailed. "We urge them to put an organization in place with the task of compiling very specific handover requirements and then tracking the handover process throughout the life of the project. Owner operators can't just rely on the EPC to provide all the correct and complete data at the end. They must follow up on this throughout the project because if they don't receive high quality data during the project, then the problem will persist throughout the lifecycle of the finished project."

To help owner operators with this task, Intergraph offers its VTL (Validation, Transformation and Loading) application as part of the SmartPlant Enterprise for owner operators. VTL is capable of managing data import from multiple sources. It submits imported data to quality control before data extraction for loading into target systems, which can include SmartPlant Enterprise information management and engineering design tools or third-party applications. The system allows owner operators to use any mapping tool capable of generating extensible style sheet language transformations (XSLT) to map incoming data from the EPC or export data into target systems. VTL also permits users to define their own rules and to add pre-defined rules to rule sets that then run against future data submissions. Once information is in the staging area, users can validate the quality of the data against those pre-defined rules. It then supports the initiation of loading programs to get data into the SmartPlant or third-party applications.

"This allows owner operators, throughout the process, to check that data are correct and complete, which is the goal of getting involved in the handover process early," says Park.

Anne-Marie Walters, global marketing director with Bentley Systems (Exton, Pa.) agrees that tackling handover earlier in the project is helpful, but says that it's not without it's share of problems. "Owners have been asking EPCs to break the data handover into bite-sized chunks and give it to them in bits," she says. While this makes it seem less overwhelming for the owner, the resultant challenge is that EPCs can't leave it to the end to run quality checks on the data and have had to change their internal processes regarding data management.

Compounding this problem for EPC firms is that all its clients have different data delivery requirements and

CH2M HILL

In brownfield projects, a lot of time is needed just getting old data to a workable point

preferences regarding P&IDs, data sheets and symbols on drawings. "As an EPC we have to be efficient and consistent in our work process and provide training for our staff in those work processes in order to deliver high quality," explains Marc-Henri Cerar, information manager and engineering systems manger with AMEC Paragon Engineering Services (Houston, Tex.). "If we have a customer come in with their own specific requirements, that creates a learning curve for us, which amounts to additional costs for us, making it difficult to be competitive in that realm."

Kathryn Lust, department manager for Project Information Management at Mustang Engineering (Houston), agrees that as clients become more sophisticated, handovers are becoming more difficult for EPCs. "Previously handovers weren't complicated by information management requirements, but since our clients have become more sophisticated, we've officially adopted information management as a discipline here that focuses on handover, as well as sharing information during the life of the project," says Lust.

One aspect of Mustang's information management includes Pacesetter, a multi-functional project execution management software tool. It incorporates a number of modules, including scope management, time management, cost management, communications and procurement, which are integrated and synchronized with the document repository. "This gives us the necessary ability to plan, access, report and handover deliverables in a consistent manner," says Lust.

Through the tracking tool and repository, the data and information Mustang needs to supply to its clients' enterprise systems are aligned and synchronized. "So when we do an export out of our document repository, it matches what we hand over out of our document tracking system."

Because not all engineering firms have their own software designed to handle the challenges associated with the now-continual process of handing over data, Walters says. Bentley has developed ProjectWise Lifecycle Server to assist both parties with data handover. As a data quality control mechanism, Lifecycle Server provides a built-in import/export engine, task-based data-stream definitions for repeatable exchange needs, control filters for quality analysis of incoming data, class-based features for data template definitions, a context-based identification scheme for enabling consolidation from multiple sources and validation mechanisms for numbering schemes on an object-based class basis.

The application is also capable of managing change through attribute-level change history tracking, segregation of proposed changes from current

PROJECT MANAGEMENT SERVICE PROVIDERS

AMEC Paragon Engineering Services	www.paraengr.com	Fiatech	www.fiatech.org
AVEVA Inc.	www.aveva.com	Intergraph	www.Intergraph.com
Bechtel Corp.	www.bechtel.com	Mustang Engineering	www.mustangeng.com
Bentley Systems	www.Bentley.com	The Sword Group	www.sword-group.com
CH2M Hill	www.ch2m.com	Synergis Software	www.synergissoftware.com
		Zachry Engineering	www.zachryengineering.com

data and configurable permissions and sign-off levels.

"It saves a lot of time and effort for both the EPC and the project owner," says Walters.

Although the advent of software tools has alleviated some of the pain associated with handover management, the solutions have, in some ways, birthed their own set of problems.

Digital plant handover problem

To fully understand the newest handover challenges, it's important to see how data are managed by the recipient. Consider, for example, the project owner DuPont, which has in place best practices that describe the documentation that needs to be turned over to the plant. The best practices let the engineering firm know what parts of the documentation they need to turn over to operations and maintenance — a step that was recommended by the experts above.

According to Jehu Burton, project engineering manager with DuPont (Wilmington, Del.), DuPont employs several software applications. One is a project repository. "It's our practice today that as we design a new project, we collect all the engineering documents in our document management system and put them into the appropriate project folder structure," he says.

DuPont also uses 3D plant models. "As we design the plant in 3D using engineering software, we turn the digital plant over to the operators who can go online and call up a 3D model of the project, locate items and do searches to find a particular valve or vessel.

SAP is also used by DuPont as a business and enterprise application. Other SAP modules for plant maintenance are employed, as well. "We populate modules in SAP for plant maintenance with equipment information from the project," explains Burton. "All major equipment has an equipment master associated with it, which provides additional data that maintenance uses to monitor the assets." He adds that DuPont makes use of additional software that links with SAP on the maintenance side to track equipment reliability.

Engineering portals, too, are applied by DuPont to link all this information together, allowing users to click quickly through a variety of applications and look at multiple pieces of information about the same piece of equipment on one computer screen.

"In the old world, maintenance had to go to the drawing room, pull up hard copies, locate the equipment on a drawing and then find a catalog with the equipment specs," says Burton. "But now we can use all these applications tied together via an engineering portal to quickly access information without leaving the desk. The software has provided accessibility and visibility of information."

Although the visibility is a step in the right direction, there are existing issues with interoperability and data models. "Today we have what I call an application centric environment," explains Burton. This means the information is stored within separate applications. There are islands of automation, manually input data, little connectivity and information is still hard to find because there are many user interfaces.

"What we want to get to is what I call an information centric environment," he says. "In this world applications are transparent. What you think of is the information you want, not which application the information is in."

Engineering portals are helping somewhat. For instance AVEVA NET Portal provides an intuitive web-browser interface with contextual searching, making information access quick, easy and thorough. All types of static and dynamic data can be cross-referenced including all process P&IDs, 3D model views, as-built engineering data and operating procedures. With the ability to bring together information from disparate applications and data sources, the portal provides a unified, Web-based, digital plant.

According to Clive Wilby, principle consultant with AVEVA, this helps with handover (because it can check the quality of data and ensures that no gaps exist) and later provides a database of information for the project owner.

However, Burton and others in the industry say some problems still persist because good, standard data integration does not yet exist. "To try to integrate data within applications we have to internally create point-to-point maps," says Burton. "This means we write and interface applications that say, 'in this field and in this application, this code, number or symbol is the same as the different code, number or symbol in this other field and application.' Each processor makes their own internal code up for this."

This type of integration, often referred to as spaghetti integration, gets very complex and is very costly to maintain.

Making matters more difficult is that most of the projects undertaken today, due to the poor economy, are improvement projects on existing facilities, rather than greenfield projects. "Because there is less capital investment today most of our work has been in brownfield upgrades," says Bruce Strupp, technical director with CH2M Hill (Denver, Colo.). "And these cases deal with existing information and systems, which often is not in a useable format for today's software, so you have to regenerate all that information which creates more of a headache throughout the project and during handover."

He says that with greenfield projects it is easy to control information with the

Mustang Engineering

Mustang Engineering has made information management a key component on projects like this one at a U.S. chemical facility

proper codes and symbols from the beginning, which allows owners and EPCs to better control the documentation. But in a brownfield project "you never know exactly what documents you have to start with" and they are usually in many different formats and locations. "We spend a lot of time just trying to get the old data to a point where we can even begin to work with it."

Interoperability on the horizon

Due to the lack of standardized codes on brownfields and between disparate software applications, involved industries — chemical (and other) processors, EPCs and software providers — are working toward using a common data integration scheme. Fiatech, a consortium of these parties originally assembled to promote the use of hardware technologies such as RFID tags and robotics by industry, is trying to develop an aligned strategy on how to integrate data between disparate applications. Part of Fiatech's mission, according to Richard Jackson, director with Fiatech, involves promoting ISO 15926, which is an industry reference data library. It is actually a set of definitions for how to use terms, including use cases and descriptions of how combinations of dictionary terms can be used in a particular environment for communicating information.

"Eventually we will be able to use this created infrastructure to achieve interoperability standards because there will exist a similar structure that will allow connections across different communities of interest to be made," says Jackson.

In laymen's terms, ISO 15926 will provide a mechanism by which everyone can export and import information according to the same format and not have to worry about doing their own integration because all software, owner operators and EPCs will be using the standard as a neutral file format, explains Jackson.

While there is still much work to be done on the standard, Jackson says an agreement has been struck with the ISO organization that allows the progress that has been made to be used under the ISO 15926 WIP (work in progress) label.

As a result, some chemical processors, EPCs and software providers are already beginning to use the standard definitions and codes, allowing small amounts of interoperability to be achieved.

"While ISO 15926 hasn't solved all the problems yet, I think I will begin to see benefits on the next jobs for which we are currently mobilizing," says AMEC Paragon's Cerar. "I am hopeful that it's going to make a lot of the things I need to do easier. To me, that's a measurable improvement." ■

Joy LePree

Cover Story

ACHEMA DEFIES

Even in a recession year, over 180,000 visitors from 100 countries are anticipated at this triennial event

The current economic recession has hit trade show attendance especially hard. A number of events for 2009 have been cancelled, while others are implementing contingencies. Discounted registration fees are common, while at least one event offered to cover attendees airfare before finally deciding to postpone altogether. Some of the more resilient organizations are offering the alternative of live webcasts for attendees who can't make the trip.

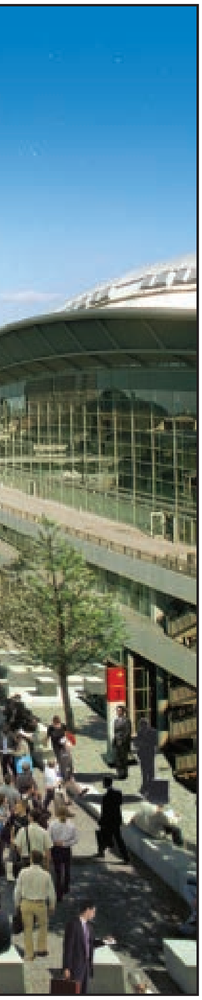
Despite this slump, the chemical process industries (CPI) do not appear to be turning away from Achema 2009, the world's largest exhibition-congress for chemical engineering, environmental protection and biotechnology, which takes place in Frankfurt, Germany next month (May 11–15; www.achema.de/en). Dechema e.V., the event's organizer (a nonprofit society for chemical engineering and biotechnology), says that so far, the current economic turbulence has had no measurable effect on the event. At the time of this printing, booked exhibition space is nearly at the final level of the last Achema, at 3,721 exhibitors — and over six weeks are still left to go.

In fact, at a press conference on the 19th of February, Thomas Scheuring, head of exhibition congresses at Dechema said, "I'd even say we notice a clear commitment, rather, not to miss this particular Achema, as it is the one event for our industries which gives its exhibitors worldwide visibility and exposure — no doubt a great asset in times like these."

Scheuring's expectations for attendance are likewise optimistic and — at 180,000 — are on par with the last Achema. "From experience, we know there is a correlation between final attendees' figures and lecture submissions; and the response to this year's congress was impressive — remarkably higher than in the past," Scheuring says. "For the first time, we even had a waiting list."

Over 27,000 visitors attend the congress, which consists of 925 lectures on topics such as new reaction pathways, white biotechnology, advanced fluids, ionic liquids, microchemical engineering, process intensification and energy generation and supply. Podium discussions and plenary lectures provide a multi-faceted, highly topical and high-level congress program, reflecting the great diversity of process engineering.

ECONOMIC ODDS



The conference is rounded off by four panel discussions with high-ranking personalities from politics, economics and science, which address hot topics of public interest.

Many of the congress topics overlap with the exhibition, while other sessions present emerging trends. Or, as Scheuring puts it, "Topics of today's congress will be seen in tomorrow's exhibition."

Indeed, Achema has developed the reputation of a launching pad for innovation. Many companies intentionally time the announcement of new technologies around the week-long event.

A key point that differentiates Achema from many other events is that Achema only takes place once every three years. "So if you miss one, you will not be visible on our platform for six years," notes Scheuring. That can be a very long time, whether your business depends on selling process technologies or buying them. By the same token, in hard times, travel expenditures that only occur once every three years are much easier to justify than those that come up on an annual basis.

Meanwhile, a three year cycle is not excessively onerous on the many delegates who make the journey from outside Germany. Incidentally, a key ingredient in Achema's recipe for success is the global stage it offers to exhibitors and attendees alike.

In 2006, attendees came from 98 countries; and, for the first time, more than 30% were from outside Germany. Among these visitors were large delegations from Japan, China and the Middle East. Many exhibitors told Dechema that more than half of the contacts they made were with individuals from outside Germany. This year, a similar representation is expected.

Exhibitors also come from far and wide. Foreign exhibitors represented 50 countries in 2006 — 44% of the total, and Dechema projects that figure to increase by two percentage points in 2009 (Figure 1). Next to Germany, the individual countries represented by the largest number of exhibitors in 2006 were, in descending order, Italy, the U.K., Switzerland, the U.S., France

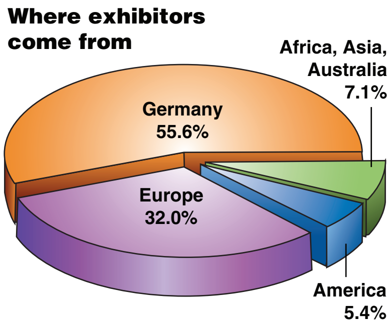


FIGURE 1. In 2006, more than 44% of exhibitors came from outside Germany. That figure is very conservative, since in many cases, foreign exhibitors are represented by their German subsidiaries (and are therefore classified as German). If those exhibitors were instead included in the foreign classification, more than 50% of Achema's exhibitors would be foreign

and the Netherlands. The Asian region stood out in terms of growth in the number of exhibitors: the number of exhibitors from India was up by 61%, that from South Korea by 143% and that from China by 185%.

"We have intensified our campaigns internationally, because we still think we could increase our attendance from the Middle East and Asia," adds Scheuring. "We want to make our visibility better in countries like India. We have special mailings going to Arabic countries."

Beyond the quality of technologies that are presented at Achema and the impressive distances from which they come, there is yet one more obvious reason for its success: the vast opportunities to initiate new business contacts and to network with such a broad range of influential colleagues. Consider, for instance, that the technologies for an entire project could be specified from Achema.

Altogether, Achema and its organizers have a number of secrets that have protected the event from the misfortunes that have fallen elsewhere. Scheuring's comment on this topic is particularly thought provoking, "One secret of Achema is that we are not [just] a trade fair. We are strongly anchored in our community." Assuming that connection is indeed strong enough to keep Achema afloat in these times, let's hope for the CPI's sake that the good fortune flows both ways. ■

Rebekkah Marshall

CHEMICAL ENGINEERING
FACTS AT YOUR FINGERTIPS
Department Editor: Kate Torzewski

Energy Efficiency in Steam Systems

In today's typical process plants, preventing steam loss and improving condensate return are key opportunities to make a process more energy efficient.

To be the most effective, steam generally needs to be dry (such as for process usage), or superheated (for instance, for use in turbines). These requirements dictate utility-system operating procedures for generating the highest quality steam possible, and then distributing it to the points of use with minimal deterioration. Since steam becomes condensate after its heat energy is expended, strategies must be in place to remove condensate as quickly as it is formed, in the steam-supply portion of the circuit and during steam usage alike.

Furthermore, superheated steam is typically desuperheated by injecting hot condensate into the system. As a result, excessive wetness can also occur downstream of the desuperheating station. In either case, if such condensate is not removed from the steam supply, the negative impact on the steam system can be substantial, as seen in Table 1.

Improving condensate return. At many plants, the operators admittedly realize that condensate must be removed as quickly as it is formed, but a suitable condensate drainage or transportation system is not in place. In such cases, the condensate is often sewered or sent to a field drain. Some possible outcomes of removing condensate but not handling it effectively are outlined in Table 2.

Condensate is traditionally removed from steam systems by steam traps or by equipment combinations involving level pots and outlet control valves. Process situations in which high backpressure from the downstream portion of the condensate-return system tend to create a "stall." Then, a different system incorporating both a pump and trap in the design is needed to drive the condensate while also trapping the steam; this process may be referred to as pump-trapping or power-trapping.

Because there are at least three condensate-drainage alternatives, it makes more sense to think in terms of required "condensate discharge locations" rather than referring to condensate removal devices indiscriminately as "steam traps." This broader mind-set helps avoid any predisposition to install steam traps in applications that need a different type of condensate drainage solution.

Engineered separator-drains remove condensate that is entrained in a moving steam supply (including flash or regenerated steam). The result is highest quality steam delivered for plant use. Compare that to steam traps, which remove condensate that has already fallen out of the steam. As their name suggests, steam traps remove condensate and "trap steam." Meanwhile, level pots can be used in certain instances where steam traps cannot meet the high pressure or capacity requirements.

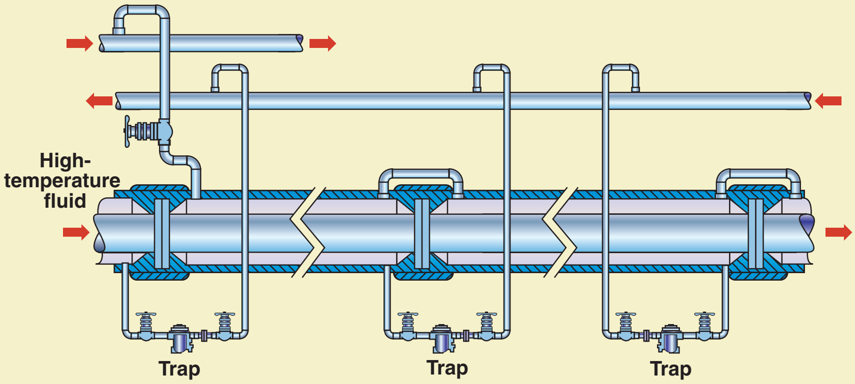


FIGURE 1. Preferred method to drain jacketed pipe for high-melting-point fluids, such as sulfur

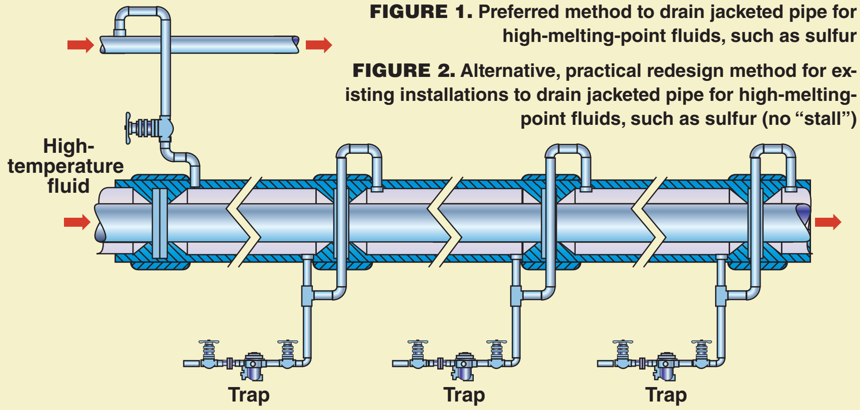


FIGURE 2. Alternative, practical redesign method for existing installations to drain jacketed pipe for high-melting-point fluids, such as sulfur (no "stall")

TABLE 1. RESULTS OF FAILING TO REMOVE CONDENSATE FROM THE STEAM SUPPLY
Loss of yield: Entrained water does not carry as much heat to a process as does steam
Damage to nozzles: Entrained water erodes nozzles and can adversely affect vacuum generation or atomization
Loss of power: Entrained water causes turbines to operate less efficiently
Increase maintenance loading; Water hammer can damage equipment such as turbine blades and control-valve packing
Increased safety risk: Water hammer can injure personnel
Poor process control: Flooding exchanges can lead to control swings

TABLE 2. RESULTS OF REMOVING CONDENSATE, BUT FAILING TO HANDLE IT EFFECTIVELY
Profit loss due to waste of heated and treated condensate
The extremely wasteful effect of opening bypass valves around process equipment or turbines to prevent waterlogging or damage
A possible increase in system corrosion because too much makeup water must be treated

Special situations. There can be many situations in a plant where effective condensate removal requires specialized drainage designs. For instance, Figures 1 and 2 show two options for condensate drainage from a jacketed pipe that conveys high-melting-point materials, such as liquid sulfur or high-boiling hydrocarbons.

Other examples of specialized applications include options to effectively drain steam-supplied heat exchangers. A key consideration is to first determine whether a stall condition exists or not; when it does, condensate will not drain effectively through a simple steam trap. Such a situation typically arises when modulating steam pressure creates a negative pressure differential across the condensate drain device. So-called, Type II secondary pressure drainers of the pump-trap type are used on equipment with a negative pressure differential. Because wasted condensate is a valuable resource to be saved, use Type I secondary pressure drainers of a "pump only" type to recover collected condensate and power it back to the boiler.

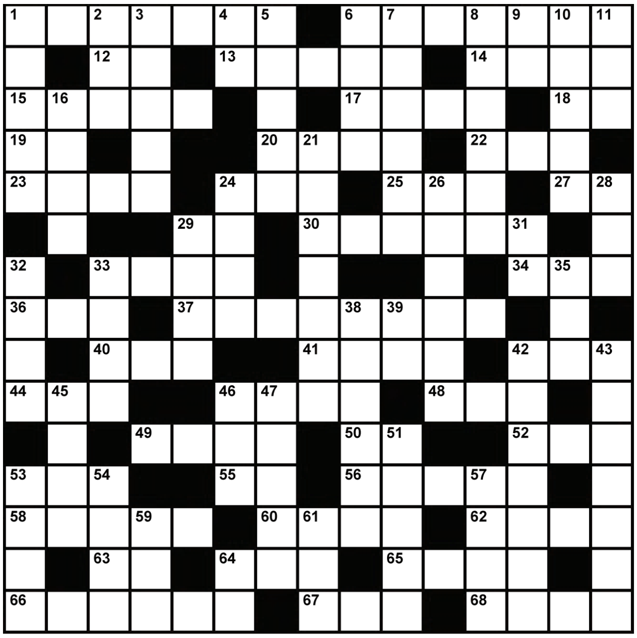
References

1. Risko, J., Handle Steam More Intelligently, *Chem. Eng.*, November 2006, pp. 38–43.
2. Aggarwal, S., Boost Energy Efficiency In Plant Utilities, *Chem. Eng.*, April 2002, pp. 70–73.

CE Community

April Crossword

By Myles Mellor



ACROSS

1. CPI part
6. ___-tape inserts, heat-transfer coefficient enhancement device
12. Two way
13. An opening through which molten metal is poured into a mold
14. Floor piece
15. Greenish
17. Rum cake
18. ___, shucks
19. Hawaiian bird
20. Chemical Engineers, for short
22. Demolition compound
23. To obstruct a tube
24. Important pollinator
25. Electronically stored information, for short
27. What?
29. Per __
30. Purple flowers
33. Soothing plant
34. Institute of Petroleum
36. Board member: abbr.
37. Surface resistance to relative motion
40. Time piece?
41. Surface ___, the extent of a 2-dimensional surface enclosed within a boundary
42. Zero
44. US car club
46. Home of the Bruins
48. New York college
49. California wine valley
50. "__ I ruled the world....."
52. Total amount
53. Scientist's question
55. Small, for short
56. Star explosions
58. Gives out
60. Simple
62. Average
63. Naval abbreviation
64. ___vection, heat transfer by the circulation of currents from one region to another
65. Alkene + hydroxyl group
66. Fundamental ChE course, for short
67. Neither's partner
68. Move

DOWN

1. Explosion____
2. Star Wars Jedi
3. Public works engineer type
4. This is one ID card, abbr.
5. Aero___, engineering branch for Alan Shepard?
6. Hollow body of a material used for conveying liquids or gases
7. Sneaky person
8. Hydro___ pressure, the pressure exerted by a fluid at equilibrium at a given point due to the force of gravity
9. Atomic number 22
10. Make proud
11. ___ point, upon cooling a vapor mixture, this is the point at which droplets of liquid first appear
16. See
21. Spiral shaped
24. Popular fermentation outcome
26. Polynesian person, perhaps
28. Chroma
29. Couch
31. Madrid agreement
32. ___batic, without loss or gain of heat
33. Length times width
35. Luau lunch option
38. Gets ready for the job
39. That is, abbr.
42. ___ number, the ratio of convective to conductive heat transfer across the boundary
43. ___ flow, nonturbulent streamline flow in parallel layers
45. Nucleus container
46. Brown carrier?
47. Special guest appearance
51. Lobby
53. ___ flux, the flow of energy per unit of area per unit of time
54. ___ matrix inserts, these are used to suppress fouling associated with corking during the heating of tar oil residues
57. Famous cookie
59. Paving material
61. Taylor or Margaret
64. Efficient preceder?

Look for the solution at www.che.com

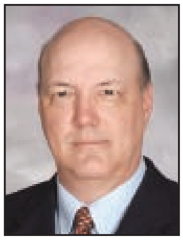
WHO'S WHO


Wood


Duran


Reichert


Jones


Dalton

Michael D. (Mike) Wood becomes business manager for the SOLVAir Products Group of **Solvay Chemicals** (Houston).

Linde North America (Murray Hill, N.J.) names *Warren Arenz* head of safety, health, environment and quality.

Luis Duran is now the business development manager for safety systems in the Americas Region for **ABB** (Houston).

John W. Dalton, Sr., of energy services company **Mustang** (Houston), is elected 2009 chairman of the executive committee for the **Construction Industry Institute**.

Paul Jones becomes business manager — sulfite and trona for **Solvay Chemicals** (Houston).

OPW Engineered Systems (Lebanon, Ohio) appoints *Jeff Reichert* general manager. Former president *Tim Warning* is now president of parent company **OPW Fluid Transfer Group** (Mason, Ohio).

BASF AG (Ludwigshafen, Germany) names *Ehrenfried (Fred) Baumgartner* head of its paper chemicals division. *Stefano Pigozzi* succeeds Baumgartner as head of the inorganics division.

Rajeev Gautam is named president and CEO of **UOP LLC** (Des Plaines, Ill.).

Paul K. Whitcraft, the director of quality, safety and engineering at **Rolled Alloys** (Temperance, Mich.), is elected the 2009 chairman of **ASTM International.** ■

Suzanne Shelley

Alfa Laval

ACHEMA 2009

ChargePoint Technology

KMPT

Bronkhorst Cori-Tech

Flottweg

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www.flottweg.de

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www.westfalia-separator.com

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The Pressure Drum Filter (photo) consists of a fully opening pressure vessel with a fixed bumped boiler end on the drive side and a moveable cylindrical housing on the opposite side. Both parts are locked pressure tight by a snap closure. The continuously operating pressure drum filters are available in three designs: as single cell filters, multi-cell filters and multi-chamber filters. Systems are designed to handle 8 bars pressure difference and 240°C operating temperature, and have a filtration area of up to 60 m^2. The drum velocity ranges from 0.1 to 10 rpm. Specific throughputs of up to 10,000 kg/m^2h are achieved for well-filterable products. The manufacturer says pressure drum filters can save considerable energy compared to that required for decanters, while also lowering investment and operating costs. Hall 5.0, Stand D13–E16 — *KMPT AG, Vierkirchen, Germany*
www.kmpt.com

A new, larger version of this compact heat exchanger

The newest and largest member of the Compabloc family of heat exchangers, the Compabloc 120 (photo), will be on display for the first time at this firm's stand. The Compabloc 120 offers a big boost to any natural gas, petroleum, fertilizer or petrochemical plant aiming to increase its capacity or energy efficiency, says the manufacturer. The heat exchanger provides a high capacity, "excellent" heat transfer, high up time, small footprint and easy cleaning. It also provides better efficiency and fouling resistance than shell-and-tube heat exchangers, claims the firm. Hall 4.0, Stand H2–J8 — *Alfa Laval AB, Lund, Sweden*
www.alfalaval.com

Note: For more information, circle the 3-digit number on p. 70, or use the website designation.

Show Preview

Rembe

Pieralisi Deutschland

List

Flowmeters for very low flow

The mini Cori-Flow (photo, p. 40D-1) is the latest model in this firm's series of compact Coriolis Mass Flow Meters/Controllers, and is designed for accurate measurement and control of very low flowrates. The full-scale capacity of the device has been extended from 1kg/h to 30 kg/h, for both liquid and gas applications. The effective turndown is no less than 1,000:1, with easy, onsite possibility for the user to rerange the instrument to meet the requirements. The device is available with approval for use in hazardous areas (ATEX Cat. 3 Zone 2). Hall 10.1, Stand B34–C35 — *Bronkhorst Cori-Tech B.V., Ruurlo, Netherlands*
www.bronkhorst-cori-tech.com

A safe way to transfer hazardous powders

The new, improved "sterile as standard" ChargeBag (photo, p. 40D-1) for contained transfer of potent powders ensures maximum product recovery, quality and operator protection. High containment, with operator exposure limits of less than 1 µg/m^3 during the transfer process is achieved when the ChargeBag is used in conjunction with a Split Butterfly Valve. Maintaining containment integrity, the bag is connected to the split valve "Passive" via a simple patented EziDock tri-clamp connection. Cleaning time, and therefore process downtime, and validation costs are reduced. Hall 4.1, Stand F32–F33 — *ChargePoint Technology, Liverpool, England*
www.thechargepoint.com

Achieve the benefits of dry processing in this reactor

The proven KneaderReactor technology (photo) combines specialized mechanical and thermal features, and allows polymers, chemicals, fibers and food products to be manufactured without the addition of solvents. Designed for high torques, the systems are capable of processing highly viscous, pasty and solid products that pass through sticky and crust-forming phases. The benefits of dry processing include: process intensification, yielding smaller plants with greater throughputs; maximum process yield per unit volume; continuous processing; reduced handling; and lower energy consumption. Hall 4.1, Stand F8–G9 — *List AG, Arisdorf, Switzerland*
www.list.ch

A large-bowl centrifugal separator for industrial applications

The new FPC 24 self-discharging, vertical-disc stack separator (photo) features a large equivalent clarification area, which is realized with a disc-stack geometry that is adapted to the individual application. The FPC 24 has a maximum speed of 5,800 rpm. The system has a 610-mm dia. bowl and an efficient sediment discharge system for fast and reproducible partial and total discharges. A low-shear feed-zone design provides efficient separation due to the gentle acceleration of products. The ATEX-compliant design also allows for nitrogen purging. Hall 5.0, Stand B40–C41 — *Pieralisi Deutschland GmbH, Eibelstadt, Germany*
www.pieralisi.de

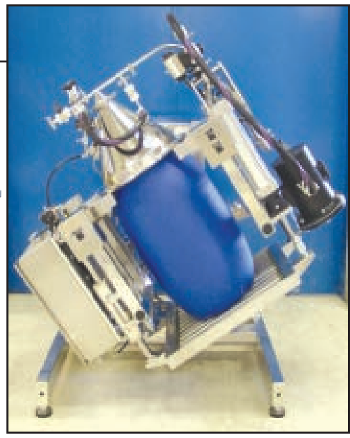
Exact and continuous metering of bulk solids

Developed in cooperation with the University of Applied Science (Düsseldorf), the C-Lever direct measurement system (photo) is based on the proven C-Lever II system. The system features a specially designed sensor area that is impact-free constructed and connected with a special load cell.


Swagelok


Pompetravaini


Ekato


Dietrich Engineering Consultants

This feature makes it possible to dynamically record bulk solids in- and online without adverse effects on accuracy due to fluctuations of material characteristics. Incorporating Friction Compensation Technology, the system does not require drives or other mechanically moving parts, which means less maintenance, and particle grinding does not arise. Hall 9.1, Stand K30–N31 — *Rembe GmbH Safety + Control Division, Brilon, Germany*
www.rembe.de

A flexible, inert hose for high purity applications
With a silicone and stainless-steel reinforced, smooth-bore PFA core, Core-flex Series U-COR hose (photo) offers increased flexibility, yet resists kinking. This flexibility allows for easy installation and short offset orientations, and additional use in applications that promote drainability and flow. A stainless-steel reinforcement encapsulated within the silicone jacket enhances the hose pressure rating. A smooth-bore PFA core provides a chemically inert, non-aging, nonstick surface. U-COR hose is non-absorbent and will not impart taste or odor, is easy to clean and features ultralow extractibles. Hall 8.0, Stand P38–P44 — *Swagelok Co., Geneva, Switzerland*
www.swagelok.com

Achieve low pressures with this combination system
The Hydrotwin (photo) is a compact vacuum-pump package that guarantees a vacuum level down to 5 mbar

Beumer Maschinenfabrik

(absolute) — previously not achievable by conventional stand-alone liquid-ring vacuum pumps, says the manufacturer. Capacities of up to 2,000 m^3/h can be handled by the system. Developed in cooperation with Bora Blowers, the Hydrotwin minimizes power requirements, with energy savings of 30–40% achievable. An optimized control system (DVD2) was jointly developed to operate the booster and liquid-ring pump for optimum performance and safety. Hall 8.0, Stand N8–N10 — *Pompetravaini S.p.A., Castano Primo, Italy*
www.pompetravaini.it

Reactors and agitators for very large capacities

This firm offers world-scale reactors with large agitators for continuous operation with volumes from 1,000 m^3 upwards, and production rates of more than 1 million ton/yr/vessel. Power inputs or 2,500 kW or torques above 500,000 Nm are possible. In addition to new solutions for process technology, dynamic loads on the vessel and internals are being taken into consideration. All components are designed using finite element and modal analyses. Such large units lead to economy of scale with reduced operating, personnel and investment costs. Hall 5.0, Stand B19–C26 — *Ekato RMT, Schopfheim, Germany*
www.ekato.com

Keep shipments safe and weatherproof with this patented unit

Covered by a number of patents, the stretch hood method (photo) combines the advantages of shrink wrap and stretch wrap while avoiding the disadvantages of these traditional packaging methods. With the so-called biaxial stretch, the vertical expansion of the foil during the stretch procedure is expanded vertically by more than 5%. The residual expansion that results from this ensures that vertical tensions remain in the foil that have a decisive effect on transport safety, while also reducing consumption of packaging material. With biaxial stretch, excellent stacking stability persists, even after repeated transloading. With the unstretch technique, this firm ensures a weatherproof and shipment-safe loading unit. Hall 3.0, Stand L20–L21 — *Beumer Maschinenfabrik GmbH & Co. KG, Beckum, Germany*
www.beumer.com

Dose I_2 powder into reactors without admitting air

The Drum Inverter system (photo, p. 40D-4) allows discharging drums of iodine powder in a closed and controlled way into a reactor. The system uses the patent-pending Pow derflex system in order to avoid any contact with air during the transfer phase,

since the charging process can take several hours. This technology allows continuous transfer and dosing with high accuracy of small to medium quantities of powder. The Pow derflex system runs continuously, reaching a maximum transfer capacity (235 kg/h in this case) at a predetermined charging time, or the operator can add 3–5 kg according to certain requirements. The drum inverter system is installed on load cells, and the weight sent to the control system that operates the Pow derflex unit. Hall 4.2, Stand O8–O11 — *Dietrich Engineering Consultants S.A., Ecublens, Switzerland*
www.dec-sa.com

A large globe valve for high-capacity control

This firm's response to the increasing demand for high capacity globe-style control valves, especially as anti-surge valve on turbo compressors, is the Ecotrol Control Valve (photo) with size 24 in. (DN 600). With a standard body material of carbon and stainless steel; the standard trim is a pressure-balanced perforated plug with maximum flow coefficient, C_v, of 7,020. Hall 8.0, Stand H2–J4 — *ARCA-Regler GmbH, Tönisvorst, Germany*
www.arca-valve.com


ARCA-Regler


Alconbury Weston

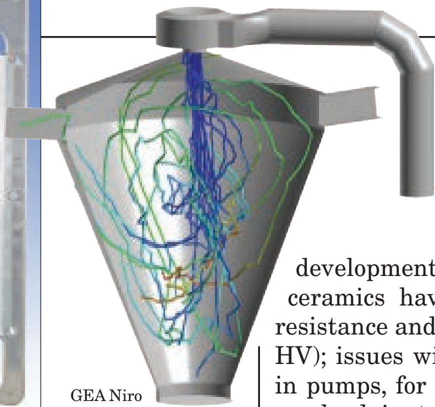
Upgrade ailing equipment to meet the latest standards

This company offers re-manufacturing and upgrading solutions for existing chemical and pharmaceutical processing equipment (photo). These solutions allow equipment to be CE certified at the end of the process, inclusive but not limited to pressure ratings, ATEX, EU safety regulations and PED (Pressure Equipment Directive) on modification. The company has recently opened a service and sales office in Basel. Hall 4.1, Stand N34 — *Alconbury Weston Ltd. (AWL), Stafford, U.K.*
www.a-w-l.co.uk

This membrane module can be cleaned by backwashing

With a membrane area of 10 m^2 and a 10-kD molecular weight cutoff, this new

Microdyn-Nadir



GEA Niro

Formatec Technical Ceramics

Flow-Cel module (photo) is optimally designed to filter protein-containing liquids with high solids content. The key feature of this cassette system is the ability to clean by permeate-sided backwashing. This increases the cleaning effectiveness and saves chemicals, time and manpower, says the manufacturer. Not just fermentation processes, but all protein-concentration applications with a high amount of solids — for instance cream cheese — can be handled. The Flow-Cel has been developed and tested together with operators in the biotech industry. The modular design, with different feed side height levels, allows the system to be modified according to the needs of each operator. Hall 4.2, Booth O15 — *Microdyn-Nadir GmbH, Wiesbaden, Germany*
www.microdyn-nadir.de

Optimize spray drying with this simulation tool

Developed over the last three years, Drynetics is a concept for using computer simulations to optimize a spray drying plant (photo). The model is put into the computational fluid dynamics (CFD) simulations of full-scale spray dryers, and incorporates the know-how of this firm's engineers. The content of the feed can be varied to determine which is the best solution for spray drying. The Drynetics method will be demonstrated at this firm's stand using a large flat screen and videos, as well as with an ultrasonic levitator in which a single drop of liquid will be suspended in the air. Hall 4.0, Stand D13–G22 — *GEA Niro, Søborg, Denmark*
www.niro.com

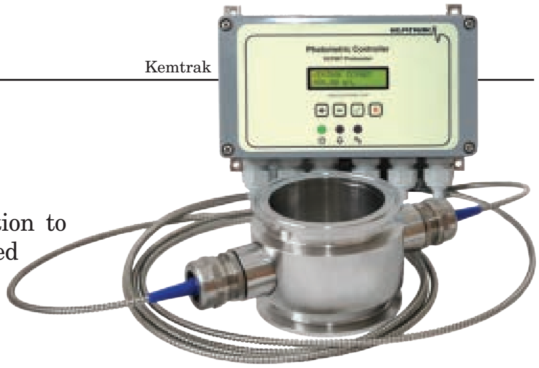
Injection molding makes ceramic components for pumps

This ceramic-injection-molding company is able to provide solutions to wear, corrosion and temperature issues in existing parts and for new developments. The firm's technical ceramics have very high chemical resistance and high hardness (>1.500 HV); issues with wear and corrosion in pumps, for example, can easily be resolved in technical ceramics. The firm develops and manufactures pumps and pump parts for diverse markets. Next to gear pumps (photo), technical ceramics are also used in piston pumps, centrifugal pumps and micro pumps. With ceramic injection molding any shape or geometry is possible,. Hall 9.1,

Stand D9–E10 — *Formatec Technical Ceramics, Goirle, Netherlands*
www.formatec.nl

A new process control system for O&M applications, too

Version 7.1 of the Simatic PCS 7 process control system has been equipped with a number of new functions aimed at helping to reduce engineering, installation and commissioning times while reducing operation and maintenance (O&M) costs. For engineering, the Advanced Process Library offers several new operating modes and facilitates enhanced interaction between operator and equipment. The user interface has also been modified with the aim of achieving greater efficiency and productivity. Polling and analysis of historical and current process data have been simplified. An improved Trend Control function allows access to and visualization of trends directly at the operator station. With the new Data Monitor tool, a direct connection to process data can be established in Excel. Hall 9.2, Stand A6–E24 — Siemens, AG, Industry Sector, *Industry Automation Division, Nürnberg, Germany*
www.siemens.com/automation



Kemtrak

This photometer measures a wide range of concentrations

The DCP007 Series of industrial photometers (photo) can measure the concentration of light-absorbing substances over the wavelength of 280 to 2,000 nm. The new units use solid-state LED lamps and laser diode technology, and a dual wavelength, four-channel measurement technique enables the device to determine concentrations from high down to trace (ppm) amounts. All units are CE marked, IP65 housed, and ATEX-enclosure certified (I I 2 GD EExd-IIB-T5). Lamps have a typical lifetime of more than 100,000 h. Hall 10.1, Stand F20–G21 — *Kemtrak AB, Täby, Sweden*
www.kemtrak.com

Ball valves for high-pressure applications

The new VB-15 and VB-65 ball valves will be launched at Achema. These valves are said to be safe and reliable, and are suitable for high-temperature or high-pressure applications. The VB-15 consists of three pieces and four bolts to facilitate installation and allow easy maintenance. A wide range of special, corrosion-resistant alloys are available. Hall 9.0, Stand A13 — *Tecval S.L., Barcelona, Spain*
www.tecval.es ■

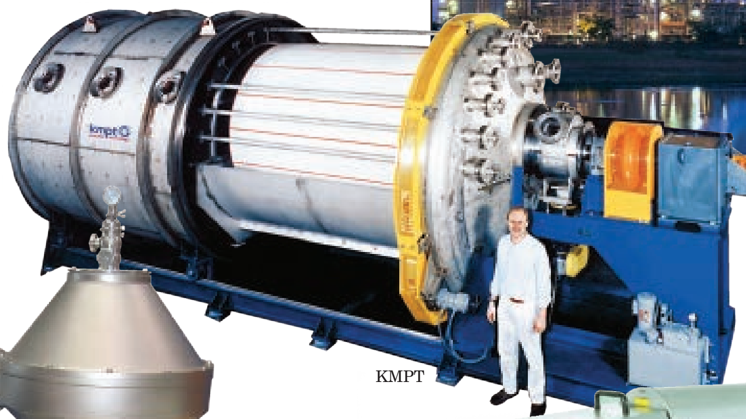
Gerald Ondrey

Alfa Laval

Show Preview

ACHEMA 2009

ChargePoint Technology



KMPT

Bronkhorst Cori-Tech

Flottweg

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www.flottweg.de

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www.kmpt.com

A new, larger version of this compact heat exchanger

The newest and largest member of the Compabloc family of heat exchangers, the Compabloc 120 (photo), will be on display for the first time at this firm's stand. The Compabloc 120 offers a big boost to any natural gas, petroleum, fertilizer or petrochemical plant aiming to increase its capacity or energy efficiency, says the manufacturer. The heat exchanger provides a high capacity, "excellent" heat transfer, high up time, small footprint and easy cleaning. It also provides better efficiency and fouling resistance than shell-and-tube heat exchangers, claims the firm. Hall 4.0, Stand H2–J8 — *Alfa Laval AB, Lund, Sweden*
www.alfalaval.com

Note: For more information, circle the 3-digit number on p. 70, or use the website designation.

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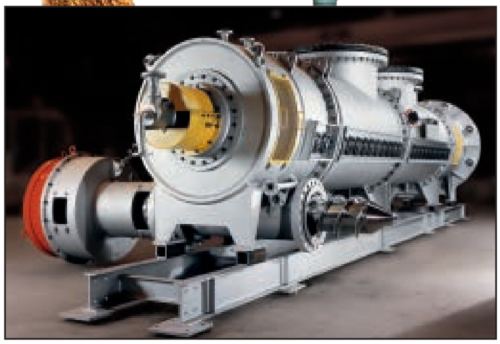
Rembe

Pieralisi Deutschland



List

Flowmeters for very low flow

The mini Cori-Flow (photo, p. 40I-1) is the latest model in this firm's series of compact Coriolis Mass Flow Meters/ Controllers, and is designed for accurate measurement and control of very low flowrates. The full-scale capacity of the device has been extended from 1kg/h to 30 kg/h, for both liquid and gas applications. The effective turndown is no less than 1,000:1, with easy, onsite possibility for the user to re-range the instrument to meet the requirements. The device is available with approval for use in hazardous areas (ATEX Cat. 3 Zone 2). Hall 10.1, Stand B34–C35 — *Bronkhorst Cori-Tech B.V., Ruurlo, Netherlands*
www.bronkhorst-cori-tech.com

A safe way to transfer hazardous powders

The new, improved "sterile as standard" ChargeBag (photo, p. 40I-1) for contained transfer of potent powders ensures maximum product recovery, quality and operator protection. High containment, with operator exposure limits of less than 1 μg/m^3 during the transfer process is achieved when the ChargeBag is used in conjunction with a Split Butterfly Valve. Maintaining containment integrity, the bag is connected to the split valve "Passive" via a simple patented EziDock tri-clamp connection. Cleaning time, and therefore process downtime, and validation costs are reduced. Hall 4.1, Stand F32–F33 — *ChargePoint Technology, Liverpool, England*
www.thechargepoint.com

Achieve the benefits of dry processing in this reactor

The proven KneaderReactor technology (photo) combines specialized mechanical and thermal features, and allows polymers, chemicals, fibers and food products to be manufactured without the addition of solvents. Designed for high torques, the systems are capable of processing highly viscous, pasty and solid products that pass through sticky and crust-forming phases. The benefits of dry processing include: process intensification, yielding smaller plants with greater throughputs; maximum process yield per unit volume; continuous processing; reduced handling; and lower energy consumption. Hall 4.1, Stand F8–G9 — *List AG, Arisdorf, Switzerland*
www.list.ch

A large-bowl centrifugal separator for industrial applications

The new FPC 24 self-discharging, vertical-disc stack separator (photo) features a large equivalent clarification area, which is realized with a disc-stack geometry that is adapted to the individual application. The FPC 24 has a maximum speed of 5,800 rpm. The system has a 610-mm dia. bowl and an efficient sediment discharge system for fast and reproducible partial and total discharges. A low-shear feed-zone design provides efficient separation due to the gentle acceleration of products. The ATEX-compliant design also allows for nitrogen purging. Hall 5.0, Stand B40–C41 — *Pieralisi Deutschland GmbH, Eibelstadt, Germany*
www.pieralisi.de

Exact and continuous metering of bulk solids

Developed in cooperation with the University of Applied Science (Düsseldorf), the C-Lever direct measurement system (photo) is based on the proven C-Lever II system. The system features a specially designed sensor area that is impact-free constructed and connected with a special load cell.

Show Preview


Swagelok


Pompetravaini


Ekato

This feature makes it possible to dynamically record bulk solids in- and online without adverse effects on accuracy due to fluctuations of material characteristics. Incorporating Friction Compensation Technology, the system does not require drives or other mechanically moving parts, which means less maintenance, and particle grinding does not arise. Hall 9.1, Stand K30–N31 — *Rembe GmbH Safety + Control Division, Brilon, Germany*
www.rembe.de

A flexible, inert hose for high purity applications

With a silicone and stainless-steel reinforced, smooth-bore PFA core, Coreflex Series U-COR hose (photo) offers increased flexibility, yet resists kinking. This flexibility allows for easy installation and short offset orientations, and additional use in applications that promote drainability and flow. A stainless-steel reinforcement encapsulated within the silicone jacket enhances the hose pressure rating. A smooth-bore PFA core provides a chemically inert, non-aging, nonstick surface. U-COR hose is nonabsorbent and will not impart taste or odor, is easy to clean and features ultralow extractibles. Hall 8.0, Stand P38–P44 — *Swagelok Co., Geneva, Switzerland*
www.swagelok.com

Keep shipments safe and weatherproof with this patented unit

Covered by a number of patents, the stretch hood method (photo) combines the advantages of shrink wrap and stretch wrap while avoiding the disadvantages of these traditional packaging methods. With the so-called biaxial stretch, the vertical expansion of the foil during the stretch procedure is expanded vertically by more than 5%. The residual expansion that results


Beumer Maschinenfabrik

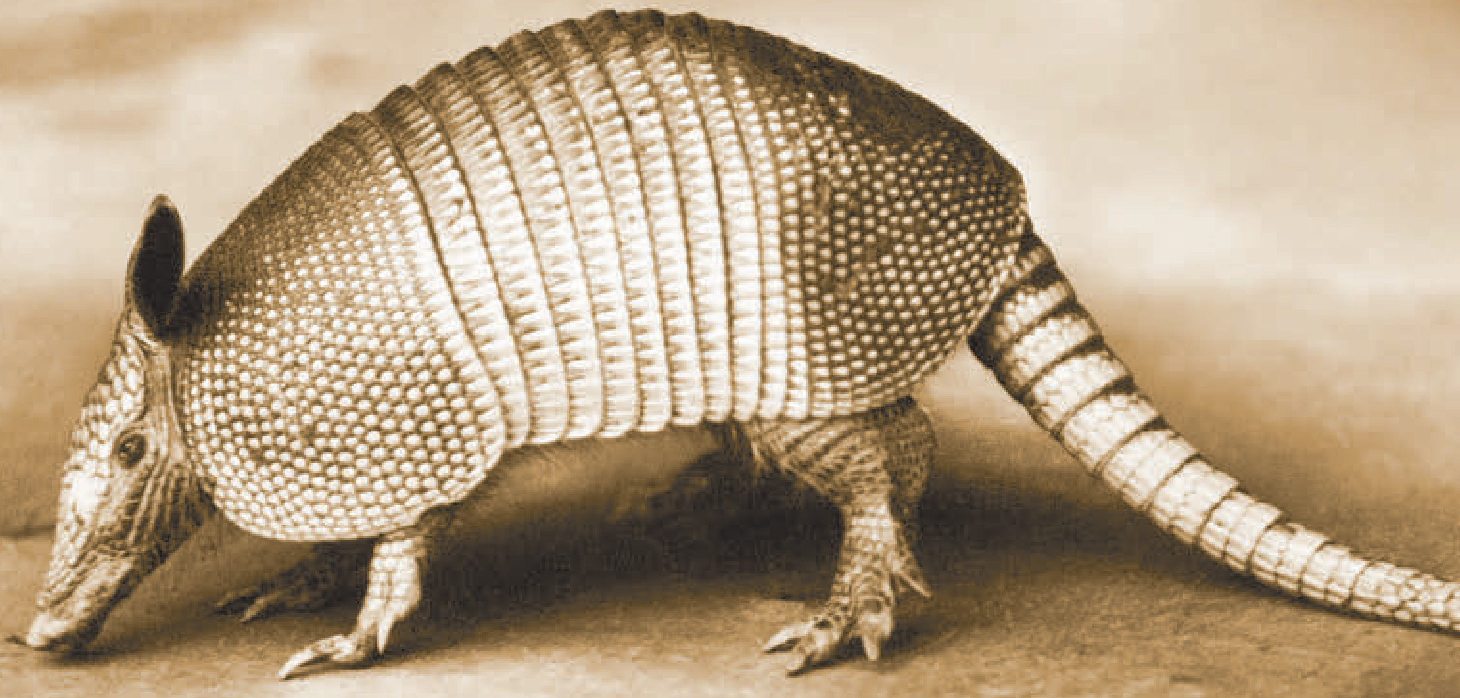
from this ensures that vertical tensions remain in the foil that have a decisive effect on transport safety, while also reducing consumption of packaging material. With biaxial stretch, excellent stacking stability persists, even after repeated transloading. With the unstretch technique, this firm ensures a weatherproof and shipment-safe loading unit. Hall 3.0, Stand L20–L21 — *Beumer Maschinenfabrik GmbH & Co. KG, Beckum, Germany*
www.beumer.com

Achieve low pressures with this combination system

The Hydrotwin (photo) is a compact vacuum-pump package that guarantees a vacuum level down to 5 mbar (absolute) — previously not achievable by conventional stand-alone liquid-ring vacuum pumps, says the manufacturer. Capacities of up to 2,000 m^3/h can be handled by the system. Developed in cooperation with Bora Blowers, the Hydrotwin minimizes power requirements, with energy savings of 30–40% achievable. An optimized control system (DVD2) was jointly developed to operate the booster and liquid-ring pump for optimum performance and safety. Hall 8.0, Stand N8–N10 — *Pompetravaini S.p.A., Castano Primo, Italy*
www.pompetravaini.it

A large globe valve for high-capacity control

This firm's response to the increasing



demand for high capacity globe-style control valves, especially as anti-surge valve on turbo compressors, is the Ecotrol Control Valve (photo) with size 24 in. (DN 600). With a standard body material of carbon and stainless steel; the standard trim is a pressure-balanced perforated plug with maximum flow coefficient, C_v, of 7,020. Hall 8.0, Stand H2–J4 — *ARCA-Regler GmbH, Tönisvorst, Germany*
www.arca-valve.com

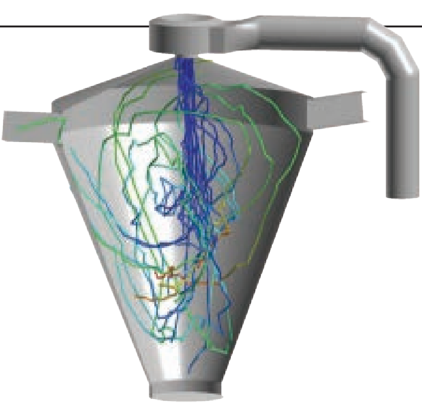

ARCA-Regler


Alconbury Weston

Reactors and agitators for very large capacities
This firm offers world-scale reactors with large agitators for continuous operation with volumes from 1,000 m^3 upwards, and production rates of more than 1 million ton/yr/vessel. Power inputs or 2,500 kW or torques above 500,000 Nm are possible. In addition to new solutions for process technology, dynamic loads on the vessel and internals are being taken into consideration. All components are designed using finite element and modal analyses. Such large units lead to economy of scale with reduced operating, personnel and investment costs. Hall 5.0, Stand B19–C26 — *Ekato RMT, Schopfheim, Germany*
www.ekato.com

Upgrade ailing equipment to meet the latest standards
This company offers re-manufacturing and upgrading solutions for existing chemical and pharmaceutical processing equipment (photo). These solutions allow equipment to be CE certified at the end of the process, inclusive but not limited to pressure ratings, ATEX, EU safety regulations and PED (Pressure Equipment Directive) on modification. The company has recently opened a service and sales office in Basel. Hall 4.1, Stand N34 — *Alconbury Weston Ltd. (AWL), Stafford, U.K.*
www.a-w-l.co.uk

Optimize spray drying with this simulation tool
Developed over the last three years, Drynetics is a concept for using com-


GEA Niro


Microdyn-Nadir


Dietrich Engineering Consultants

puter simulations to optimize a spray drying plant (photo). The model is put into the computational fluid dynamics (CFD) simulations of full-scale spray dryers, and incorporates the know-how of this firm's engineers. The content of the feed can be varied to determine which is the best solution for spray drying. The Drynetics method will be demonstrated at this firm's stand using a large flat screen and videos, as well as with an ultrasonic levitator in which a single drop of liquid will be suspended in the air. Hall 4.0, Stand D13–G22 — *GEA Niro, Søborg, Denmark*
www.niro.com

This membrane module can be cleaned by backwashing
With a membrane area of 10 m^2 and a 10-kD molecular weight cutoff, this new Flow-Cel module (photo) is optimally designed to filter protein-containing liquids with high solids content. The key feature of this cassette system is the ability to clean by permeate-sided backwashing. This increases the cleaning effectiveness and saves chemicals, time and manpower, says the manufacturer. Not just fermentation processes, but all protein-concentration applications with a high amount of solids — for instance cream cheese — can be handled. The Flow-Cel has been developed and tested together with operators in the biotech industry. The modular design, with different feed side height levels, allows the system to be modified according to the needs of each operator. Hall 4.2, Booth O15 — *Microdyn-Nadir GmbH, Wiesbaden, Germany*
www.microdyn-nadir.de

Injection molding makes ceramic components for pumps
This ceramic-injection-molding company is able to provide solutions to wear, corrosion and temperature issues in existing parts and for new developments. The firm's technical ceramics have very high chemical resistance and high hardness (>1.500 HV); issues with wear and corrosion in pumps, for example, can easily be resolved in technical ceramics. The firm develops and manufactures pumps and pump parts for diverse markets. Next to gear pumps (photo, p. 40I-8), technical ceramics are also used in piston pumps, centrifugal pumps and micro pumps. With ceramic injection molding any shape or geometry is possible,. Hall 9.1, Stand D9–E10 — *Formatec Technical Ceramics, Goirle, Netherlands*
www.formatec.nl

A new process control system for O&M applications, too
Version 7.1 of the Simatic PCS 7 process control system has been equipped with a number of new functions aimed at helping to reduce engineering, installation and commissioning times while reducing operation and maintenance (O&M) costs. For engineering, the Advanced Process Library offers several new operating modes and facilitates enhanced interaction between operator and equipment. The user interface has also been modified with the aim of achieving greater efficiency and productivity. Polling and analysis of historical and current process data have been simplified. An improved Trend Control function allows access to and visualization of trends directly at the operator station. With the new Data Monitor tool, a direct connection to process data can be established in Excel. Hall 9.2, Stand A6–E24 — Siemens, AG, Industry Sector, *Industry Automation Division, Nürnberg, Germany*
www.siemens.com/automation

This photometer measures a wide range of concentrations
The DCP007 Series of industrial photometers (photo, p. 40I-10) can mea-

Show Preview

Formatec Technical Ceramics

sure the concentration of light-absorbing substances over the wavelength of 280 to 2,000 nm. The new units use solid-state LED lamps and laser diode technology, and a dual wavelength, four-channel measurement technique enables the device to determine concentrations from high down to trace (ppm) amounts. All units are CE marked, IP65 housed, and ATEX-enclosure certified (I I 2 GD EExd-IIB-T5). Lamps have a typical lifetime of more than 100,000 h. Hall 10.1, Stand F20–G21 — *Kemtrak AB, Täby, Sweden*
www.kemtrak.com

Dose I_2 powder into reactors without admitting air

The Drum Inverter system (photo, p. 40I-7) allows discharging drums of iodine powder in a closed and controlled way into a reactor. The system uses the patent-pending Pow derflex system in order to avoid any contact with air during the transfer phase, since the charging process can take several hours. This technology allows continuous transfer and dosing with high accuracy of small to medium quantities of powder. The Pow derflex system runs continuously, reaching a maximum transfer capacity (235 kg/h in this case) at a predetermined charging time, or the operator can add 3–5 kg according to certain requirements. The drum inverter system is installed on load cells, and the weight sent to the control system that operates the Pow derflex unit. Hall 4.2, Stand O8–O11 — *Dietrich Engineering Consultants S.A., Ecublens, Switzerland*
www.dec-sa.com

Large-scale pressure filtering gets a redesign

In response to the increased demand for tailings and fine iron-ore filtration, this firm has created a platform for large-scale pressure filtration in mining applications. The Hoesch Fast

GEA

C-Polymers 1 CBC

We know what makes a OUTSTANDING POLYMERS

No one knows more about drying polymers and resins than GEA Niro. Which is why we count most of the leading producers worldwide among our customers. Our expertise extends from engineering powder properties to designing and supplying efficient drying solutions. We can help you determine the optimum drying solution – designed to match your exact product and plant specifications.

Our full range of drying systems includes spray, flash and fluid-bed drying systems. Our experience encompasses some of the world's largest projects within the petrochemical industry, as well as small units for very specialised applications.

GEA Niro will help you address the industry's toughest safety and environmental compliance challenges. Our state-of-the-art equipment is designed to increase manufacturing availability and reduce downtime. And we can help you minimise production costs through efficient energy utilisation. For more information about how GEA Niro can help you produce outstanding polymers and resins, please visit **www.niro.com**.

ACHEMA 2009

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Stand D13 - G22
Hall 4.0

Process Engineering

GEA Niro

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E-mail: chemical@niro.dk Website: www.niro.com

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Opening Filter Press is the latest development, which is one of the largest membrane filter presses on the market, and offers various improvements in user's processes through increased volume, savings in energy and maintenance costs. The FFP 2512 is the result of a comprehensive redesign of traditional Hoesch Filter Presses. The plates are fully made from PP carrying an exchangeable diaphragm and replacement components that simplify maintenance and extend component lifetimes. Hall 5.0, Stand H30–J35 — *Larox Corp., Lappeenranta, Finland*
www.larox.com

Kemtrak

Perform density profiling on vessels, even at high temperatures
The Profiler (photo, p. 40I-11) works by giving a density profile of the cross section of a vessel and then a visual interpretation of the data in much the same way an MRI scanner would provide a slice of a human body. The instrument provides a range of data in realtime that can be interpreted to identify the quality of oil-water interface and any emulsion/foaming layers that may be forming. The Profiler has already been proven in many upstream multiphase oil-and-gas separation processes at temperatures up to 125°C. Now, the system has been redesigned to enable it to withstand the elevated operating temperatures experienced with a desalter. Hall 10.2, Stand A9 — *Tracerco, Cleveland, U.K.*
www.tracerco.com

These rotary valves are suitable for pharmaceutical applications
The ZSV Rotary Valve series features a housing and cell wheel made of 1.4571 stainless steel, and is suitable for applications in the chemical and pharmaceutical industry according to clean in place (CIP) norms and ATEX. The valve is driven by a helical gear motor with explosion-proof coupling and has a rotor speed of 25 rpm. The valve has a rotor volume of 1.73 dm^3 and has a theoretical conveying capacity of 2.6 m^3/h. Hall 4.2, Stand M8 — *Kreisel GmbH & Co. KG, Krauschwitz, Germany*
www.kreisel.eu

Track compressor health with this new monitor
This manufacturer is launching the next level of its tried-and-tested system for monitoring reciprocating compressors, the new RecipCOM generation. In addition to continuously monitoring the status of all critical compressor components, the RecipCOM system offers reliable realtime machinery protection and, if required, machine shutdown within seconds.

Tracerco

One important innovation of this new system is the integrated machine protection system compliant with IEC 61508; RecipCOM ensures that every rotation is monitored in real time and that the machine protection cut-out is activated, if required. The system also meets the API 670 standard. *Hall 8.0, Stand P34–P37 — Hoerbiger Kompressortechnik Holding GmbH, Vienna, Austria*
www.hoerbiger.com

Seamless integration of design and planning data
With Comos PDMS Integration, this firm (formerly innotec GmbH) offers a tool for seamless integration of Comos planning in the PDMS model for the planning of chemical, petrochemical, pharmaceutical and other complex plants in the process industries. The PDMS user receives data from different systems, such as Visio, AutoCAD, and MicroStation. This data is mostly provided as a PDF or in Excel format. During the entire planning phase, a status check of all documents with the engineering database and the PDMS 3D model has to be executed. With Comos PDMS Integration, every modification is automatically displayed in the documents via redlining function and transferred to the PDMS model. Thanks to the interactive interface between the Comos engineering database and PDMS, a secure bidirectional import/export of engineering objects and engineering data is ensured. Hall 9.2, Stand A6–E24 — *Comos Industry Solutions GmbH, Schwelm, Germany*
www.comos.com

Control nearly all reactor parameters with this modular device
The 4848 Reactor Controller (photo, p. 40I-12) offers PID control; ramp and soak programming; separate heating and cooling control loops; motor-speed control; full- or half-power option; lockout relay and reset for over temperature protection; expansion modules for tachometery; pressure and high-temperature alarm; and auto-tuning PID parameters. A total of seven different modules are available for this controller. Software is provided with each unit to allow bidirectional communications between controller and a user-provided PC. All operating set points and control parameters can be sent from the PC to all of the operating modules installed. Data gathered by the modules are transferred to the PC for display and logging. Hall 6.2, Stand C6–C7 — *Parr Instrument Co., Moline, Ill.*
www.parrinst.com

Ball valves for high-pressure applications
The new VB-15 and VB-65 ball valves will be launched at Achema. These

Show Preview

Parr Instrument

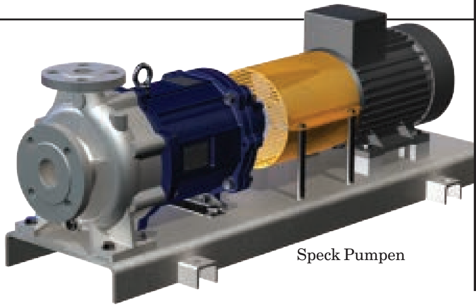
Tecval

valves are said to be safe and reliable, and are suitable for high-temperature or high-pressure applications. The VB-15 (photo) consists of three pieces and four bolts to facilitate installation and allow easy maintenance. A wide range of special, corrosion-resistant alloys are available. Hall 9.0, Stand A13 — *Tecval S.L., Barcelona, Spain*
www.tecval.es

For process upscaling, use this reaction calorimiter first
Adiabatic reaction calorimeters, such as the APTAC (photo, p. 40I-13), are used in the CPI to help ensure processes run securely and efficiently. These minireactors measure the thermal and pressure rise of most exothermic reactions in accordance with ASTM E1981. The resulting data help identify potential risks affecting process safety and optimization as well as the storage and thermal stability of chemicals. Process interruptions can be minimized and the onset of thermal runaway reactions in the minireactor can be translated to the real production process (upscaling). Hall 6.3, Stand N23–O23 — *Netzsch Gerätebau GmbH, Selb, Germany*
www.netzsch-thermal-analysis.com

Move hot fluids with this mag-drive pump
The Toe-MN Series of heat-transfer pumps (photo, p. 40I-13) feature a radial impeller and magnetic coupling. The pumps handle a flowrate of up to 220 m^3/h with total head of up to 100 m. The pumps can be used for pumping oil up to a temperature of 330°C, and have bearing bracket, hydraulics and dimensions according to EN 733. Transferable torques of up to 500 Nm are possible. Hall 8.0, Stand M38–N41 — *Speck Pumpen GmbH & Co. KG, Roth, Germany*
www.speck-pumps.de

A wide range of well-known and new pumps exhibited here
Formed by its parent company, Dover Corp., in 2008, this firm combines the following companies into a cohesive pump organization with a broad array of pump technologies: Wilden, Blackmer, Mouvex-Blackmer, Griswold and Neptune. At Achema, the organization will be debuting several technologies that will assist chemical process companies to meet the challenges of improving environmental protection, energy efficiencies and processes.



Speck Pumpen

Netzsch Gerätebau

Hall 8.0, Stand M27–M29 — *Pump Solutions Group, Redlands, Calif.*
www.pumpsg.com

These heat exchangers offer benefits of a new welding process

Welded plate heat exchangers in plate-and-shell design (photo) provide a large heat exchange area in a small space, uniform distribution of pressure- and temperature-related stresses and low shell thicknesses. This firm has developed a process to execute weld seams of the plate pack as laser weld seams. This process is said to achieve greater connection cross sections and minimizes heat-affected zones and changes in the material's microstructure. No elastomers are used, which allows operation of the heat exchangers between –200 and 550°C. Hall 4.0, Stand M3–M5 — *Gesmex GmbH, Scherin, Germany*
www.gesmex.com

This system mixes, dries and more

With the multifunctional vertical vacuum mixer and dryer (photo; p. 40I-14), both functions are possible for applications in product development through production. The HVW-VT ensures optimal heat-transfer values by means of the wall-hugging agitator, and nearly complete discharge provides minimal cleaning and low product losses. The installation is complete with all the required peripheral equipment, such as vacuum, condensation and heating systems and discharge valves. With a surface finish in accordance to GMP requirements and documentation and validation assistance provided, the system is especially suitable for pharmaceutical applications. Hall 6.0, Stand D26–D28 — *AVA-Huep GmbH &Co. KG, Herrsching, Germany*
www.ava-huep.com

An inexpensive and simple sampling valve

Traditional steam-sterilizable Keofitt valves are dead-leg free and fully drainable. The Keofitt Simplex sanitary sampling valve (photo, p. 40I-14) is based on the well-known technology of the existing Keofitt W9 sterile sampling valve, and is intended for extracting samples for physical and chemical analyses. The Simplex valve can be cleaned in place and comes with EHEDG certification. Other features include a machined 316L stainless-

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steel body; manual or pneumatic operation; FDA-approved membranes; 3.1 material certification; and a surface finish of Ra ≤0.5 µm. Hall 9.1, Stand Q5–R5 — *Keofitt, Odense, Denmark*
www.keofitt.dk

Ensure the entire vessel is cleaned with this CIP lance
Static spray balls create spray shadows in bioreactors, which lead to insufficient cleaning and potential sources of contamination. The CIP lance RotaCIP with spray ball eliminates this problem by the application of dynamic motion. The force imparted by the CIP fluid causes the lance to rotate around its axis. Plain bearings ensure low maintenance and safe performance. Modular, custom-made construction of the RotaCIP ensures perfect cleaning of the reactor. Hall 4.1, Stand A9–A11 — *Bioengineering AG, Wald, Switzerland*
www.bioengineering.ch

Gesmex

AVA-Huep

A breakthrough in precision gear pump design
Gear pumps have, for many years, offered pulse-free flow for a wide range of pressure and viscosity conditions, but in some cases, even the precision gear pump could not meet the pressure requirement of an application due to relatively low viscosity of the fluid. This firm has developed and tested a new breakthrough in precision gear pump designed for applications with a combination of high pressure and low viscosity. Through gear design and special materials of construction, the new design has achieved pressures of 50–60 bars with 1.6-cP viscosity fluid. Hall 8.0, Stand L33–L34 — *Witte Pumps & Technology GmbH, Uetersen, Germany*
www.witte-pumps.de

Pulsation dampers in all types of materials
For 30 years, this firm has been developing and manufacturing hydropneumatic accumulators and pulsation dampers. The company also offers the dampers in a wide range of elastomers, including NBR, Viton, ECO, Butyl, and EPDM as well as PTFE and metal.


Keofitt


Biar

The patented pulsation throughflow dampers are ideal for highly viscous liquids and are suitable for inline washing in applications where sterilization and cleaning are required without removing the damper from the line. Hall 8.0, Stand S12–S13 — *SAIP Srl., Opera, Italy*
www.saip.it

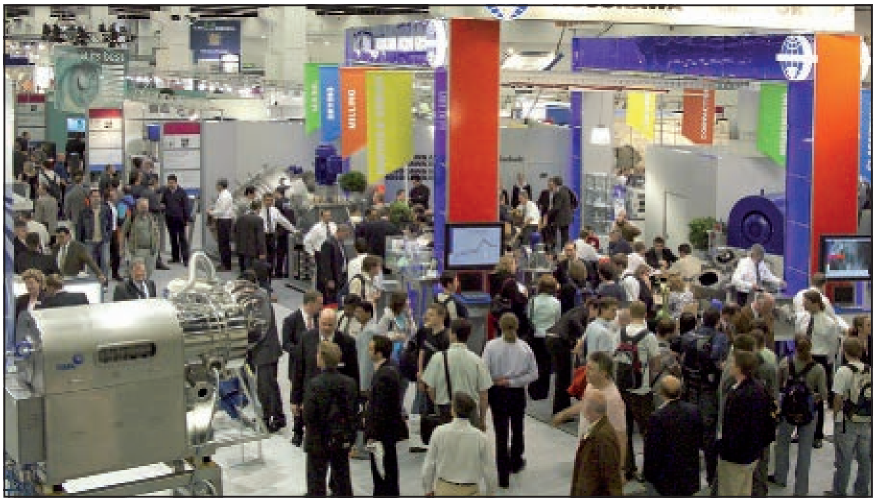
No pumps required for this sampling system
This firm has developed a PFA version of its Deep Flow sampling system (photo) as an economical alternative to corrosion-resistant metals such as titanium, tantalum or alloys. Deep Flow uses a magneto-pneumatic drive to circulate the product to be analyzed out of the reactor into a sampling valve, and then the sample is returned to the reactor by means of gravity. The absence of pumps reduces material and maintenance costs. Deep Flow operates over the temperature range from –40 to 180°C. Hall 8, Stand L1A — *Biar S.A., Lourtier, Switzerland*
www.biar.com

This containment valve is easy to clean
The Müller Containment Valve is designed for handling highly potent or toxic substances in the pharmaceutical industry. The split-valve system is pressure resistant up to 2 bars. The valve system can be cleaned very quickly and no disassembly is required. The product-contacting components are made of AISI 316L, and Hastelloy is also available on request. The system is available in sizes of DN 100, 150, 200 and 250. Hall 3.1, Stand B5–B6 — *Müller GmbH, Rheinfelden, Germany*
www.mueller-gmbh.com

Incinerate hazardous waste and comply with emission regulations
This firm develops and builds incinerators, based on the natural draft principle, for incinerating hospital, slaughterhouse and other hazardous wastes. Furnaces are made from massive steel construction, which is lined with several layers of fire-resistant insulation (refractory that is heat resistant up to 1,400°C). Incinerators have capacities from 5 to 500 kg/h, and comply with the current emission guidelines according to Directive 2000/76/EC and 17.BlmSchV. Hall 9.2, Stand A26 — *Incinis GmbH, Graz, Austria*
www.incinis.com ■

Gerald Ondrey

An optimistic outlook for Achema 2009



Melting pot: Achema 2006 attracted more than 180,000 visitors

Under difficult economic conditions, it is more important that ever to innovate, seek new business opportunities, and use new technology to cut manufacturing costs. This seems to be the view of exhibitors at Achema 2009, the giant three-yearly exhibition-congress which takes place in Frankfurt am Main, Germany, May 11–15.

"We assume that Achema 2009 will be even a little larger than Achema 2006," said Gerhard Kreysa, CEO of Achema's organizer, Dechema e.V. (Frankfurt, Germany), at a press conference in January. "We notice the aspiration rather not to miss an event like Achema, especially in a time like this." Reflecting the challenging times, Dechema expects energy efficiency and process intensification to be two of the hottest topics.

Around 4,000 companies are expected to exhibit at Achema. Nearly one-quarter of these fall into the Pumps, Compressors, Valves and Fittings group, followed by Laboratory and Analytical Techniques (671 exhibitors), and Engineering (567 exhibitors). Nearly half the exhibitors come from outside Germany, with a noticeable increase from China this year.

More than 900 congress presentations, plus panel discussions and a special event on renewable resources and energy will be among the other attractions at Achema.

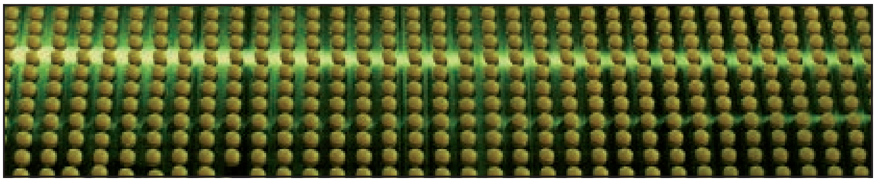
The following pages offer a brief but varied insight into some of the developments on show this year.

Visit **www.achema.de** to find out more about Achema 2009. ■

Inside

A world leader in dropforming and steel belts

Steel belts and related equipment from the Berndorf group form the basis for dust-free pastillation processes, as well as the smooth casting of films and foils



Uniform, dust-free pastilles are a hallmark of Berndorf Band steel belt technology

Berndorf Band (**Hall 4.0 B9–C11**) is a world leader in steel belts for process applications. Selected grades of stainless steel and advanced manufacturing technologies combine to yield long belt operating life and improved machine availability.

Applications for endless steel belts in the chemical process industries range from standard cooling and pastillation for dust-free granular products, to high-end applications such as film and foil casting on mirror-polished belts.

SBS Steel Belt Systems uses steel belts supplied by Berndorf Band for its cooling and pastillating equipment. The SBS Rolldrop transforms molten products into pastilles with diameters of 5–10 mm, and works with almost any product with a melt viscosity of 5–10,000 cP. Advantages include easy removal of the solidified pastilles from the belt, easy cleaning for quick product changeover, low-cost gaskets, easy assembly, rapid and low-cost maintenance, short downtime, and low wear.

Berndorf Belt Systems USA presents the BBS AccuDrop, a high-capacity pastillation system for sulfur. By eliminating the use of water or air as the forming medium, AccuDrop avoids the dangers of sulfur dioxide and sulfur dust emissions. The square spray pattern used in the cooling section eliminates hot spots on the belt, resulting in uniform pastilles and better product quality.

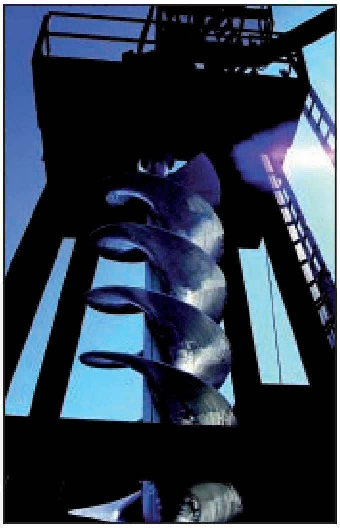
Kaiser Steel Belt Systems GmbH has accrued more than 60 years of experience in the solidification and granulation of molten products using endless steel belts form Berndorf Band. Kaiser SBS was the first company to develop and patent the pastillation process. The Rollomat system designed by Kaiser SBS can be used for melt viscosities of 15–30,000 mPas.

Together, the group companies — SBS Steel Belt Systems (Italy), Berndorf Belt Systems (USA), Kaiser Steel Belt Systems (Germany), and Berndorf Band (Austria) — form a unique source of expertise.

As well as equipment ranging from pastillator heads to complete turnkey units, plus up- and downstream equipment, the Berndorf group supplies comprehensive technical know-how and customer services through its international network. Service offerings include installation, inspection, emergency repair, preventive maintenance, and training for customers' own maintenance engineers. **www.berndorf-band.at**

Five companies, one plan

The **EKATO Group** (**Hall 5.0 B19–C26**), founded in 1933 and since 2004 the world market leader in mixing technology, has five member companies offering tailor-made solutions for the process industries.



EKATO RMT, a leader in process technology for more than 75 years, designs agitators and reactors for liquid applications.

EKATO FLUID manufactures modular and standardized agitators for the chemical industry, as well as for biodiesel and bioethanol production.

EKATO SYSTEMS specializes in complete units for the cosmetic and pharmaceutical industry (EKATO UNIMIX) and mixers and dryers for solids processing (EKATO SOLIDMIX).

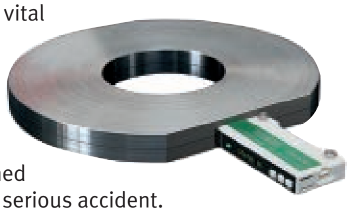
EKATO ESD develops innovative mechanical seals for all types of process equipment.

EKATO Process Technologies coordinates the sales activities of all EKATO subsidiaries and representatives worldwide.

A worldwide service network with a 24-hour hotline completes the portfolio of the EKATO Group. **www.ekato.com**

Keep an eye on bolt loads

Maintaining correct bolt loading is vital to many items of process equipment, from ethylene compressors to nuclear reactors. Early warning of fastener looseness on critical joints enables prompt attention by maintenance crews, avoiding unplanned shutdowns and possibly preventing a serious accident.



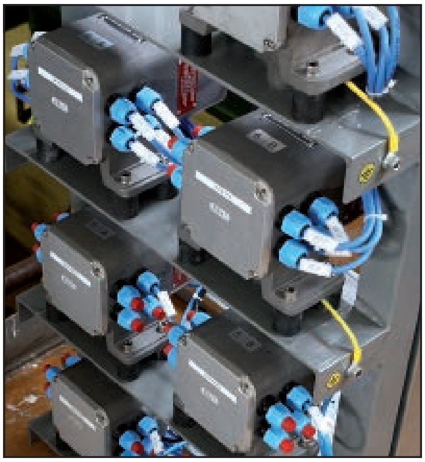
REMBE FibreForce (**Hall 9.1 K30–N31**) is demonstrating the SPASS-DREMODISC, a new type of fiber optic load sensor incorporated into a washer. This compact device measures the stress between the bolt head and the washer, and shows this on an integral display. Any drop in bolt stress causes an LED to light and triggers an electrical output signal. If remote monitoring is required, an optional wireless module can transmit the identification number and stress value of each washer to the plant's control system.

Benefits include simple installation, lower maintenance costs, fewer unplanned shutdowns, and reduced risk of accidents, environmental contamination, and bad publicity. **www.rembe.com**

Taking compressor protection to new levels

HOERBIGER is launching a new generation of RecipCOM, its condition monitoring system for reciprocating compressors

The **HOERBIGER Group** (**Hall 8.0 P34–37**) is a worldwide leader in technology for compression, automation, and drives. Its 6,400 employees achieve sales of around €1 billion. Under the slogan “Reliable Performance”, the HOERBIGER Group sets the standard for key components of compressors, engines and turbomachines, for piezo- and electro-hydraulic valve actuators, and as a worldwide service partner to the oil, gas and process industries.



Fast TIM² provides decentralised data acquisition for RecipCOM

At Achema 2009 HOERBIGER is launching the next generation of its RecipCOM system, which combines well-proven continuous monitoring of reciprocating compressors with SIL-compliant (IEC 61508) machine protection. The new-generation RecipCOM continuously checks the status of all critical compressor components, and provides reliable emergency shutdown within seconds if required. HOERBIGER’s deep know-how in compression technology facilitates analysis and “therapy” of compressors via the new-generation RecipCOM.

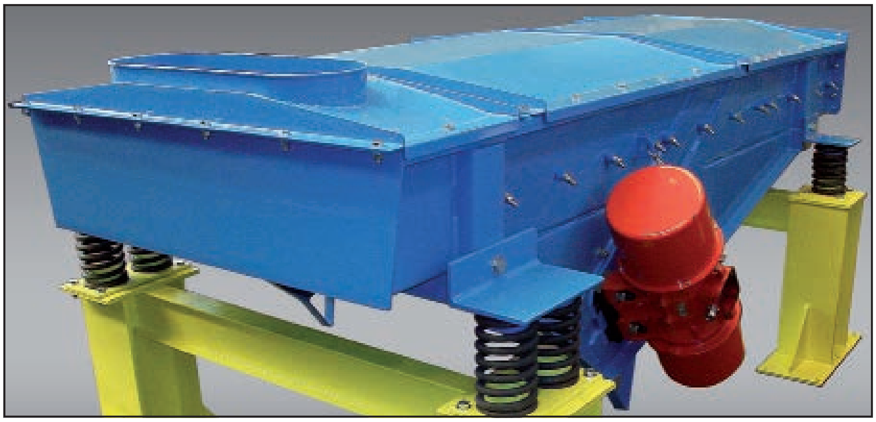
HOERBIGER is also giving a preview of its innovative BCD packing, designed to reduce emissions from reciprocating compressors. An important contribution to a cleaner environment, the BCD packing will be launched in the fourth quarter of this year.

Also at the booth will be the CP profiled plate valve. This is made from HOERBIGER’s HP material, which is more reliable than steel, even in oxygen service. The CP valve cuts energy consumption and opens up new dimensions in compressor cylinder design via improved compression density.

Alongside HOERBIGER Compression Technology, HOERBIGER Automation Technology will introduce its piezo-pneumatic and electro-hydraulic valve actuators for hazardous areas. With their compact design, fail-safe operation and high efficiency, they can be installed on all types of valves. **www.hoerbiger.com**

Vibrating screens herald a growing product range

Italian company Comber, traditionally a specialist in hygienic dewatering and drying, has branched out into equipment for size classification of solids



Comber's Model RS rectangular vibrating screen, used from chemical plants to quarries

Comber (**Hall 4.0 Q14–15**) is a leading manufacturer of batch equipment for solid-liquid separation and vacuum drying. Established in 1960, the firm has its headquarters in Milan, Italy, and a manufacturing plant in Colzate (Bergamo). To adapt to new market demands, Comber recently established a new business area, Screening Separation Technology, specializing in vibrating screens and conveyors.

The new range of Comber vibrating equipment includes the PS circular screen, the RS rectangular screen, and the VC vibrating conveyor, all designed and manufactured to Comber's high quality standards.

The Model PS ("Plus Screen") circular vibrating screen offers high throughput in a range of frame diameters from 400 mm to 2,200 mm. It can be used in any application where size separation, screening, dust removal, filtration, or liquid draining is required. Units are available with up to six stages and a wide range of mesh sizes. Options include various screen cleaning systems and inverter speed control.

The Model RS rectangular vibrating screen has one or more stages and mesh sizes for product size classification. High capacity and accurate size control makes these machines valuable for industrial sectors including food, chemicals, pharmaceuticals, minerals, foundries, and quarries.

Model VC vibrating conveyors use precisely controlled vibration to transport materials even over long distances. Typically coupled to belt conveyor, ferrous metal traps and mills, they combine high reliability with low maintenance costs.

www.comber.it / www.comberservice.ie

Advancing separation solutions

KMPT is the leading innovator in process technology for solid/liquid separation equipment, including centrifuges, filters and dryers

KMPT (**Hall 5.0 D13–E16**) designs, manufactures and services Krauss-Maffei centrifuges, filters and dryers, and engineers systems individually tailored to customers' specific needs. The company's expertise comes from decades of experience supplying separation solutions to the chemical, pharmaceutical, environmental and mining industries.

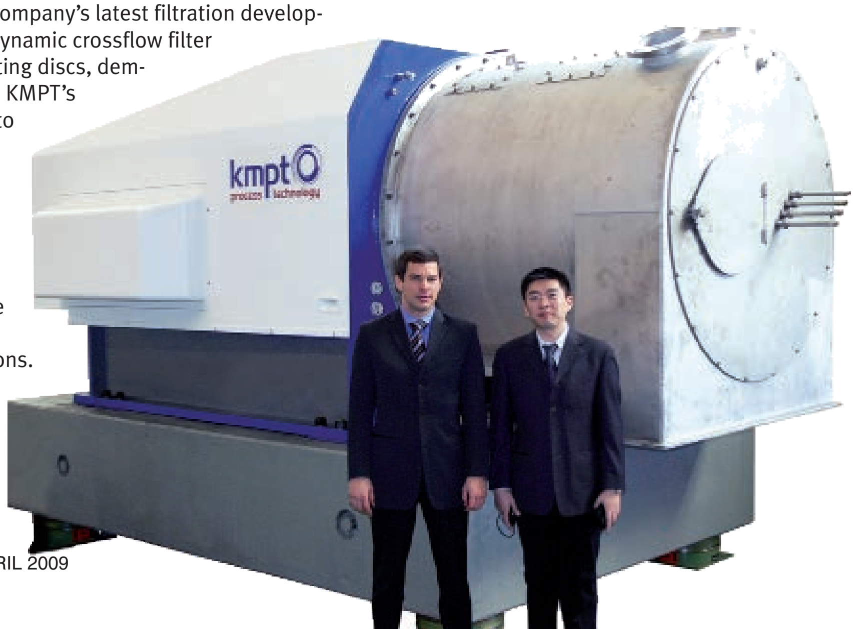
KMPT provides efficient technologies to reduce life cycle costs and environmental impact. Krauss-Maffei centrifuges, filters and dryers are renowned globally for quality and reliability. The company's dynamic and flexible approach to assisting its clients makes KMPT a trustworthy partner throughout the service life of the equipment.

Krauss-Maffei centrifuges include horizontal peeler centrifuges known for reliability, pharma centrifuges designed to meet the highest quality standards, innovative vertical basket centrifuges, and continuously operating pusher centrifuges. With this range, KMPT has the capability to handle a broad range of separation applications in the chemicals, pharmaceuticals and environmental industries.

For vacuum or pressure filtration, Krauss-Maffei rotary drum and disc filters combine high yield with low production costs in the processing of chemicals, plastics and minerals. The company's latest filtration development, a dynamic crossflow filter with rotating discs, demonstrates KMPT's capacity to innovate and to provide cost-efficient solutions for a wide range of applications.

For drying, KMPT offers Krauss-Maffei mixer dryers for batch operations, and plate dryers for the continuous drying of free-flowing materials. **www.kmpt.com**

The Krauss-Maffei SZ 1250 is the largest pusher centrifuge in the world



Save energy in bioethanol plants

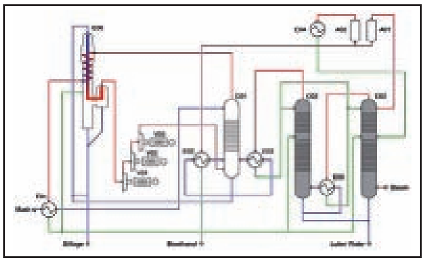
GEA Wiegand uses mechanical vapor recompression to improve the energy efficiency of bioethanol plants

GEA Wiegand (**Hall 4.0 D13–G22**) is an expert in separation processes including evaporation, distillation, and membrane filtration, and also—following a merger with GEA Jet Pumps in January—in process vacuum, jet pumping and gas scrubbing.

In bioethanol production, the company specializes in reducing energy consumption. This not only reduces greenhouse gas emissions, but also can significantly reduce plant operating costs.

Conventional bioethanol use two distillation columns which are thermally coupled to reduce energy consumption. To save even more energy, GEA Wiegand has introduced a mechanical vapor recompression system based on electrically powered multi-stage compressors. By allowing steam to be recycled, this halves the amount of steam needed to produce a given quantity of bioethanol.

The formation of an azeotrope means that simple distillation cannot concentrate an ethanol-water mixture beyond 95.6% ethanol. Techniques for the production of dehydrated ethanol include molecular sieve adsorption, azeotropic distillation, and pervaporation.



Heat recovery through MVR and improved molecular sieve drying can cut the energy used to make bioethanol by more than half

Molecular sieve technology is particularly suited to bioethanol production and is increasingly being used. GEA Wiegand has improved this process, creating significant possibilities for energy recirculation to the distillation column. This improves both heat recovery and process reliability.

www.gea-wiegand.com

Putting valves in their places

New products from Samson include a pneumatic booster and a self-diagnosing valve position monitor

Samson's Type 3755 booster aids rapid and precise control of large pneumatic actuators

Used in combination with a positioner, the new Type 3755 pneumatic booster from **Samson** (**Hall 10.2 F15–J18**) allows control valves with large pneumatic actuators to be controlled quickly and exactly, even at high flowrates or pressure drops.

With its precisely manufactured bypass orifice, the Type 3755 can be adjusted exactly before installation, making grueling trial-and-error tuning during start-up a thing of the past. As the booster is completely pressure-balanced, its output is stable even under changing pressure conditions. The signal pressure is transmitted with defined hysteresis, with minimal losses and noise.

Samson's new Type 3738 electronic valve position monitor can be used with on/off valves in any application, indicating the end positions and controlling the actuator. A contactless, magnetoresistive sensor eliminates the need for adjustment, while the integrated microprocessor allows configuration at the push of a button.

The Type 3738 works with a NAMUR signal in compliance with IEC 60947–5–6 and is powered by a two-wire supply. As a result, it can replace solenoid valves and limit switches without having to change the wiring or signal levels. Included functions like self-tuning and diagnostics open up many opportunities for control and asset management.

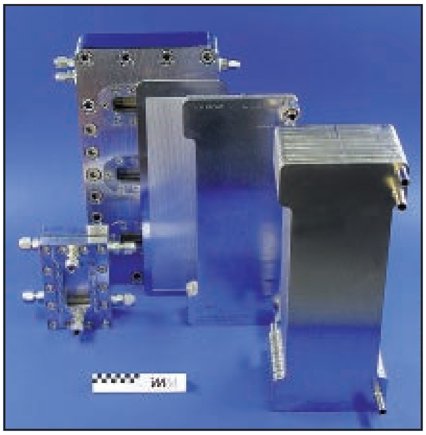
The supply air for the actuator is routed through the housing, so mounting is simple and rugged.

www.samson.de

Intensification via microtech

IMM specializes in micro and milli technologies

The *European Roadmap for Process Intensification 2008* recognizes the high potential of micro and milli technologies in process intensification and the development of sustainable processes. The **Institut für Mikrotechnik Mainz** (IMM; **Hall 9.1 D23–E24**) is an application-oriented public R&D company bridging the gap between basic research and application.



With throughputs of 1,000 l/h or more, "microtech" does not always mean "small"

Microstructured reactors are IMM's core technology. They cover the complete size range from laboratory (for example, 1 l/h for single-phase liquid flows) to pilot scale (typically 100 l/h), and even in some cases production scales of 1,000 l/h and more.

Key benefits of microreactors are their high heat and mass transfer rates, and defined residence times. These properties allow highly exothermic reactions to be carried out almost isothermally. Benefits include intensifying processes, eliminating unwanted side-reactions, and new windows of process conditions not accessible via conventional equipment.

IMM's main interests are in fine chemicals, pharmaceuticals, and fuel processing for fuel cells, though the Institute is also working on applications in other areas. IMM also has expertise in integrating devices to create, for example, complete micro mixer/heat exchangers and complete fuel processors. Recent achievements include a falling-film microreactor for ozonolysis with a liquid throughput of 10 l/h, and a microreactor assembly to produce up to 100 kg/day of ionic liquids. **www.imm-mainz.de**

Separation. Solution. Success

GEA Westfalia Separator manufactures centrifuges, with an emphasis on safety, quality, and performance

GEA Westfalia Separator (**Hall 4.0 D13–G22**) has been making centrifuges since 1893. The company says it makes them so well, in fact, that centrifugal separation has become a key technology in chemicals and pharmaceuticals, biotechnology, the recovery and production of food and biofuels from renewable resources, and the beverage and dairy industries.

Centrifuges from GEA Westfalia Separator span the full range of applications, from PTA to cell cultures

Equipment in these sensitive areas of application has to meet particularly stringent requirements, with no compromises on safety and quality. GEA Westfalia Separator guarantees maximum product quality and constant improvement through innovation.

Centrifuges in the chemical industry are challenged by concentrated acids and bases, explosive mixtures, and high temperatures and pressures. GEA Westfalia Separator meets its obligation to protect people and the environment, down to the smallest detail of materials, design, production and control. The centrifuges meet all the relevant standards for potentially explosive atmospheres, while design features such as the unique corrosion-resistant lining of the separator bowls, and optional direct drive, ensure profitable production.

For the pharmaceutical and biotech industries, GEA Westfalia Separator offers self-cleaning disc-type separators with a hydrohermetic feed for gentle product handling in a special steam-sterilizable design to ensure aseptic processing and bio-containment. More than 50 sales and service companies worldwide help to ensure that every machine runs smoothly.

www.westfalia-separator.com

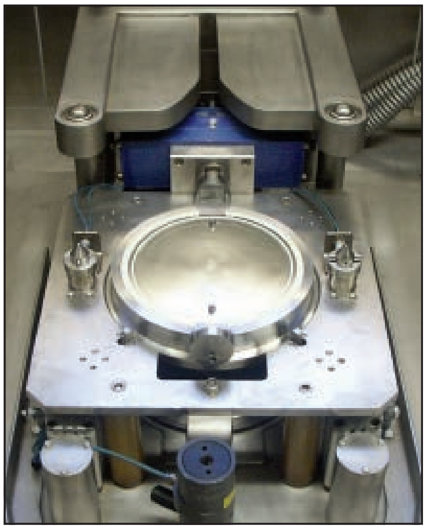
Hygienic powder handling

New products from Müller include easy-clean drums for the pharmaceutical industry, and solids-handling valves

Müller (**Hall 3.1, B5–6**), a specialist in stainless steel drums, containers, container handling systems and modular process systems for solids, is using Achema to present several new products.

First is a new generation of mobile drum lifters. Developed from Müller's well-known existing mobile drum lifter, the new version has received not just a facelift but also a technical redesign.

The company has also developed two new valves. The Müller Containment Valve (MCV) is a split valve for high-containment products that is more than ready to take on the competition. Like its big brother the Müller MC valve, the Müller MC Light valve can easily be disassembled without tools, but is lighter in weight. Customer benefits are easy handling and a lightweight price, thanks to the smaller amounts of materials required for construction.



Müller's new split valve, shown here with docking station, ensures high containment

Another highlight is the new Müller Ultra Clean drum. Most pharmaceutical companies already use Müller drums in their production, and this new line is designed for perfect cleaning in automatic drum washing machines. **www.mueller-gmbh.com**

Try dry, forget wet

LIST is a pioneer in "dry processing" — processing in the concentrated phase, which avoids or greatly reduces the use of solvents

LIST's (**Hall 4.1 F8–G9**) proven KneaderReactor technology uniquely combines specialized mechanical and thermal features that no other technology can deliver, and allows polymers, chemicals, fibers and food products to be manufactured without added solvents or water.

Designed for high torques, KneaderReactor systems are extremely robust, and so capable of processing highly viscous, pasty, and solid products that pass through sticky and crust-forming phases.

Dry processing with LIST KneaderReactor technology brings many advantages

Such difficult materials are a common consequence of dry processing, but the KneaderReactor handles them easily.

The benefits of dry processing include:

- process intensification, yielding smaller plants with greater throughput;
- maximum process yield per unit volume;
- continuous instead of batch processes;
- scalable, flexible processes;
- minimal use of solvents;
- reduced product handling; and
- lower energy consumption.

Individually and together, these advantages help customers carry out their operations more efficiently and economically, and to design processes that would be inconceivable using conventional technology.

At ACHEMA 2009, LIST is presenting dry processing applications from the polymer, chemical, fiber and food industries, and demonstrating the benefits of solvent-free operation. **www.list.ch**

Flowmeter is easy to use

The new FLUXUS F601 portable flowmeter from **FLEXIM** (**Hall 10.2 D27–E28**) is the successor to the company's classic ADM 6725, known for its high reliability and versatility.

Non-invasive flow measurement with ultrasound offers unmatched flexibility. Clamp-on-transducers are fixed to the pipe rapidly, and without interrupting the process. Only two transducer pairs are needed to cover most common pipe diameters (DN10–DN2500), though the full transducer range spans DN6–DN6500. No zeroing is necessary, since calibration data and transducer parameters are saved in non-volatile memory, and the whole installation process takes less than five minutes. A new Li-ion battery allows the F601 to run for more than 14 hours on one charge, and there is a display of remaining battery capacity.

Other features include the innovative HybridTrek measuring mode for fluids containing high percentages of gas or solids, and advanced algorithms to correct for wall echoes and transducer positioning issues in difficult measuring conditions. **www.flexim.com**

Innovation in packing

Bag filling and solids handling specialist **Haver & Boecker** (**Hall 3.0 Q18–R31**) is showing a number of innovative products at Achema. The Haver PumpPacker (photo) uses new pumping technology to support high-speed filling, precise weighing and optimum bag volumes when filling bags with light materials such as pigments, graphite, carbon black, or stearates.

The Cyrus, the latest model from the Haver FFS product group, was developed for dust-free filling of micro-granulates and blended products into bags made from tubular PE film.

Handling more than 2,400 bags/h, the Haver Delta NT bag filling machine has made a name for itself with its smooth operation and extremely low noise levels.

A new quality assurance system to check the leak-tightness of closed bags, a multiple-deck screening machine, and special laboratory equipment for powder testing are among other products on show at Achema. **www.haverboecker.com**

Circle 81 on p. 70 or go to adlinks.che.com/23013-81

Feature Report

Optimizing Pumping Systems

Often overlooked, pump system efficiency makes a dramatic impact on process performance

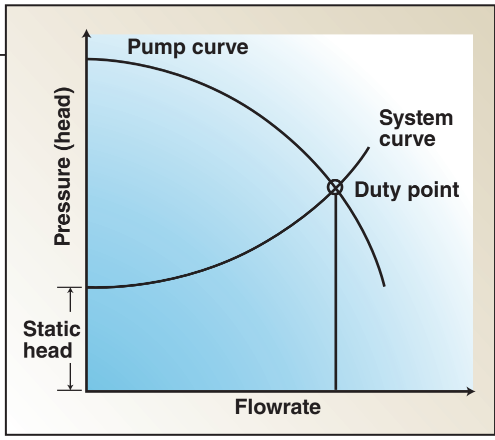


FIGURE 1. Rotodynamic (centrifugal) pumps have a variable flow-pressure relationship, which is described by a pump curve. Likewise, system curves graphically represent the operation of a given piping system

Robert Asdal
Hydraulic Institute and
Pumps Systems Matter

Interest in energy efficiency is not a fad. The economics of industrial production, the limitations of global energy supply and the realities of environmental conservation will be enduring themes for decades, if not the millennia. As energy costs increase, pump manufacturers respond with an understanding of the importance of making equipment more efficient at saving energy.

Traditional methods of specifying and purchasing piping, valves, fittings, pumps and drivers often result in lowest first cost, but also often produce subsequent unnecessary, expensive energy consumption and higher maintenance costs. An organization that incorporates the energy, reliability and economic benefits of optimum pumping systems can enhance profits, gain production efficiency and move ahead with essential capital upgrades necessary for long-term business survival.

System fundamentals

Pumping systems are typically designed to support the needs of other systems, such as process fluids transfer, heat transfer and the distribution of water and wastewater. Systems are generally classified as closed-loop or open-loop. Closed-loop systems recirculate fluid around set paths, whereas open-loop systems have specified inputs and outputs, transferring fluids from one point to another. For closed-loop systems, the frictional losses of system piping and equipment are the dominant loads. Open-loop systems often have significant static head requirements due to elevation and tank pressurization needs.

Pumps, piping, valves and end-use equipment typically compose these systems. Other common components include filters, strainers, and heat exchangers. Any evaluation of a pumping system should consider the interaction between these components, not just the pump itself. This is referred to as a systems approach to pumping system evaluation. The pumps and the system must be designed and treated as one entity, not only to ensure correct operation, but also to reap the benefits of energy efficient pumping.

The Hydraulic Institute (Parsippany, N.J.; www.pumps.org) recognizes about 40 different types of pumps, broadly classified into two categories that relate to the manner in which the pumps add energy to the working fluid: positive displacement and rotodynamic also known as centrifugal.

Rotodynamic pumps are much more common and have a variable flow-pressure relationship, which is described by a performance curve that plots the rate of flow as various pressures. Positive displacement pumps have a fixed displacement volume. Their flowrates are directly proportional to speed.

The other major components of typical pumping systems have a large effect on the system efficiencies. The selection of efficient and properly sized electric motors is vital, along with the use of variable speed drives when appropriate. Proper piping inlet and outlet configurations are also important for efficient system operation. Additionally, the appropriate selection and operation of valves is critical, especially any throttling or bypass valves.

Along with pump-speed control and multiple-pump arrangements, bypass valves and throttling valves are the primary methods for controlling rates of flow in pumping systems. The most appropriate type of speed control depends on the system size and layout, fluid properties, and sometimes other factors. Bypass arrangements allow fluid to flow around a system component but at the expense of system efficiency since the power used to bypass any fluid is wasted. Throttling valves restrict fluid flow at the expense of pressure drops across the valves.

Proper systems design

Pump engineers have long been trained that the highest level of pumping efficiency and equipment reliability is achieved by matching the pump to the system. Applying a total-systems-optimization approach, for instance, Pump Systems Matter (see box on additional information resources) advances significant savings opportunities with both existing and new pumping systems.

Proper system design and modification require an understanding of the operating range of the pumps being considered. A pump curve is a graphical representation describing the operation of a rotodynamic pump for a range of flows. Likewise, system curves graphically represent the operation of a given piping system. When a pump is installed in a system, the effect can be illustrated as shown in Figure 1, where the x-axis is the rate of flow and the y-axis is the head (pressure). The intersection of the pump curve and system curve is the duty point.

Figure 1 shows that increasing the system pressure will reduce the rate of

SYMPTOMS OF AN INEFFICIENT PUMPING SYSTEM

The key to improving the efficiency of existing pumping systems is process optimization. To begin, look for typical symptoms of an inefficient pumping system, such as those contained in the following checklist:

- Flow control valves that are highly throttled
- Bypass-line (recirculation) flow regulation
- Batch type processes in which one or more pumps operate continuously during a batch
- Frequent on-off cycling of a pump in a continuous process
- Presence of cavitation noise, either at the pump or elsewhere in the system
- A parallel pump system with the same number of pumps always operating
- A pump system that has undergone a change in function, without modification
- A pump system with no means of measuring flow, pressure or power

flow. If the pressure reaches a certain point, the flowrate may approach zero, a condition to be avoided. To allow for unforeseen pressure increases, pumping system designers often select an oversized pump. The consequence of this oversizing is that the system will operate with excessive flow or will need to be throttled, thereby increasing energy use, increasing maintenance requirements and decreasing the life of the pump.

Specific energy is a useful measure to consider when evaluating combinations of pump type, model and system. Specific energy is the power consumed per unit volume of fluid pumped. It is determined by measuring the flow delivered into the system over a period of time and calculating the power consumed during the same period of time. This measure takes into account all of the factors that will influence the efficiency of an installation, not just pump efficiency.

Specific energy also takes into account where the pump is operating on its curve when delivering flow into that particular system. Thus, a pump with a lower efficiency may consume less power than a higher efficiency pump, simply because of how its characteristics fit with the system in question.

Another benefit of using specific energy as a measure is that it allows some approximate comparisons between similar pumping installations.

Steps to improving efficiency

Existing systems. Process optimization is the process of identifying, understanding and cost effectively eliminating unnecessary losses while reducing energy consumption and improving reliability in pumping systems. Pumping systems possessing one or more symptoms that are typical of an inefficient system (see box) should be considered for further investigation, with priority given to large, high-maintenance systems that are mission critical to the process or facility operation.

Next, the pump systems selected for assessment should be thoroughly evaluated to determine the system requirements. In some situations, it may be determined that the system is operating with excessively high pressure or rates of flow. Occasionally, this analysis will find one or more pumping systems that can actually be turned off without compromising the process. An awareness of system-demand variability will help to better match flow and pressure requirements more closely to the system need.

The next step in the system optimization process involves data collection. Data may be acquired with installed process transmitters or portable instruments to determine discharge flowrate, discharge pressure and power consumption. The instruments used should be both accurate and repeatable. The data acquisition equipment should be matched to the application, and the length of data collection should provide statistically valid averages. Systems with varying or seasonal loads may require long-term data logging equipment.

The collected data can be used to compare the measured rates of flow and head to the required rates of flow and head. This may reveal an imbalance between measured and required conditions, which is evidence of an inefficient system. Comparing the existing operating conditions to the design conditions can also reveal an improperly sized pump.

If the original pump performance curve is available, it will be useful to construct a curve for the operating points of the existing system. Comparing the two can provide a general understanding of the current pump condition. Even a comparison of a single test point to the original curve can determine whether the first step is to overhaul a worn pump or to investigate the system further. Every rotodynamic pump has a best efficiency point (BEP). A pump operating outside of an acceptable operating range (within a reasonable range of BEP) will be inefficient and have higher energy use and shorter mean time between failures (MTBF).

Other components of the existing system must also be assessed. Incorrectly sized valves can create excessive pressure drops across the valves, and the different types of valves have different loss coefficients. When throttling valves or bypass lines are used to control flow, an analysis should be conducted to determine the most efficient means of flow control. These variable flow systems may benefit from pump speed control, such as variable speed drives.

The system piping configuration should be evaluated for optimization opportunities. A proper configuration will include a straight run of pipe leading into the pump inlet to ensure a uniform velocity of fluid entering the pump. Turning vanes or some other means of "straightening" the flow should be used when this is not possible. Also, the suction piping should be of sufficient size to minimize friction losses.

New systems. The design and selection of new systems provide the opportunity to optimize for minimum lifecycle costs, including energy, maintenance and other costs. Significant lifecycle opportunities exist through optimal pipe sizing (larger pipes can deliver fluid at lower pressures), variable-speed pump control, and pump and valve selection.

The selection of pump type and size, the impeller size and pump operating speed all impact the pump operating point and determine the pump's BEP. Getting the BEP matched to the actual system operating point is an important part of designing an efficient system. The piping size, material, and associated fittings and other

ADDITIONAL INFORMATION RESOURCES

Pump Systems Matter (PSM; www.pumpsystemsmatter.org) is an educational initiative created to assist North American pump users gain a more competitive business advantage through strategic, broad-based energy management and pump-system-performance optimization. PSM's mission is to provide the marketplace with tools and collaborative opportunities to integrate pump-system-performance optimization and efficient energy-management practices into normal business operations.

PumpLearning.org is the knowledge center of the Hydraulic Institute, and was created to serve as the ultimate "go to" center for information on pumps and pumping tehnologies. ❏

components influence the system resistance and hence the system curve and operating point. These materials should be selected through the consideration of lifecycle costs, especially since they are the most difficult parts of the pumping system to change in the future.

It is also important to note that all pumping systems change over time, affecting their operating points. As the systems age, corrosion, abrasion or solids buildup are likely to occur in the piping, altering the effective piping diameters. Cyclic mechanical and thermal loadings may cause piping fatigue damage over time. Valves, gaskets and other components are subject to wear and corrosion as well. Worn or damaged impellers and other parts in the pump itself will impact system performance. This also has a degrading impact on the process control loop associated with the pumping system.

Additionally, operational changes over the life of the system will influence system efficiency, as industrial processes are often evolving or changing to changing demands. Thus, the pump operating parameters can change as well as the duty cycles.

Economics: Lifecycle costing

The pursuit of optimum systems efficiency is typically not a sufficient justification for a pumping-system improvement or replacement project. Fortunately, systems optimization projects can often be justified based on having lower total cost of ownership. The odds of receiving approval for optimization projects are greatly enhanced when the potential projects can be proven to improve plant profitability and reduce operating costs.

Since industrial and municipal pumping systems often have life spans of 15 years or longer, it is valid to consider the total cost of ownership for each project, factoring in the lifetime costs of energy, maintenance, and other elements. A lifecycle cost (LCC) analysis is one proven way to determine and compare the total costs for projects.

The basic elements of lifecycle cost include the following:

- Initial purchase
- Installation and commissioning
- Electrical or other energy costs
- Operation costs (labor costs of normal system supervision)
- Maintenance and repair costs
- Downtime costs
- Environmental costs
- Decommissioning and disposal costs

LCC analysis requires evaluation of alternative systems. It is quite common for the lifetime energy and maintenance costs to dominate lifecycle costs. Thus, it is important to know the current cost of energy and to estimate the annual price escalation for energy and maintenance costs. Other LCC elements can often be estimated based on historical data for the facility.

The various costs incurred in the operation of a pumping system will occur at varying times throughout the life of the system. Therefore, the analysis should use present or discounted value for these cost elements to accurately assess the different solutions. Minimizing lifecycle costs often requires trade-offs between cost elements, such as paying a higher initial or installation cost to reduce maintenance, energy and downtime costs.

Winning project approval

An analysis showing the financial benefits of a pumping system optimization project may not always be sufficient to ensure approval of a given project. To help ensure success, the project developer should do the following:

- Seek support from a key member of management before pursuing any projects
- Obtain input from key department personnel to identify current corporate priorities
- Begin with simple projects to increase chances of success
- Create a written summary or proposal that clearly identifies the options with the greatest net benefits

Some of the benefits of pumping system optimization cannot be readily quantified through a cost-benefit or LCC analysis, but are nonetheless important to consider and qualify. These benefits may include the following:

- Increased productivity
- Reduced production costs
- Improved product quality
- Improved capacity utilization
- Improved reliability
- Improved worker safety

These benefits should be documented in any presentation or proposal to management. Existing industry literature can be very helpful and supportive in convincing management of the available opportunities.

When management is reluctant to approve a project based on perceived risks or lack of familiarity with similar projects, it may also be helpful to reference documented case studies of successful projects implemented at other facilities. The Industrial Technologies Program within the U.S. Department of Energy (www.eere.energy.gov/industry) and the Pump Systems Matter initiative both have case studies and tip sheets on various pumping systems efficiency projects at a variety of industrial and municipal facilities, as well as a wealth of other pump-system related information.

The future

Pump systems do matter. Industrial companies face stiff competition for global market share. This puts downward pressure on price, while labor, capital and raw material costs are all escalating at the same time. Faced with margin pressure from multiple fronts, companies must find new avenues to reduce operating costs. In many cases, sustainable net earnings increases can only be achieved through higher manufacturing efficiencies, requiring reengineering of existing or new processes to achieve quantum leaps in performance. Making pumping systems more intelligent and integrating them into production and asset management systems is becoming of paramount importance for the future.

Historically, the fundamental building blocks of process automation have been process sensors and control valves, with little consideration given to the role of pumps. Still, one of the easiest and often overlooked ways to make a dramatic impact on process performance is through increased pump systems efficiency.

Pump manufacturers have made substantial improvements in mechanical efficiency over the years. Unfortunately, once a pump is installed, its efficiency is determined predominantly by process conditions. The major factors affecting performance include efficiency of the pump and system components, overall system design, efficiency of pump control, efficiency of drives and appropriate maintenance cycles.

To achieve the best efficiencies available from mechanical design, pump manufacturers must work closely with pump users to consider all of these factors when specifying pumps. In the future, pump selection and sizing should be considered in the context of the overall system, not just the efficiency of the individual components.

Industry consolidation and outsourcing are major trends driven by the need to reduce cost and achieve economies of scale. Accordingly, end users are increasingly seeking new services from their suppliers. Some manufacturers have embedded the service into the product itself. However, even with these design upgrades, it is difficult to provide everything that is needed in the product or system. Increasingly, suppliers are offering the required mix of products, information, training, plus application and implementation services to fully address the user's needs.

Outsourcing has opened the door for pump manufacturers to provide new and innovative products and services that support plant optimization. While this is the good news, as is often the case, there are significant barriers to entry in the market.

In spite of the financial and operating benefits, industrial managers face many hurdles when implementing new technology. Among the major barriers is the lack of awareness among facility managers, plant engineers and distributors of new technologies and strategies to improve plant performance. When understood, the perceived risk from changing long established operating practices often delays decisions and project implementation.

Low levels of staffing in maintenance, operations and engineering departments limit time available for evaluating and commissioning new technologies. Considering these constraints, a common attitude among plant staffs is "If it ain't broke, don't fix it."

Alternately, on the supplier side of the equation, there are conflicting incentives for promoting efficient systems and practices. Many pump users continue to make buying decisions based on first cost rather than spend the incremental capital required to achieve long-term savings.

To capture the many benefits of pump optimization, pump users, manufacturers and distributors, as well as design engineers, must work together to change the way they do business. This is no easy task, but the payback for all of these stakeholders is too compelling to delay the journey. ■

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Feature Report

Capital Costs Quickly Calculated

Estimating capital costs early can prevent unnecessary expenditures on dead-end projects

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University of New Hampshire

A chemical executive once noted that his firm derives one-third of its income from products that are less than ten years old. Indeed, existing companies thrive and new ones proliferate through innovation and product improvement. They depend on scientists and engineers working "in the trenches" or "at the bench" to drive development. Yet, most potential innovations never succeed. Engineers who can separate lucrative concepts from duds early on are worth their weight in gold. Mastery of the information in this article can help you become one of those engineers.

It's important to define promising projects quickly so that money is not wasted on dead ends. Economic evaluation should begin at conception and continue in parallel with research and pilot studies before design and development expenses begin to balloon. Costs of prolonging a project and securing more detail increase exponentially with time. Clearly, if the project is a "loser," the sooner it is abandoned, the better. Any engineer with practical experience can cite projects that were supported far beyond the point of viability.

One can construct the economic profile for a manufacturing process from a few basic data, such as raw material prices, labor, and other costs. Details on how to put these together are explained in Chapter 6 of Ref. [*1*]. Several vital manufacturing expenses hinge on capital.

This article describes how to estimate that capital quickly and with an accuracy of about +30 to –20%. This range is good enough to define feasibility before a lot of money is spent on advanced development activities.

The sticker price of a process is technically known as fixed capital, what one would pay if a manufacturing line could be bought in the same way that a house, automobile, or washing machine is purchased. It is "fixed" because (a) it represents real equipment that cannot be converted easily to another asset, and (b) once built, it must be paid whether the plant operates or not.

Unlike consumer goods and appliances that are bought directly and put into service immediately, process equipment is usually custom designed in advance, then built and installed by specialists. Thus, a development team is faced with predicting the future price of a process that doesn't exist. Fortunately, through the efforts of generations of cost engineers, translation of technical specifications into future expenses can be done with amazing accuracy.

With a process flow diagram and using short-cut design techniques, an engineer can size major equipment, draw purchase prices from graphs such as Figure 2, and build a capital cost estimate.

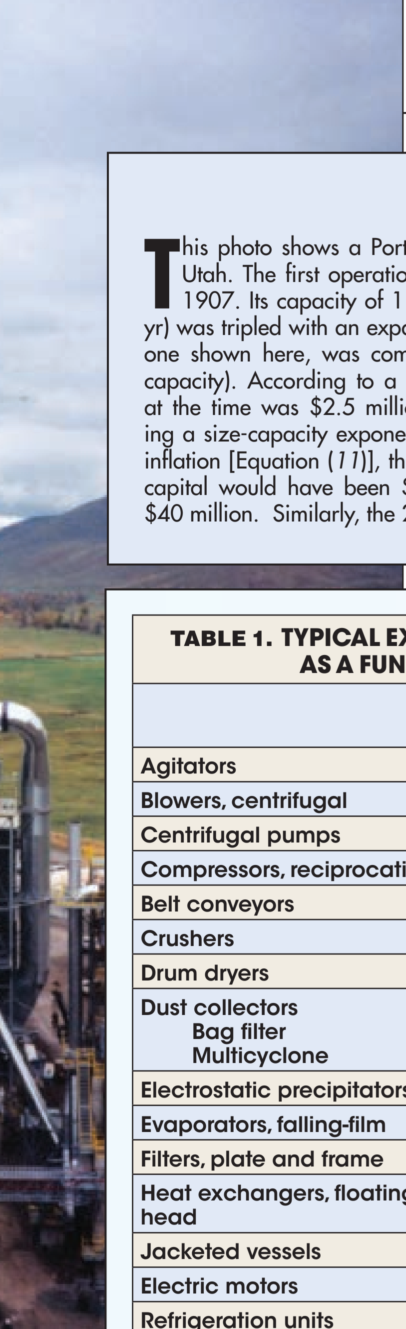
Purchase prices are, by necessity from the past. To estimate for the future, engineers must scale from one size or capacity to another and from one time to another. Then, to assess total capital, they must add costs for installation. How to go from flow sheet to final capital is described below.

Variation of cost with size

Relationships between cost and capacity are part of everyday experience. If, for example, one were transporting people in taxicabs and one cab held four persons (excluding driver), the capital cost to convey eight people is twice that of carrying four. For 20 to 30 people, a bus or van could be used where equipment cost is no longer directly proportional to number of people. This can be expressed mathematically as follows:

$$C_{P,v,r} = C_{P,u,r}\left(\frac{v}{u}\right)^{a} \qquad (1)$$

where $C_{P,v,r}$ is the purchase price of the equipment in question, which has a size or capacity of v in the year r, and $C_{P,u,r}$ is the purchase price of the



SCALING BY THE 'SIX-TENTHS' RULE

This photo shows a Portland cement plant in Devil's Slide, Utah. The first operation on this site began production in 1907. Its capacity of 110,000 metric tons per year (m.t./yr) was tripled with an expansion in 1948. A third factory, the one shown here, was completed in 1997 (635,000 m.t./yr capacity). According to a 1909 letterhead, company capital at the time was $2.5 million. Using that as a basis, assuming a size-capacity exponent equal to 0.8, and escalating for inflation [Equation (*11*)], the 1948 estimated grass-roots fixed capital would have been $2.5 million × 30.8 x (80/12) = $40 million. Similarly, the 2004 value extrapolated from these numbers would be $40 million × 20.8 × (400/80) = $350 million. According to local tax records, the 2004 evaluation is slightly greater than $100 million. This reveals the danger of extrapolating over large time periods with no correction for improved technology. For a more realistic estimate, a 2 million m.t./yr cement plant in the northeastern U.S. was reported to cost $300 million in 1998. Based on this number, the calculated grass-roots value of the Utah plant would be $300 million × (0.635/2)0.8 × (400/390) = $120 million. (Photo courtesy John Sommers of Holcim [U.S.], a wholly owned subsidiary of Holcim Ltd., Switzerland. Used with permission.) ❏

TABLE 1. TYPICAL EXPONENTS FOR EQUIPMENT COST AS A FUNCTION OF CAPACITY *

	Size range	Capacity unit	Exponent *a*
Agitators	1–200	kW	0.7
Blowers, centrifugal	50–8,000	kW	0.9
Centrifugal pumps	0.01–270	kW	0.3
Compressors, reciprocating	10–2,000	kW	1.0
Belt conveyors	10–50	m	0.8
Crushers	10–1,000	kg/s	0.8
Drum dryers	2–100	m^2	0.6
Dust collectors			
Bag filter	2–1,100	m^3/s	0.9
Multicyclone	0.1–40	m^3/s	0.6
Electrostatic precipitators	5–1,200	m^3/s	0.8
Evaporators, falling-film	30–320	m^2	1.0
Filters, plate and frame	1–170	m^2	0.75
Heat exchangers, floating head	10–900	m^2	0.6
Jacketed vessels	1–800	m^3	0.6
Electric motors	10–8,000	kW	0.9
Refrigeration units	5–10,000	kJ/s	0.6
Vibratory screens	1–130	kW	0.6
Tanks			
Floating roof	200–70,000	m^3	0.6
Spherical, 0–5 barg	50–5,000	m^3	0.7

*Exponents were determined from slopes of the curves in our collection of data found in Figures 3–61 of Chapter 5, Ref. [*1*]. Results are included here primarily for illustration. It is much better to use the curves themselves in a cost estimate.

EXPONENTIAL SIZE-CAPACITY RELATIONS

Exponential size-capacity relationships are useful for individual equipment items and for entire processing plants. The fixed capital of a component or plant having one capacity is scaled to that of another capacity by using Equation (1). This practice is known popularly as the "sixth-tenths rule" because 0.6 is a common exponent. Although quick and easy to use, this rule has limitations. One must know, at least, the capital cost of a plant or component at one capacity. The range in exponents is quite large, so one should have experience or know cost estimates for at least two capacities to go on.

The six-tenths rule is valuable for rapid order-of-magnitude plant cost estimates where inaccuracy can be tolerated. It is also useful for predicting product price as a function of capacity when a capital estimate is available at only one rate.

There is a danger of extrapolating with the six-tenths rule beyond its range of validity. For example, according to Equation (1), prices decrease with equipment size. This is reasonable and logical. But, with precision items, costs level off when a certain *minimum size* is reached. Savings in materials are offset by more labor required to make miniature equipment. Prices might even go up as size decreases further, changing *a* to a negative number.

Extrapolation to larger capacities is risky when predictions "create" equipment that is too large to be fabricated or shipped. When any maximum size is exceeded, multiple equipment items become necessary and the scaling exponent *a* becomes unity. Holland and Wilkinson avoid this problem by specifying the size range (Ref. [*2*], Table 9–50) for which Equation (1) is valid. You are safe using graphs such as Figure 2 if you stick with existing curves and don't extrapolate. ❏

same type of equipment in the same year but of capacity or size u. In the twin taxicab example, u is 4, v is 8, and the size exponent a is unity. Although a is 1 for multiple taxicabs, it is usually less than unity when relating cost to size in a bus or van.

The same is true for chemical process equipment. This is easily demonstrated by comparing costs of two storage tanks. Assume they are spherical, made of identical materials, but of different capacity. The volume of tank u is

$$V_u = \frac{4}{3}\pi R_u^3 \qquad (2)$$

The volume of tank v can be similarly expressed. Dividing Equation (2) by its analog for tank v, the volume or capacity ratio is

$$\frac{V_v}{V_u} = \left(\frac{R_v}{R_u}\right)^3 \qquad (3)$$

Costs of tanks are proportional not to the volume, however, but to surface area or the quantity of metal plate used in fabrication. The area of tank u is

$$A_u = 4\pi R_u^2 \qquad (4)$$

The area ratio of v versus u is

$$\frac{A_v}{A_u} = \left(\frac{R_v}{R_u}\right)^2 \qquad (5)$$

At C_s dollars per square meter of tank surface, purchase prices of the tanks are given by the following:

$$C_{P,v} = 4\pi R_v^2 C_s \quad (6)$$

$$C_{P,u} = 4\pi R_u^2 C_s \quad (7)$$

Their relative cost, found by combining Equations (6) and (7), is

$$C_{P,v} = C_{P,u}\left(\frac{R_v}{R_u}\right)^2 \quad (8)$$

Radius ratio can be replaced with capacity ratio via Equation (3):

$$\frac{R_v}{R_u} = \left(\frac{V_v}{V_u}\right)^{1/3} = \left(\frac{v}{u}\right)^{1/3} \quad (9)$$

and substituted into Equation (8) to yield

$$C_{P,v} = C_{P,u}\left(\frac{v}{u}\right)^{2/3} \quad (10)$$

Comparing Equations (1) and (10), we see that the size exponent a is 2/3. In other words, doubling the size of a spherical storage tank increases its price by about 60%.

Exponents for various individual equipment items are listed in Table 1.

For our purposes, the form of Equation (1) is more important than the expression itself. It tells us that plotting capacity versus cost on log-log coordinates will yield a straight line of slope a. That is the basis for the format of Figure 2. Plots such as this one have several advantages over equations.

1. The range of valid sizes is defined by lengths of curves.
2. Exponent a can be estimated by a quick glance at the curves (45 deg. slope represents an exponent of 1.0, for example; 30 deg. an exponent of about 0.6, and so on).
3. Changes in a are visually obvious through curvature of a line.

(Fee-based software, such as that described in Ref. [3] can be used when machine computation is preferred over reading from a chart.)

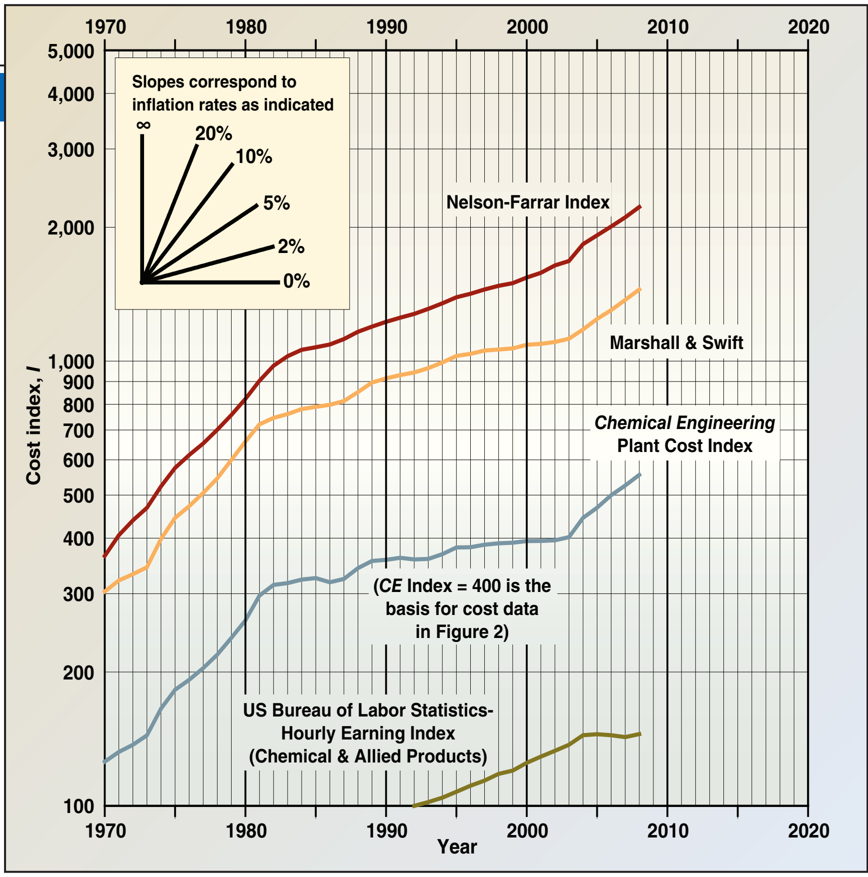


FIGURE 1. A history of selected cost indices pertinent to chemical processing

TABLE 2. TYPICAL COSTS ASSOCIATED WITH PURCHASE AND INSTALLATION OF A HEAT EXCHANGER* IN A PROCESS MODULE

Direct Project Expenses	Cost	Fraction of f.o.b. ** equipment
Direct materials		
Equipment f.o.b. price, C_P	$10,000	$1.0C_P$
Materials used for installation	7,100	$0.71C_P$
Direct labor	6,300	$0.63C_P$
Total direct materials and labor	**$23,400**	$\mathbf{2.34C_P}$
Indirect Project Expenses		
Freight, insurance, taxes	1,400	$0.14C_P$
Construction overhead	4,400	$0.44C_P$
Contractor engineering expenses	2,600	$0.26C_P$
Total indirect project costs	**$ 8,400**	$\mathbf{0.84C_P}$
Bare module capital, C_{BM}	$31,800	$3.18C_P$
Contingency and Fee		
Contingency	4,800	$0.48C_P$
Fee	1,000	$0.10C_P$
Total contingency and fee	**$ 5,800**	$\mathbf{0.58C_P}$
Total module capital	**$37,600**	$\mathbf{3.76C_P}$

*Purchase price, $10,000; ** f.o.b. = free on board

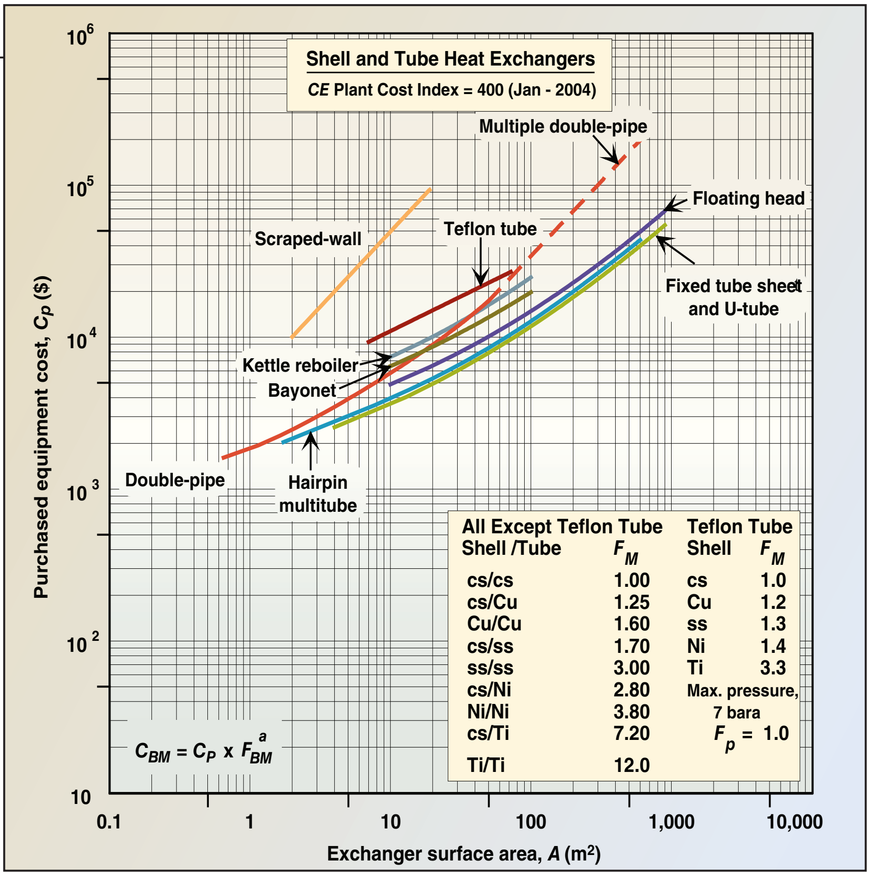
Adjusting for inflation/deflation

Predesign estimates are usually made for products of the future but must be assembled from prices of the past. Because of inflation or deflation, the price of a pump or filter will change as it sits on a warehouse shelf. The Consumer Price Index, Wholesale Price Index, and Salary Survey Index are indicators of inflationary trends in the general economy. Similar indices are available for chemical engineers to scale equipment capital from one time period to another.

To use an inflation index, I, simply include its ratio in Equation (1). For example, if the purchase price of equipment of capacity v in year r is $C_{P,v,r}$, its price in year s is:

$$C_{P,v,s} = C_{P,v,r}\left(\frac{I_s}{I_r}\right) \quad (11)$$

A predicted cost index for year s is



All Except Teflon Tube Shell /Tube	F_M	Teflon Tube Shell	F_M
cs/cs	1.00	cs	1.0
cs/Cu	1.25	Cu	1.2
Cu/Cu	1.60	ss	1.3
cs/ss	1.70	Ni	1.4
ss/ss	3.00	Ti	3.3
cs/Ni	2.80	Max. pressure, 7 bara	
Ni/Ni	3.80		
cs/Ti	7.20	F_p = 1.0	
Ti/Ti	12.0		

FIGURE 2. Purchased equipment costs for shell-and-tube and double-pipe heat exchangers. Bare module factors F^a_{BM} are obtained from Figure 4 using material factors given here and pressure factor F_p from Figure 3 (cs = carbon steel, ss = stainless steel)

divided by its historic value for year r to form the escalation ratio.

A number of different indices are used by cost engineers. Three of them, developed specifically for chemical and petroleum plants, are illustrated in Figure 1. The Nelson-Farrar index applies particularly to petroleum refinery construction, whereas the Marshall & Swift (M&S) and *Chemical Engineering* (*CE*) indices are overall chemical industry averages. Up-to-date M&S and *CE* values are published monthly on the “Economic Indicators” page of *Chemical Engineering* (see p. 72), where trends, historic values, and other economic data are also displayed. That page is reprinted as the last of each issue, changing as newer data accumulate. Because of its accessibility and accuracy, the *Chemical Engineering* Plant Cost Index (*CE*PCI) is favored by us. (Further information on the *CE*PCI can be found in Ref. [*4–8*].)

Installation costs

From plots such as Figure 2, one can determine purchase prices, $C_{P,v,r}$, for major equipment items that appear on a process flow diagram. But, each item must be transported to the site and placed on a foundation where it becomes shrouded with piping, structural steel, insulation, instruments, and other paraphernalia to form a process module. Because of these added steps, installed cost is several times greater than purchase price.

To obtain overall plant capital costs, one can sum purchase prices for all the equipment items on the flowsheet and multiply the total by a so-called Lang factor. In a paper mill, where the precise, high-speed machinery is expensive, a larger fraction of total cost is invested in the original purchase. Installation, though costly, is a smaller fraction of purchase price than for pumps and heat exchangers. Thus, the Lang factor itself is relatively small for a paper mill, about 2.5.

In an oil refinery, process vessels and equipment themselves are somewhat simpler, but installation of piping, insulation, and instruments is more expensive, creating a larger Lang factor. Holland and Wilkinson (pp. 9–68 of Ref. [*2*]) recommend values of 3.8 for a plant that processes primarily solids (for instance, a cement plant); 4.1 for a process containing both solid and fluid streams (a fertilizer plant, perhaps), and 4.8 for a fluid processing plant such as an oil refinery.

Guthrie [9, 10] proposed individual "module factors," unique to each equipment type. We like this technique because it is accurate, direct, and relatively easy to use. In essence, Guthrie's approach is an efficient and accurate way to synthesize a Lang factor for any process.

For estimates of pre-design accuracy, one merely needs appropriate installation factors. Cost charts that include prices and installation factors for any equipment likely to be found on a chemical engineering flow sheet are provided in Figures 3–61 of Ch. 5, Ref. [1].

Installation expenses for a heat exchanger are listed in Table 2. In this case, the bare module value of a \$10,000 heat exchanger is \$31,800. Its bare module installation factor F_{BM} is therefore 3.18.

It should be emphasized that one need not go through the process described in Table 2 to use cost data from sources such as Ref. [1] where installation factors are provided. Look, for example, at Figures 2, 3 and 4. Assume we need to estimate what a floating head heat exchanger having 50 m^2 heat transfer surface area contributes to capital cost. We find the January 2004 purchase price, C_P, to be \$10,000 from Figure 2. If shell and tubes are made of carbon steel, F_M is 1.0 from

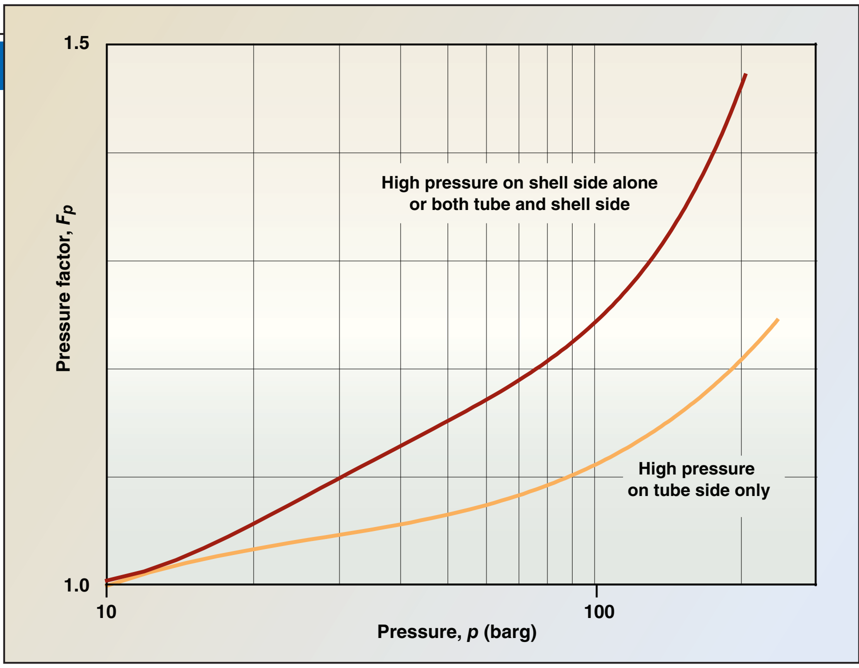


FIGURE 3. Pressure factors (ratio of purchase price of a high pressure heat exchanger to one designed for conventional pressures)

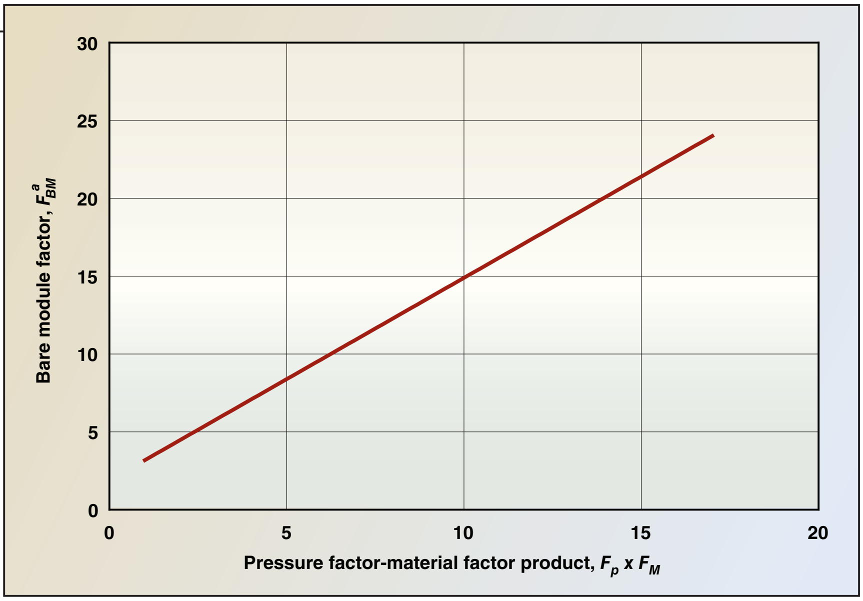


FIGURE 4. Bare module factors are a function of material and pressure factors for heat exchangers

the list in the lower right from Figure 2. If service pressure is below 10 barg, the pressure factor, F_P, is also 1.0, and, of course, their product $F_P \times F_M$ is unity. For this value of the abcissa, one reads a bare module installation factor F^{cs}_{BM} of 3.18 from the ordinate of Figure 4. Thus, the heat exchanger's contribution to the cost of its process module is \$10,000 × 3.18 = \$31,800 (the value derived in Table 2.)

Contingency and fee

To obtain total module cost, that is, the total expense required to procure and install the heat exchanger in the battery limits and to make it ready for operation, contingency and fee must be added. These, according to Guthrie's data, are 15% and 3% of bare module capital, respectively. Thus, as illustrated in Table 2, the cost of a \$10,000 heat exchanger, after installation, is \$37,600 (3.18 × 1.18 = 3.76 times the purchase price).

Auxiliary facilities

To derive the contribution of a heat exchanger to a grass-roots plant, its share of site development, auxiliary building, and offsite capital must be considered. Guthrie recommends an added 30% above total module capital for auxiliaries. Thus, the capital cost associated with a \$10,000 heat exchanger in a grass-root plant is estimated to be approximately \$49,000. The appropriate Lang factor is thus 4.9, near the number recommended in Perry (pp. 9–68, Ref. [2]) for a fluid processing plant.

Severe or extreme service

With compatible process streams, carbon steel is normally the most economical material from which to make chemical equipment. But, corrosion, erosion, and other harsh conditions, often demand more expensive alloys. Extreme temperatures and pressures sometimes require extra-heavy vessel walls or special materials.

To reflect demanding service conditions, we developed special correction factors (denoted F^a_{BM}) that are listed in our cost charts. The purchase price of an equipment item fabricated from the most common or base material (usually carbon steel) is multiplied by this special bare module factor to yield the installed price of equipment constructed from the material in question.

We describe how special bare module factors are derived for piping in Ref. [*11*]. Figures 3 and 4 were developed for heat exchangers in a similar way. By following the path described in Figures 2, 3 and 4, one finds that F^{ss}_{BM} for a stainless-steel shell-and-tube exchanger is 5.8 (below 10 barg service pressure). Thus, the 2004 bare module cost of a 50 m^2 floating head exchanger is \$10,000 × 5.8 = \$58,000 if constructed of stainless steel. With a current *CE* Plant Cost Index in the range of 550, the bare module capital of that heat exchanger today will be approximately \$58,000 × (550/400) = \$80,000.

Summary and application

With more than 30 years experience teaching process design and economics, we find that of the time and effort required by students to estimate a manufacturing cost, about 90% is consumed preparing a PFD and defining capital cost. Now that you have read this article, we suggest that you apply your learning to a project near at hand. Define the capital and go the extra 10% to estimate manufacturing economics for the product or process that pays your salary. If you do research, your path is likely to become more direct and efficient. Even people in technical service or sales will do their jobs better when they understand the key factors that control expenses in their business. In doing this exercise you may discover you have been spending time on a worthless project and move on to generating some of that gold you are worth. ■

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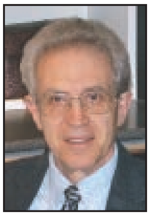

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Understanding Bends In Pneumatic Conveying Systems

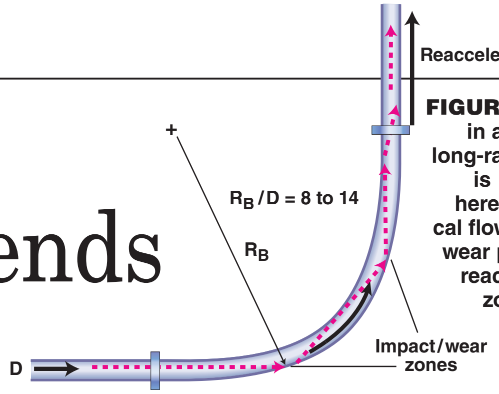

FIGURE 1. Flow in a standard, long-radius bend is illustrated here, with typical flow patterns, wear points and reacceleration zone shown

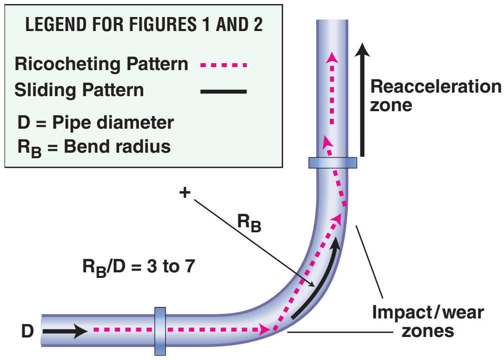

FIGURE 2. Flow in a standard, short-radius bend is illustrated here, with typical flow patterns, wear points and reacceleration zone shown

Despite their apparent simplicity, bends are often poorly understood and unless properly designed, they are potentially problematic

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Pneumatic conveying of bulk solids has been successfully practiced — in industries as diverse as chemical, agricultural, pharmaceutical, plastics, food, mineral processing, cement and power generation — for more than a century. Pneumatic conveying provides advantages over mechanical conveying systems in many applications, including those that require complex routing, multiple source-destination combinations and product containment.

Pneumatic conveying transfer lines are often routed over pipe racks and around large process equipment, giving process operators great layout flexibility. Such design flexibility is made possible by the use of bends (such as elbows and sweeps, discussed below) between straight sections (both horizontal or vertical), which enable convenient change of direction in the flow of the conveyed solids.

However, among all the components of a pneumatic conveying system, bends — despite their apparent simplicity — are probably the least understood and most potentially problematic for process operators. Findings from various research studies are often not consistent, and often times public findings do not match field experience.

The importance of bends in any pneumatic conveying assembly cannot be overstated since — if not properly selected and designed — they can contribute significantly to overall pressure drop, product attrition (degradation) and system maintenance (due to erosive wear).

Historically, a basic long-radius bend (Figure 1) has been the bend of choice for designers of pneumatic conveying systems, for a variety of reasons:

- Long-radius bends provide the most gradual change in direction for solids, and hence are most similar to a straight section of piping
- The angle of impact on the pipe wall is relatively small, which helps to minimize the risk of attrition or erosion
- For lack of other experience, to maintain the *status quo*

Years of field experience and a variety of studies conducted to troubleshoot common problems — such as line plugging, excessive product attrition (degradation), unacceptably high bend wear and higher-than-expected pressure drop — clearly indicate that the flow through bends in pneumatic piping is very complex. One should refrain from generalizing the findings until the underlying physics are well understood.

This complexity is exacerbated when innovative designs are introduced to address existing issues with common-radius bends (also discussed below). Today, most of the data still resides with vendors and there is a need for fair, unbiased and technically sound comparative evaluation.

The purpose of this article is to summarize the key concepts, outline key metrics used to evaluate bend performance, and provide guidance for their selection. The discussion is limited to dilute-phase conveying.

BEND DESIGNS

Bends are installed in a pneumatic conveying system wherever a change in direction is required along the conveying route. They can be broadly classified into three major categories:

1. Common-radius bends (including elbows, short-radius, long-radius and long-sweep bends)
2. Common fittings (including tee bends, mitered bends and elbows)
3. Specialized bends and innovative designs (such as the Gamma Bend, Hammertek Smart Elbow, Pellbow, wearback designs, and lined bends, which are described below)

Common-radius bends

Common-radius bends (Figures 1 and 2) are made by bending standard tubes or pipes. The radius of curvature (R_B) may range from 1 to 24D (where D is the diameter of the tube or pipe). Common-radius bends can be loosely classified as follows:

Elbow:	R_B/D	=	1 to 2.5
Short radius:	R_B/D	=	3 to 7

Long radius: R_B/D = 8 to 14
Long sweep: R_B/D = 15 to 24
These bends are available in a wide range of materials of construction and thicknesses, similar to the straight section of pipe (tangent) that is provided on either side of the curved section. The conveyed material may undergo multiple impacts with the pipe wall, or may slide along the outer radius, depending on material properties, solids loading (defined as mass of solids/ mass of air) and gas velocity. Bend wear and material attrition commonly occur at the impact zones.

Common fittings

The most commonly used fitting to accomplish a change in flow direction is a blind tee bend. In this design, one of the outlets is plugged thereby allowing conveyed solids to accumulate in the pocket (Figure 3). The benefit of this design is that the accumulated pocket of material cushions the impact of the incoming material, significantly reducing the potential for wear and product attrition. The extent of accumulation in the pocket will depend on the orientation of the bend, solids loading, gas velocity and material properties (such as particle size and cohesiveness).

However, in a tee bend, the conveyed solids lose most of their momentum during the impact and thus must be reaccelerated downstream of the bend. As a result, pressure drop across a blind tee can be as much as three times that of a long-radius bend. Several variations of common fittings are shown in Figure 4.

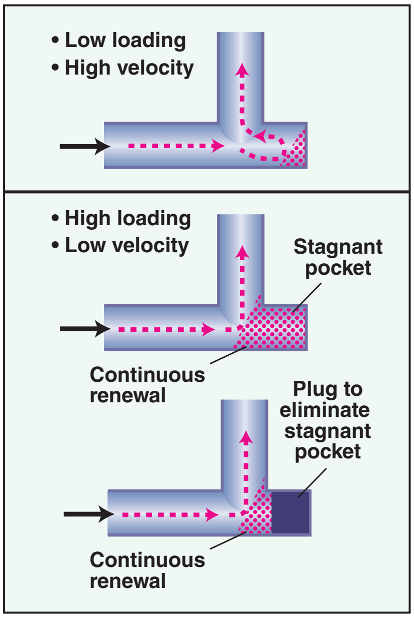

FIGURE 3. The effect of loading and gas velocity on flow patterns in a blind tee (horizontal-vertical orientation) is shown here

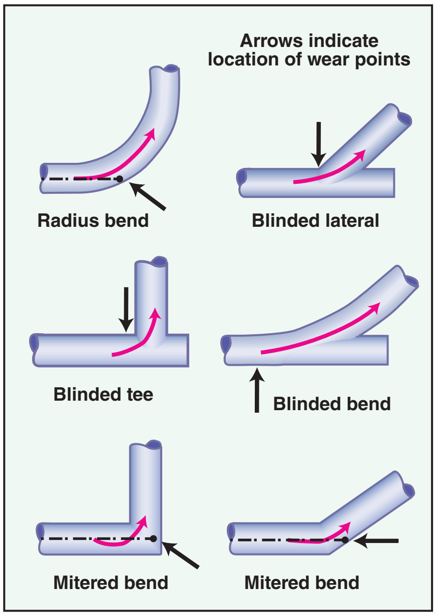

FIGURE 4. Several variations of common fittings are provided here, with typical wear points highlighted

Specialized bends

Today, a variety of specialized designs are available to control flow within the bend, in order to minimize attrition and wear. This is often achieved by creating a self-cleaning or replenishing pocket or layer of material, upon which the incoming stream impinges. Wear inside the piping is minimized by redirecting the gas-solid suspension away from typical wear points. Several of the most commonly used specialized bends are discussed below.

Proprietary designs. The Gamma Bend from Coperion (coperion.com) is shown in Figure 5. Its innovative design relies on creating particle-particle impact in the impact zone and prevents sliding motion of particles along the outer radius to minimize particle smearing, so it is especially effective in preventing the formation of streamers (also known as floss or angel hair) in polymer pellets. A minimum solids loading is required to ensure accumulation of material in the impact zone. In the absence of this layer, the particles will directly impact the target plate within the bend and may result in both particle attrition and pipe erosion. (A typical recommendation for minimum solids loading is 5, but it depends on the bulk density of the product.) Gamma Bends are typically fabricated from stainless steel, and provide a very tight bend radius (R_B/D = 4 to 6). The pressure drop is higher (20–30%) than that experienced by a typical short-radius bend (R_B/D = 3 to 7).

The Pellbow Bend from Pelletron Corp. (pelletroncorp.com) is shown in Figure 6. It is similar to a short-radius bend but has an expanded pocket. The pocket is meant to accumulate a small amount of solids at the primary impact location so that most of the impact is between particles themselves. To ensure adequate accumulation of material in this pocket, the minimum recommended solids loading is typically 3, but it depends on bulk density and particle size. According to the vendor, pressure drop will be slight higher than that experienced by a short-radius bend. A wide range of materials of construction are available.

The Vortice-Ell Smart Elbow from Rotaval (rotaval.co.uk) and the Hammertek Smart Elbow from Hammertek Corp. (hammertek.com) are similar in design (Figure 7). Both have a bulbous extension on the heel. Depending on the orientation and inlet gas velocity, the incoming material will either fill the chamber or circulate within the chamber before exiting. In either case, it results in significant reduction in wear and attrition of material. It is available in 45- and 90-deg. designs and in various materials of construction.

Wearback designs. There are two major types of wearback elbow designs (as shown in Figure 8):

1. Elbows equipped with a wear plate with a sacrificial and replaceable back plate:

- The replaceable back plate is made from hardened material, typically with Brinell hardness greater than 400 (similar to that of Ni)
- Models are typically available with short-radius designs (R_B/D = 2 to 6) and multiple angles 22.5, 45, 60 and 90 deg.

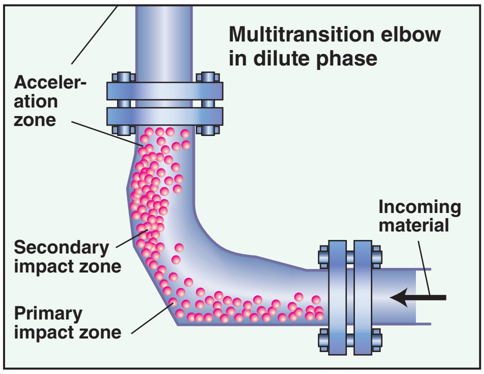

FIGURE 5. In the Gamma Bend design, accumulation of material in the primary impact zone prevents direct impact of material on the bend wall, reducing erosive damage to the pipe

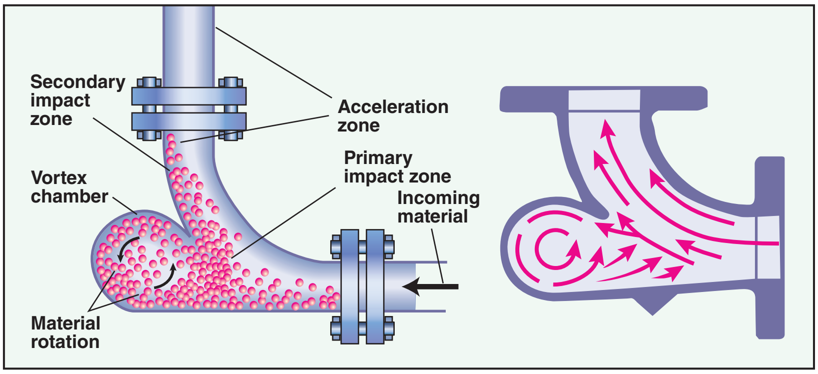

FIGURE 7. In a Vortice Ell or Hammertek Smart Elbow bend, a bulbous extension creates a circulating flow pattern or a pocket of material, which cushions the impact on incoming stream

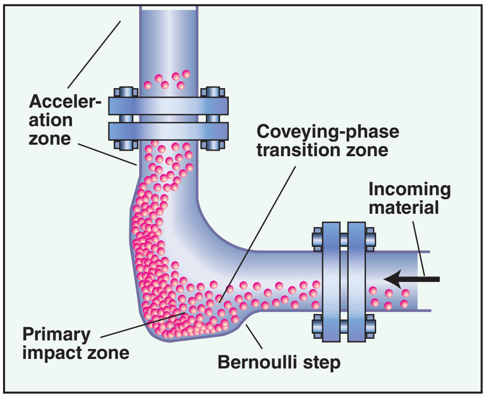

FIGURE 6. The formation of a pocket of material at the primary impact zone helps to minimize attrition and erosion in a Pellbow bends

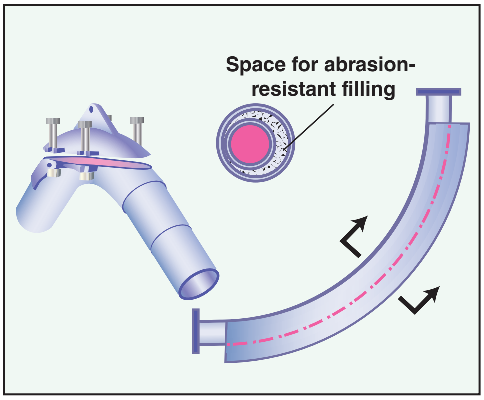

FIGURE 8. A wearback elbow design can either be a replaceable hardened piece or a wearable inner core with abrasion-resistant filling

- Segmented designs are available, which allows for partial replacement of the elbow body
- This design is commonly used in the flyash industry

2. *Tube-in-tube (pipe-in-pipe) type*:

- The space between the inner and outer casings can be left unfilled or filled with concrete or porcelain or another abrasion-resistant material
- For the unfilled design, once the inner core wears out, the product fills the cavity. Thereafter, the material impacts on a packed bed, which continuously gets replenished. This design is not suitable for abrasive products that tend to degrade, or where cross-contamination is a concern
- For the filled design, once the inner core wears out, the abrasion-resistant filling provides a longer bend life compared with many regular bends

Bends with liners. Bends with abrasion-resistant liners are used for highly abrasive products. A wide range of proprietary lining materials are available. Examples include high-density alumina ceramics, zirconium corundum, hardened cast iron, silicon carbide and tungsten carbide. The presence of a liner also extends the upper limit of the operating temperature for the bend component.

BEND PERFORMANCE

A variety of metrics are helpful in evaluating bend performance in pneumatic conveying systems, including the following:

1. Pressure drop related to the bend
2. Attrition or product degradation
3. Wear, erosion or bend life

Pressure drop

Single-phase flow of a fluid through a bend (or any component causing directional change) will result in additional pressure drop. This behavior is well understood and reported [*2*]. The pressure drop in a bend depends on the ratio of bend radius to pipe diameter (R_B/D), the gas velocity (U_g) and the internal roughness (k) of the pipe (Figure 9).

When a two-phase, gas-solid suspension undergoes a directional change, such as in a bend, the bend naturally acts as a segregator or separator of the two phases. Due to the centrifugal forces acting on the particles, they are concentrated along the outer wall of the bend. For instance, in the case of fine coal, an unusual phenomenon of roping (the formation of concentrated strands) is observed. Depending on material properties, solids loading, gas velocity and pipe-wall interactions, the particles may have multiple impacts within the body of the bend.

As a result of particle-particle and particle-wall impacts and the friction along the pipe wall, the particles exit the body of the bend at a velocity that is lower than their steady-state velocity. The particles must re-accelerate to their steady-state velocity after they exit the bend. The steady-state velocity for horizontal flow of a gas-solids suspension is typically in the range of 70–90% of the gas velocity. The energy required for reacceleration manifests itself as additional pressure loss after the bend, and the extent of the pressure drop depends on the extent to which the solids have been slowed during the transit.

Simply put, the pressure drop due to a bend in gas-solid flow is due to

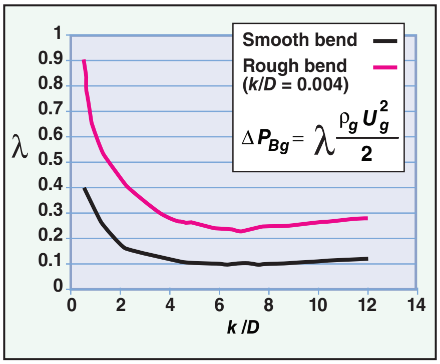

FIGURE 9. Shown is the effect of bend geometry and internal pipe roughness on the number of velocity heads (λ) for bend pressure drop

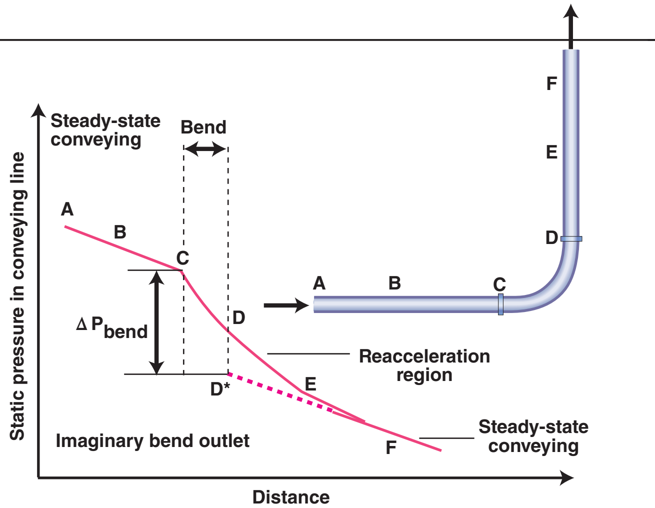

FIGURE 10. This static pressure profile in a bend region shows the pressure gradient in the bend and in the reacceleration region

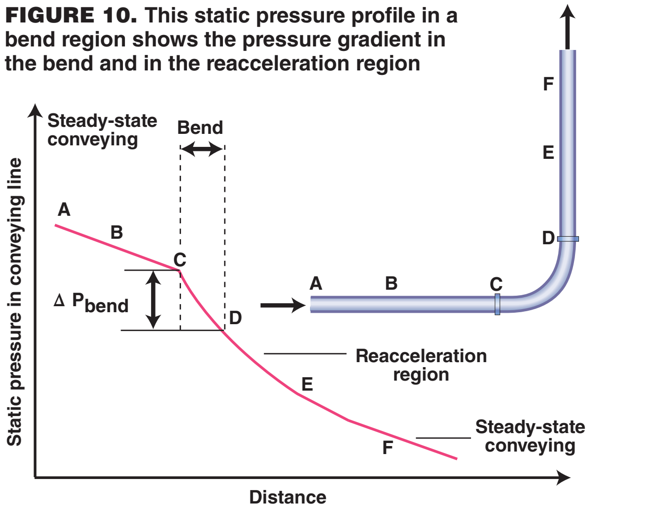

FIGURE 11. This inaccurate pressure-drop measurement does not account for the reacceleration region

the combination of frictional loss in the bend itself plus the energy required to reaccelerate the solids back to the steady state velocity. It should be noted that the friction coefficient within the bend will be different than the corresponding friction coefficient in an adjacent straight section. Meanwhile, additional losses due to static head (such as in horizontal-vertical and vertical-horizontal orientation) are usually minor but must also be considered.

The pressure drop in a bend is most accurately quantified if the static pressures along the conveying line are measured before and after the bend location (see Figure 10). The static pressure decreases linearly in the straight section preceding the bend. The pressure gradient increases in the body of the bend and continues to be non-linear even after the flow exits the bend. It may take considerable distance downstream of the bend (up to 15–20 ft; 5–6 m) for the flow to reach steady state pressure and for the gradient to become linear again.

The pressure drop incurred by a bend can be correctly estimated by extrapolating (in the upstream direction) the linear pressure gradient downstream of the bend until the imaginary outlet of the pipe bend (D*, Figure 10). As shown in Figure 11, by comparison, if two pressure taps are placed just across the body of the bend at locations C and D, an incorrect estimation of pressure drop would be made. This is a common mistake that leads to much confusion in the literature.

Calculation of bend pressure drop (EEUA). A simple approach to estimate the pressure drop resulting from standard radius bends was proposed in "EEUA Handbook" [7]. The bend coefficient (B) can be estimated by regression using actual data. In the absence of experimental data, use the values given in Table 1.

$$\Delta P_B = B(1+\mu)\frac{\rho_g U_g^2}{2}$$

Where
ΔP_B = Total pressure drop due to a radius bend
B = Bend loss coefficient
μ = Solids loading (mass of solids / mass of conveying gas)
ρ_g = Gas density at bend location
U_g = Superficial gas velocity at bend location

Equivalent-length approach. An alternate approach to represent the pressure drop due to a bend is to quote an equivalent length of straight section that would result in the same pressure drop as the bend in question. The total effect of bends on system pressure drop can be estimated by multiplying the number of bends by equivalent length, and adding it to the total length of straight sections (horizontal and vertical). An equivalent length of 20 ft (6 m) is a good first guess. This approach is practical and easy but difficult to generalize for new materials.

Qualitative comparison of bend pressure drop. Combining published data and practical experience, we have compiled a ranking for various types of available bends based on pressure drop characteristics (Table 2). Note that in certain instances, the difference in pressure drop between tee bends and short-radius elbows can be insignificant, as some studies have suggested. Also, excess pressure drop in long-sweep bends may be attributed to their greater overall physical length.

Various factors affecting bend pressure drop are summarized in Table 3.

It is important to consider the pressure drop contribution of the bends in the perspective of the overall system pressure drop. The total contribution of bends to the overall system pressure drop will depend on the number of bends per unit length. If their contribution is relatively small, then replacing one type of bend with another will make little difference to the overall pressure drop (or on the conveying capacity). One must then select the bends based on other attributes.

Despite numerous studies on bends and the presence of large amounts of operating data, there is still confusion and disagreement on pressure drop that is attributable to various bend geometries (as shown in Figure 12). Reasons for such confusion include the following:

- The techniques for measurement and data analysis are not standardized. Some studies use the static pressure profile approach described

TABLE 1. EFFECT OF BEND RADIUS ON BEND LOSS COEFFICIENT (B)	
R_B / D	B
2	1.5
4	0.75
≥ 6	0.50

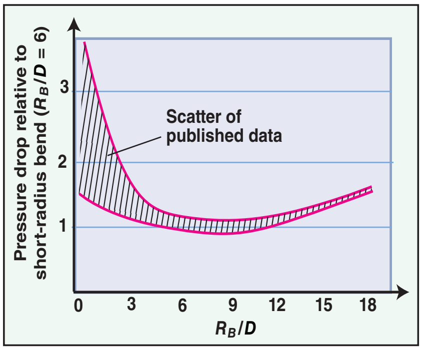

FIGURE 12. Shown here is the effect of bend curvature on pressure drop in pneumatic conveying bends

TABLE 2. COMPARISON OF PRESSURE DROP CHARACTERISTICS	
Bend type	Ranking for pressure drop
Long sweep	6 (highest)
Blind tee	5
Vortice Ell or Hammertek Smart Elbow	4
Mitered bend	3
Gamma Bend or Pellbow	2
Short-radius and long-radius bend	1 (lowest)

TABLE 3. FACTORS AFFECTING BEND PRESSURE DROP	
Factor affecting bend pressure drop	Effect on bend pressure drop with increase in value of factor
Gas velocity at bend inlet	↑
Solids flowrate (at constant gas velocity)	↑
Particle elasticity	↑
Particle size	↓
Pipe roughness	↑
Radius bend: R_B/D (1 – 24)	↓ ($R_B/D \leq 12$) ↑ ($R_B/D > 12$)

above, while others estimate pressure drop due to bends by swapping one bend type with the other
- It is not possible to critically evaluate all the studies since details are not always available
- Most studies are done on systems with multiple bends and fail to account for the effect of location and interaction between the bends due to insufficient straight sections between them
- It is difficult to generalize the results since individual studies often focus on few materials and limited range of operating conditions (such as solids loading, gas velocity, orientation)
- Large-scale test data sets are very few. Most studies are conducted on pilot-scale systems

Attrition or particle degradation

The attrition or degradation of materials during pneumatic conveying is a significant concern to the industry. Attrition generally refers to the formation of "unwanted" fractions or species in the conveyed material, which may adversely affect its value.

Attrition or product degradation can manifest itself in various ways:
- Change in particle size and shape distribution
- Surface abrasion of particles resulting in a loss of gloss
- Degradation of product due to impact heating
- Smearing on the wall, which can result in cross-contamination
- Undesirable loss of surface coating or additives

Generation of fines due to breakage, chipping or surface abrasion can also create downstream processing issues, such as dusting, poor flowability and increased caking tendency. It may also lead to increased potential for dust explosion or increased exposure to respirable dust.

During pneumatic transport of bulk solids, particles undergo multiple impacts on the pipe wall, especially at the bends. The key parameters affecting particle attrition during pneumatic conveying are summarized below.

Process-related factors:
- Mode of conveying (dense versus dilute phase)
- Gas velocity or particle velocity
- Solids loading (or concentration)
- Temperature of gas and solids (coupled with material properties)
- Conveying distance
- Materials of construction of straight pipeline sections and bends
- Surface finish of pipeline and bends
- Number of bends (frequent change in direction)
- Bend geometry and flow pattern at the bend

Material-related factors:
- Particle size
- Particle shape
- Particle strength or modulus or Vicker's hardness
- Elasticity of particles
- Breakage function of material

Attrition and degradation issues impact bend performance in several ways:
- Attrition in tee bends will be low if the primary mechanism of breakage is particle fracture due to impact loading. In tee bends, the particles are essentially impacting on a loose bed of accumulated material, which acts like a cushion. However, if the process conditions do not result in the formation of a suitable bed (for instance, the stream velocity is too high, or solids loading is too low), then particle attrition can still be significant
- Attrition in short-radius bends or elbows is generally high due to impact on the bend wall
- Attrition in long-radius bends or long-sweep bends can be high if chipping or surface abrasions are primary mechanisms. Multiple impacts or ricocheting inside the bend can aggravate the problem
- Attrition in specialized transition designs, such as the Gamma Bend, or Pellbow (discussed above), tends to be low, as long as material accumulation occurs in the transition cavity. Overall performance will depend on the orientation of the bend

The specific definition of attrition varies with the application and the product being conveyed. For agricultural products, attrition may refer to damaged or split grains, whereas for polymer pellets, attrition often manifests itself as polymer dust, chips or streamers during conveying.

Based on our experience, we recommend the following measures to mitigate attrition in existing pneumatic conveying systems:
- Reduce conveying velocity or increase the solids-loading ratio
- Reduce the number of bends by simplifying the line layout wherever possible
- Replace bends with designs that are less prone to attrition

Bend wear and erosion

Each time the particles impact the pipe and bend walls, energy is transferred to the point of impact. Depending on the comparative strength of particle and wall materials, either the particle is damaged (attrition) or the pipe/bend wears out.

There are numerous ways to quantify and analyze the wear data. For instance, in research studies, wear may be characterized by *erosion rate* (total mass of bend eroded), *specific erosion rate* (mass of bend eroded per

TABLE 4. COMPARISON OF BENDS		
Bend type	**Advantages**	**Disadvantages**
Blind tee	• Low cost • Erosion / wear resistant • Short turn radius; compact design • Easy to retrofit • Low particle attrition (no chipping or surface abrasion)	• High pressure drop • Not suitable for moist, cohesive or sticky materials • May result in cross-contamination if the pocket does not clean
Blind radius bend	• Better erosion resistance than radius bend	• Same as blind tee • Secondary impact (wear) zone on the inner radius
Blind lateral	• Better erosion resistance than blinded radius and significantly better than radius bends	• Same as blind tee
Mitered bend	• Short turn radius	• High particle attrition (due to particle impact breakage) • Not suitable for moist, cohesive or sticky materials
Elbow ($R_B/D < 3$)	• Short turn radius	• High particle attrition (due to particle impact breakage) • Not suitable for moist, cohesive or sticky materials
Radius bend: Short radius ($R_B/D = 3 - 7$)	• Available in various materials of construction and radii • No accumulation in the bend — less chances of cross-contamination • Pressure drop comparable to long radius bend	• High product degradation / attrition due to impact • Low wear resistance
Radius bend: Long radius ($R_B/D = 8 - 14$)	• Available in various materials of construction and radii • No accumulation in the bend, so less chance of cross-contamination • Pressure drop comparable to short-radius bends	• Extended particle contact on the pipe wall can result in smearing (such as streamers with polyethylene pellets) • Erosive wear on ductile materials due to low impact angle • Large space requirements
Radius bend: Long sweep ($R_B/D = 15 - 24$)	• Available in many materials of construction and radius dimensions • No accumulation in the bend, so less chance of cross-contamination • Highest pressure drop among bends	• Extended particle contact on the pipe wall can result in smearing (such as streamers with polyethylene pellets) • Erosive wear on ductile materials due to low impact angle • Large space requirements
Radius bends with liners	• Longer wear life than comparable bends • Liner material can be chosen to minimize abrasion, and thus minimize product contamination • No accumulation or cross-contamination • Suitable for high-temperature applications	• High cost • Difficult to replace • Could be heavy and may need additional line support
Radius bend with wearable backing	• Less expensive than lined bends • Easy to replace wearable backing • Easy to maintain	• Potential for product contamination due to wearable backing • Difficult to predict failure • Potential for spillage
Radius bend with internal baffles	• Erosion / wear resistant	• Higher pressure drop • Not suitable for moist, sticky or cohesive materials • Cross-contamination • More expensive than conventional bends
Short-radius bends with pocket for material (Vortice Ell, Hammertek Smart Elbow)	• Erosion / wear resistant • Short-turn radius • Generally low particle attrition • The pocket will clean out when flow stops • Low noise	• Higher cost than radius bends and blind tees • Pressure drop comparable to blind tees • Not suitable for moist, sticky and cohesive materials
Transition designs (mitered, expansion-cavity and flow-redirection, such as the Gamma Bend, Pellbow)	• Short turn radius, good for layout • Low particle attrition (no chipping or surface abrasion) • Prevents streamer generation during conveying of plastic pellets; unlike radius bends, does not require treatment (shotpeening) to prevent streamers • Self cleaning • Erosion/wear resistant if a stable material layer can be formed • Low noise	• Higher cost • Pressure drop slightly higher (20–30%) than short-radius bends • Minimum solids loading ratio (solids:air) is required for proper operation
Rubberized or flexible bends	• Excellent for soft sticky powders to prevent buildup • Good wear resistance	• Potential for product contamination due to wearing of the rubber lining

unit of mass of conveyed material), *penetration rate* (depth of penetration per unit mass of conveyed material) and *bend life* (time required to lose containment).

While the conclusions reached depend on the applied metric, there is general agreement that the major factors associated with erosion in bends are as follows:

Bend geometry: This affects the number and location of impact zones.

Orientation: Orientation affects the location of impact zones.

Flow pattern inside bend: This determines the penetration rate and uniformity of wear.

Material of construction (hardness):

TABLE 5. BEND SUITABILITY BASED ON MATERIAL CHARACTERISTICS

Bend type	Cohesive or sticky or moist	Fragile or friable solids	Hard and abrasive solids	Soft and rubbery solids	Product purity required / no cross contamination
Blind tee	NS	S*	S	NS	NS
Blind radius bend / blind lateral	NS	S*	S	NS	NS
Mitered bend (90-deg. turn)	NS	NS	NS	S	S
Elbow (R_B/D < 3)	NS	NS	NS	S	S
Radius bend: Short radius (R_B/D = 3 – 7)	S	S*	NS	S	S
Radius bend: Long radius (R_B/D = 8 – 14)	S	S*	NS	S	S
Radius bend: Long sweep (R_B/D = 15 – 24)	S	S*	NS	S	S
Radius bends with liners	S*	NR	S	NR	S
Radius bend with wearable backing	S	NR	S	NR	S*
Radius bend with internal baffles	NS	NR	S	NS	NS
Short-radius bends with pocket for material (Vortice Ell, Hammertek Smart Elbow)	NS	S	S	NR	S*
Transition designs (Gamma Bends)	NS	S	NS	S	S
Transition designs (Pellbow)	NS	S	S	S	S
Rubberized or flexible bend	S	S*	S*	NR	S*

S = Suitable NS = Not Suitable
S* = Suitable under certain conditions NR = Not Required

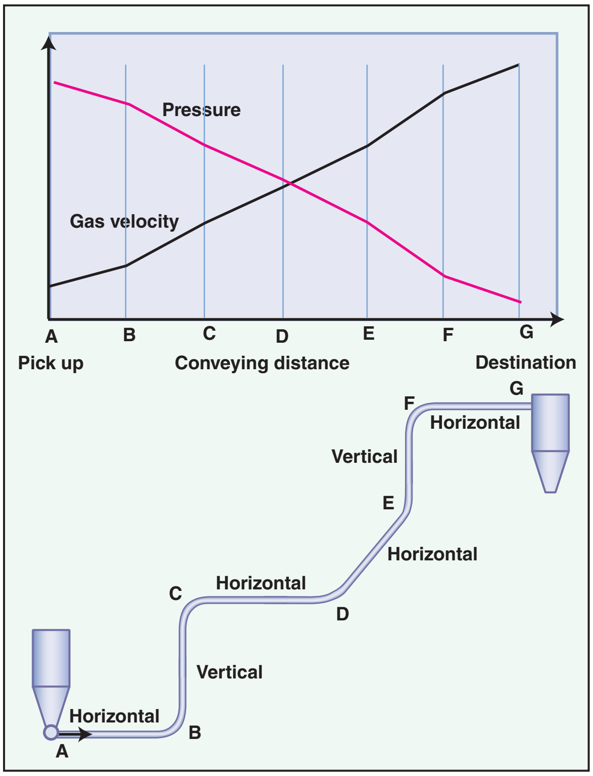

FIGURE 13. Gas velocity increases as the pressure in the system decreases from pickup to destination. The local gas velocity at each bend will depend on its location

Erosion rate is inversely proportional to the hardness of bend material.

Particle hardness: Erosion rate is proportional to particle hardness.

Particle size and shape: Three phenomena are noteworthy:

- Specific erosion rate increases with particle size until a critical particle size, then the rate does not change
- Bend failure due to penetration occurs faster with smaller particles
- Angular particles will increase erosion rate

Conveying velocity: The specific erosion rate is a strong function of gas velocity ($U_g^{2.5}$ to U_g^4).

Particle concentration: Significant reduction in specific erosion rate occurs at higher particle concentrations (due to greater cushioning effect).

From a wear standpoint, bends can be classified into three groups:

- ***Class I (most resistant to erosion):*** Blind tee, Vortice Ell or Hammertek Smart Elbow, Pellbow, radius bends with abrasion-resistant liners, wearback designs
- ***Class II (medium resistance to erosion):*** Mitered bend, Gamma Bend, long sweep
- ***Class III (very susceptible to erosion):*** Common-radius bends (short and long)

It should be noted that significant wear can sometimes be observed in the straight section downstream (up to 10 pipe diameters) of a bend depending on the flow pattern within the bend.

BEND LOCATION

Regardless of the type of conveying system (pressure or vacuum) or the mode of conveying (dense or dilute phase), *the pressure always decreases from pickup location to destination.* As dictated by the Ideal Gas Law, the gas velocity will proportionally increase from pick up location to the destination (see Figure 13). Therefore, any bends located toward the end of the conveying system will experience velocities (gas and particle) that are higher than those closer to the pickup location.

Since pressure drop, attrition and erosion are all strongly affected by gas and particle velocity, bends that are of similar geometry but located toward the end of the system will incur higher pressure loss, and thus will experience greater attrition and wear. It should be noted that the solids loading (mass of solids/mass of air) in the entire system remains constant, and does not depend on the location.

Pressure versus vacuum mode

The increase in gas velocity (from pick up to destination) is greater when the system is operating in pull mode (vacuum system) versus push mode (pressure system). A simple set of calculations (assuming isothermal conditions), shown below and referring to Figure 13, highlights the point.

As can be seen, the velocity at the exit (at location G) for a vacuum system is 42% higher than that for a pressure system. Therefore, a higher level of attrition and wear can be expected in a vacuum system, as compared to that expected in a pressure system with similar layout and overall pressure drop.

Pressure system (push mode):

Conveying pressure (at location A)
 = 8 psig (55.1 kPa gage)
Pick up velocity (at location A)
 = 4,000 ft/min (20.3 m/s)
Pressure in the destination receiver
 = 0.05 psig (0.35 kPa gage)
Velocity at the exit (at location G)
 = 6,177 ft/min (31.4 m/s)

Vacuum system (pull mode):

Conveying pressure (at location A)
 = 0 psig = 14.7 psia (101.3 kPa abs)
Pick up velocity at location A)
 = 4,000 ft/min (20.3 m/s)
Pressure in the destination receiver
 = –8 psig = 6.7 psia (46.2 kPa abs)

Velocity at exit (at location G)
= 8,776 ft/min (44.6 m/s)

SELECTION OF BENDS

The following key issues must be considered while selecting bends for pneumatic conveying applications:

Type of conveying: Dilute versus dense phase

Product characteristics:
- Particle size and shape
- Particle hardness (erosive wear)
- Attrition or fines generation
- Cohesiveness / stickiness

Process requirements:
- Free of cross-contamination
- Minimization of pressure drop or power consumption
- Layout constraints
- Consequences of wear or material leakage to environment
- Minimize fines generation or product degradation
- Materials of construction
- Minimize downtime (frequency of replacement)

Industry-specific practices: Consider, for instance, that the use of a smooth radius bend with polyolefin pellets can result in formation of streamers.

The purchase cost of a bend and its geometry (which affects the layout of the process) has a direct impact on the cost of any pneumatic conveying project. It is prudent to consider the long term cost of ownership of a bend. For instance, a low-cost bend that results in product degradation or higher energy cost due to increase pressure drop will be more expensive in the long run.

Table 5 summarizes the suitability of competing bends, based on product characteristics.

INSTALLATION GUIDANCE

By following these recommendations, process operators can minimize problems associated with bends in pneumatic conveying systems.
- Minimize the number of bends in the transfer system
- Do not install a long-radius bend (horizontal to vertical) within 20 ft (6 m) of the pick up location
- Back-to-back bends are not advisable. Avoid three bends in close proximity, if possible
- More bends toward the end of the transfer will increase pressure drop, erosion and attrition. Consider directional changes earlier in the layout, if possible. Consider stepping up the line size, if the pressure ratio permits, to minimize the velocity toward the end of the system
- Misaligned bends will increase attrition and wear
- Install critical bends such that they can be easily serviced (accessible and replaceable)
- Consider insulating pipe and bends when noise is an issue (especially indoors) or select appropriate type of bends. For outdoor installations, insulation can reduce the tendency of the material (such as plastic pellets) to smear inside the bend
- Pay close attention to the direction of flow in specialized bends during installation

Final thoughts

Bends are a critical aspect of any pneumatic conveying system layout, and proper selection is a critical aspect of system design and operation. Improper selection of bends can result in conveying capacity limitations (due to excessive pressure drop), high product degradation/attrition, and high wear rates, which can create additional maintenance, safety and environmental issues.

Optimal longterm cost of ownership can be achieved if the product characteristics and process constraints are more appropriately matched. A thorough evaluation often reveals that specialized bends may not be the best option.

Available information on pipe bends in the open literature can be confusing, and these findings often conflict with field experience. Industry need to continue studying various aspects of pneumatic flow using modern tools for flow visualization and computational fluid dynamics for modeling. ■

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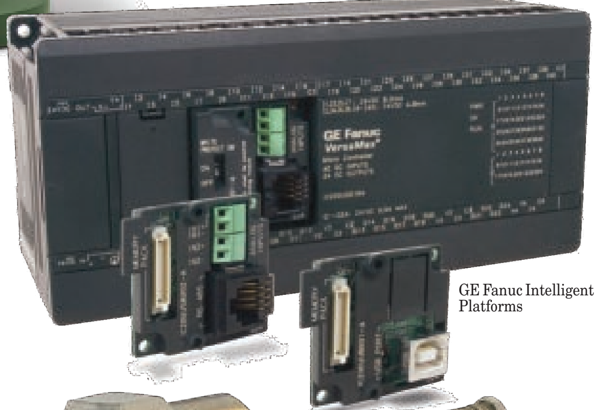

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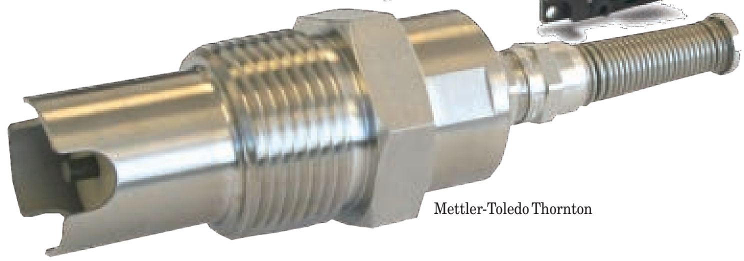

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This three-way valve improves temperature control

This company has recently unveiled the GX 3-Way control valve (photo), which has the ability to accurately control the temperature of water, oils, steam, and other industrial fluids. Applications include heat exchangers and lubricating skids. The flow cavity of the GX 3-Way valve body has been engineered to provide stable flow and reduce process variability. This linear stability is perfectly suited for temperature and pH control applications. The GX 3-Way valve covers both flow mixing (converging) and flow splitting (diverging) applications with no extra parts needed. Unlike other three-way valves, it features both side-port and bottom-port common trim. — *Emerson Process Management, Fisher div., St. Louis, Mo.*
www.emersonprocess.com

Field-ready portable temperature monitor features three scales

The TM-3 three-scale thermistor temperature monitor (photo) is portable and features Celsius, Fahrenheit and Kelvin scales in a large, easy-to-read display. The temperature ranges are 0–104°C, 2–220°F and 256–378K. With an analog output, the TM-3 can be used with data acquisition systems or pen recorders. The thermometer is dust-proof, splash-proof and battery powered, making it ideal for field use. The meter operates for approximately 100 h with a single 9-V alkaline battery or it can be powered from the supplied a.c. wall adapter. — *Warner Instruments, Hamden, Conn.*
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Get industrial boiler measurements for consistent blowdown control

This online conductivity sensor for industrial boilers can measure directly in the blowdown line without sample cooling — saving on installation and operating costs. It enables continuous automatic blowdown control, which minimizes corrosion and scaling to a greater extent than with manual measurement and control. Able to operate well above conditions of conventional sensors, the Boiler Conductivity Sensor (photo) can directly measure samples up to 250 psig (17 bar) at 392°F (200°C). The sensor is used with the manufacturer's M300 transmitter, which provides display, analog outputs and alarm relays plus on-off and PID control capabilities. It can also be used with the 770MAX transmitter, which accepts four sensor inputs in any combination of parameters including conductivity, pH, dissolved oxygen, flow, ORP, TOC, pressure and tank level, which are often used with boiler-water-treatment systems. — *Mettler-Toledo Thornton Inc., Bedford, Mass.*
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This module delivers a wide range of capabilities for temperature control

The VersaMax Micro Thermocouple (Type K, J, E, S, T, B or N) / Millivolt expansion module (photo) can be used in a wide range of temperature monitoring and controlling applications, as well as for weighing. There are two cost-effective module types available: a four thermocouple-inputs and two analog-outputs expansion module; and a four thermocouple-inputs and no analog-outputs module. The modules can also be used with the QuickPanel control as a low-cost I/O solution. Applications include packag-

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ing and assembly requiring temperature control, oven control, product curing and process control. — *GE Fanuc Intelligent Platforms, Charlottesville, Va.*
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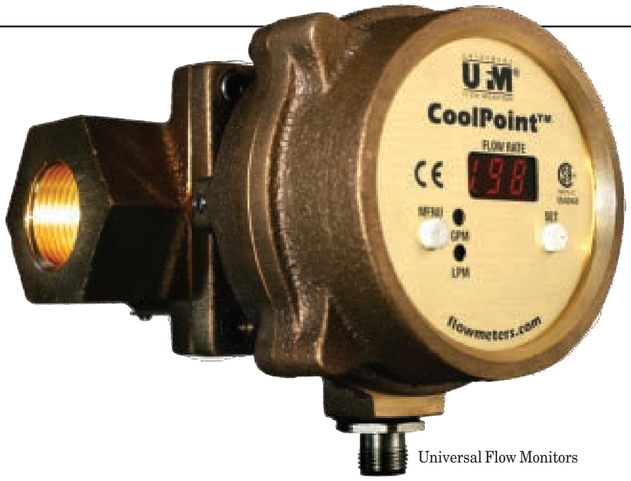
Better accuracy, reliability for harsh high-temperature environments
The R300 Series temperature sensor (photo, p. 61) is targeted for use in potential exhaust gas recirculation (EGR) applications where operating temperatures can reach 300°C (572°F). The R300 Series uses RTD (resistance temperature detector) technology and features a robust, stainless-steel, closed-tip design to enhance reliability in aggressive environments. — *Honeywell Sensing and Control, Morristown, N.J.*
www.honeywell.com

Measure flowrate and temperature with one instrument
The CoolPoint vortex shedding flowmeter (photo, p. 63) is offered with a temperature transmitter for measuring and monitoring both flow and temperature in processing water, water with chemicals added, water-glycol coolant and corrosive fluids. The flow bodies are available in brass for water and coolant, and in stainless steel for corrosive fluids and water with chemicals added. Models with the temperature transmitter are available in pipe sizes ranging from 3/4 in. (maximum flowrate 25 gal/min) to 4 in. (maximum flowrate of 600 gal/min). These meters provide temperature readouts ranging from 32°F to 210°F, which can be expressed in either degrees Fahrenheit or Celsius on the local LED readout. A



Universal Flow Monitors

temperature accuracy of ±1% FS is standard. The CoolPoint flowmeter is an electronic meter that has no moving parts to stick or coat. The meter is sold by pipe size, and all other features are selectable by pushing buttons on the meter face. Selections include a set point for flow and temperature alarm. — *Universal Flow Monitors, Inc., Hazel Park, Mich.*
www.flowmeters.com.

New infrared sensor offers improved performance in harsh industrial environments
The Modline 5 Series 5R Ratio Sensors are designed for non-contact infrared-temperature-measurement applications in harsh industrial environments. These sensors use a dual detector assembly that measures temperature by comparing infrared radiation levels in two wavelength bands (0.85–1.05 microns and 1.0–1.1 microns). Temperature readings are based on the ratio of the two signals in thse bands. Because this ratio is used rather than the absolute intensity of radiation at a single wavelength, the Modline 5 Series 5R sensors are almost immune to error caused by loss of signal. Small targets that do not fill the field of view and partial obstructions (from bursts of steam, dust and solid objects in their sight path) can be tolerated. — *Ircon, Santa Cruz, Calif.*
www.ircon.com

Check temperature-sensitive products with this label-type wireless monitor
The Ultra Wireless Label (photo, p. 62) enables users to wirelessly download time and temperature information and analyze data before unloading a perishable product from a container. These labels are activated and applied to product or product packaging before shipping. At any point during distribution, the Ultra Wireless Reader can collect data from any label within a 300-ft line-of-sight range or approximately 60-ft obstructed range with the simple touch of a button. Information from up to 30 labels can be downloaded at one time. Time and temperature data can be examined on the screen of the Ultra Wireless Reader immediately after download, which helps users make quick decisions on product quality. Detailed information from the reader, including temperature alert notifications, can then be downloaded to a PC for emailing and permanent storage. Ultra Wireless Labels are flat, about the size of a credit card, and are encased in waterproof food-grade packaging. They take up less space than competing products, says the vendor, and can be easily returned to the manufacture for recycling. — *PakSense, Boise, Idaho*
www.paksense.com ■

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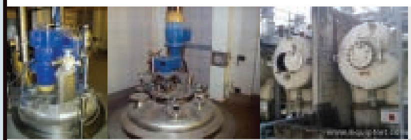

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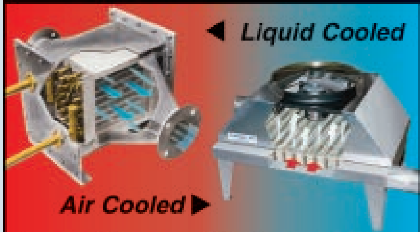

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BUSINESS NEWS

PLANT WATCH

Ineos Technologies wins HDPE license contract in China

March 18, 2009 — Ineos Technologies Ltd. (Runcorn, U.K.) has licensed its Innovene S Process for the manufacture of high- and medium-density polyethylene (HDPE and MDPE) to China Petrochemical International Co. for use at Sinopec Wuhan Co. in Wuhan, China. The 300,000 ton/yr plant will produce a full range of Ziegler-Natta and Chrome monomodal and bi-modal products. It is part of a major petrochemical expansion of Sinopec's existing refinery at Wuhan.

Clariant forms new JV for P_2O_5 production

March 17, 2009 – To meet the growing demand for phosphorus pentoxide (P_2O_5), Clariant (Muttenz, Switzerland), a specialty chemicals producer, is establishing a joint venture (JV) with two partners in the Chinese province of Yunnan. A P_2O_5 plant will be built and is scheduled to go onstream in the 1st Q of 2010. Clariant's JV partners are Kunming GaoHeng Huagong Chemical Industry Co., an exporter of yellow phosphorus, and Panchem International Trading and Industrial Co., a longterm partner of Clariant.

...and launches new production facility for surfactants in China

March 11, 2009 — Clariant is also building a surfactants plant in Zhenjiang, Eastern China. The new facility is scheduled for production in mid-2009 and will primarily serve personal care, paints and coatings as well as metal-working industries. The new facility, together with Clariant's existing plant in Tianjin, China will complement the company's already well-established manufacturing capabilities in Asia for Clariant's Functional Chemicals Div.

Foster Wheeler wins contract for Paradip Refinery in India

March 11, 2009 — Foster Wheeler AG (Zug, Switzerland) has announced that subsidiaries in its Global Engineering and Construction Group, Foster Wheeler Energy Ltd. and Foster Wheeler (G.B.) Ltd., have been awarded a contract by Indian Oil Corp. for a grassroots petroleum refinery at Paradip, Orissa State, India. Foster Wheeler will be the managing project management consultant for the major part of the development of the new 15-million metric ton per year facility.

Wacker plans to set up a polysilicon production facility in the U.S.

February 26, 2009 — Wacker Chemie AG (Munich, Germany) has mid-term plans to construct a new hyperpure polycrystalline silicon facility and has purchased approximately 550 acres of land in Tennessee for this purpose. The purchase price totals almost $20 million. Wacker expects a mid-term investment of around $1 billion to set up the new plant.

UOP to provide technology for first clean coal power station in the U.K.

February 18, 2009 — UOP LLC (Des Plaines, Illinois), a Honeywell company (Morris Township, N.J.), has announced that its Selexol technology was selected by Powerfuel Power Ltd. to remove contaminants from synthesis gas (syngas) made from coal for a new power station in the U.K. Said to be the first clean-power coal station in Europe, Powerfuel Hatfield Colliery is an integrated gasification combined cycle (IGCC) plant to be built in Stainforth, South Yorkshire. It is scheduled to start operation in 2013, and to use syngas from coal to generate 900 megawatts of power.

MERGERS AND ACQUISITIONS

GE signs agreement to establish a water technology center in Singapore

March 19, 2009 — GE Water, a business unit of GE Energy (Atlanta, Georgia), and the National University of Singapore (NUS) have announced that they have signed an agreement to establish the NUS-GE Singapore Water Technology Center on the campus of NUS. Together, GE and NUS are investing $100 million in the center, where GE scientists and engineers will develop new solutions for low-energy seawater desalination, water reclamation and more efficient water reuse. The facility is expected to be fully operational by mid-2009.

Roche and Genentech agree to combine the two organizations

March 12, 2009 — F. Hoffmann-La Roche Ltd. (Roche; Basel, Switzerland) and Genentech, Inc. (San Francisco, Calif.) have announced the signing of a merger agreement under which Roche will acquire the outstanding publicly held interest in Genentech for $95 per share in cash, or a total payment of approximately $46.8 billion to equity holders of Genentech other than Roche. The combined company will be the seventh largest U.S. pharmaceuticals company in terms of market share and will generate approximately $17 billion in annual revenues. Roche's Pharma commercial operations in the U.S. will be moved from Nutley, N.J. to Genentech's site in South San Francisco. The combined company's U.S. commercial operations in pharmaceuticals will operate under the Genentech name.

Shell and Codexis expand collaboration on biofuels

March 10, 2009 — Royal Dutch Shell plc (The Hauge, Netherlands) and Codexis, Inc. (Redwood City, Calif.) have announced an expanded agreement to develop better biocatalysts that could accelerate commercialization of next generation biofuels. Shell also increased its equity stake in Codexis and will take an additional seat on the company's board. As part of the agreement, Codexis will work closely with Shell and Iogen Energy Corp. to enhance the efficiency of biocatalysts used in the Iogen cellulosic ethanol production process.

BP and Verenium form cellulosic ethanol venture to deliver advanced biofuels

February 19, 2009 — BP (London. U.K.) and Verenium Corp. (Cambridge, Mass.) have announced the formation of a 50-50 JV to develop and commercialize cellulosic ethanol from non-food feedstocks. Together the companies have agreed to commit $45 million in funding and assets to the JV company, which will initially focus on a first commercial-scale cellulosic ethanol facility in Highlands County, Fla. with expectations to break ground on that site in 2010 and to begin production in 2012. The estimated construction cost for this 36-million-gal/yr facility is between $250 and $300 million. The new company will initially be based in Cambridge, Mass. ■

Dorothy Lozowski

For consideration in this section, please send press releases to biznews@che.com

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

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FOR MORE ECONOMIC INDICATORS, SEE NEXT PAGE

Economic Indicators

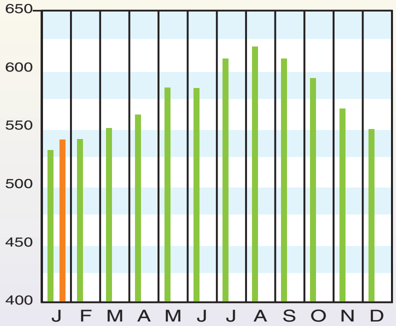
2009 **2008** **2007**

DOWNLOAD THE *CEPCI* TWO WEEKS SOONER AT *WWW.CHE.COM/PCI*

CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957-59 = 100)	Jan.'09 Prelim.	Dec.'08 Final	Jan.'08 Final
***CE* INDEX**	539.7	548.3	530.7
Equipment	642.4	654.3	632.7
Heat exchangers & tanks	603.4	618.2	602.0
Process machinery	620.0	623.2	609.3
Pipe, valves & fittings	781.8	806.1	743.8
Process instruments	389.6	397.0	413.3
Pumps & compressors	902.1	891.3	854.3
Electrical equipment	457.9	459.7	442.2
Structural supports & misc	671.5	684.0	669.1
Construction labor	324.8	328.3	314.3
Buildings	500.2	503.7	478.9
Engineering & supervision	350.3	349.9	355.1

Annual Index:
- 2001 = 394.3
- 2002 = 395.6
- 2003 = 402.0
- 2004 = 444.2
- 2005 = 468.2
- 2006 = 499.6
- 2007 = 525.4
- 2008 = 575.4

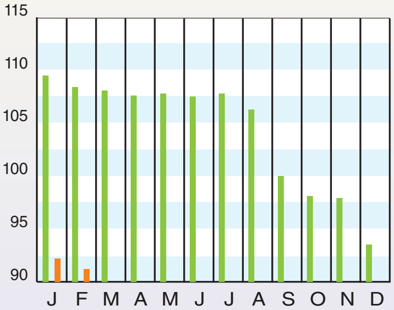


Starting with the April 2007 Final numbers, several of the data series for labor and compressors have been converted to accommodate series IDs that were discontinued by the U.S. Bureau of Labor Statistics

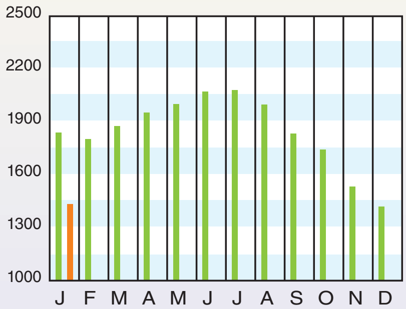
CURRENT BUSINESS INDICATORS

	LATEST			PREVIOUS						YEAR AGO		
CPI output index (2000 = 100)	Feb.'09	=	91.2	Jan.'09	=	92.2	Dec.'08	=	93.5	Feb.'08	=	108.1
CPI value of output, $ billions	Jan.'09	=	1,436.0	Dec.'08	=	1,422.1	Nov.'08	=	1,535.2	Jan.'08	=	1,839.4
CPI operating rate, %	Feb.'09	=	67.0	Jan.'09	=	67.8	Dec.'08	=	68.7	Feb.'08	=	80.5
Producer prices, industrial chemicals (1982 = 100)	Feb.'09	=	224.1	Jan.'09	=	226.2	Dec.'08	=	225.2	Feb.'08	=	252.1
Industrial Production in Manufacturing (2002=100)*	Feb.'09	=	98.3	Jan.'09	=	99.1	Dec.'08	=	101.8	Feb.'08	=	113.1
Hourly earnings index, chemical & allied products (1992 = 100)	Feb.'09	=	146.1	Jan.'09	=	144.5	Dec.'08	=	143.9	Feb.'08	=	141.3
Productivity index, chemicals & allied products (1992 = 100)	Feb.'09	=	126.0	Jan.'09	=	125.2	Dec.'08	=	124.8	Feb.'08	=	135.7

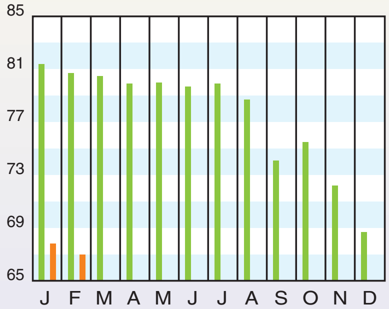
CPI OUTPUT INDEX (2000 = 100)



CPI OUTPUT VALUE ($ Billions)



CPI OPERATING RATE (%)



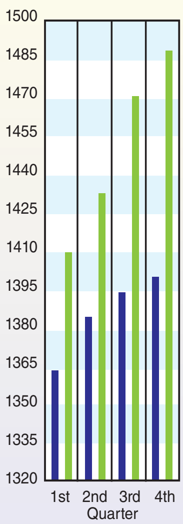
*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
Current business indicators provided by Global insight, Inc., Lexington, Mass.

MARSHALL & SWIFT EQUIPMENT COST INDEX

(1926 = 100)	4th Q 2008	3rd Q 2008	2nd Q 2008	1st Q 2008	4th Q 2007
M & S INDEX	1,487.2	1,469.5	1,431.7	1,408.6	1,399.2
Process industries, average	1,561.2	1,538.2	1,491.7	1,463.2	1,452.3
Cement	1,553.4	1,522.2	1,473.5	1,448.1	1,435.3
Chemicals	1,533.7	1,511.5	1,464.8	1,438.5	1,427.9
Clay products	1,524.4	1,495.6	1,453.5	1,429.1	1,415.0
Glass	1,448.1	1,432.4	1,385.1	1,359.7	1,348.8
Paint	1,564.2	1,543.9	1,494.8	1,467.6	1,457.1
Paper	1,462.9	1,443.1	1,400.0	1,377.7	1,369.2
Petroleum products	1,668.9	1,644.4	1,594.4	1,555.8	1,543.7
Rubber	1,604.6	1,575.6	1,537.5	1,512.3	1,500.1
Related industries					
Electrical power	1,454.2	1,454.4	1,412.8	1,380.4	1,374.9
Mining, milling	1,567.5	1,546.2	1,498.9	1,473.3	1,460.8
Refrigeration	1,818.1	1,793.1	1,741.4	1,711.9	1,698.8
Steam power	1,521.9	1,499.3	1,453.2	1,426.8	1,416.4

Annual Index:

2001 = 1,093.9	2003 = 1,123.6	2005 = 1,244.5	2007 = 1,373.3
2002 = 1,104.2	2004 = 1,178.5	2006 = 1,302.3	2008 = 1,449.3



CURRENT TRENDS

While the decline in the CEPCI continues in the preliminary January numbers (top), it is not as dramatic as in late 2008. The decrease in raw material prices appears to be moderating, which is probably due to a shortening surplus. Still, preliminary numbers for February suggest that the CEPCI will hit its first year-over-year recession since the beginning of this particular slowdown. Meanwhile, the drop in the CPI operating rate (middle) continues.

Visit www.che.com/pci for more on the CEPCI. ■