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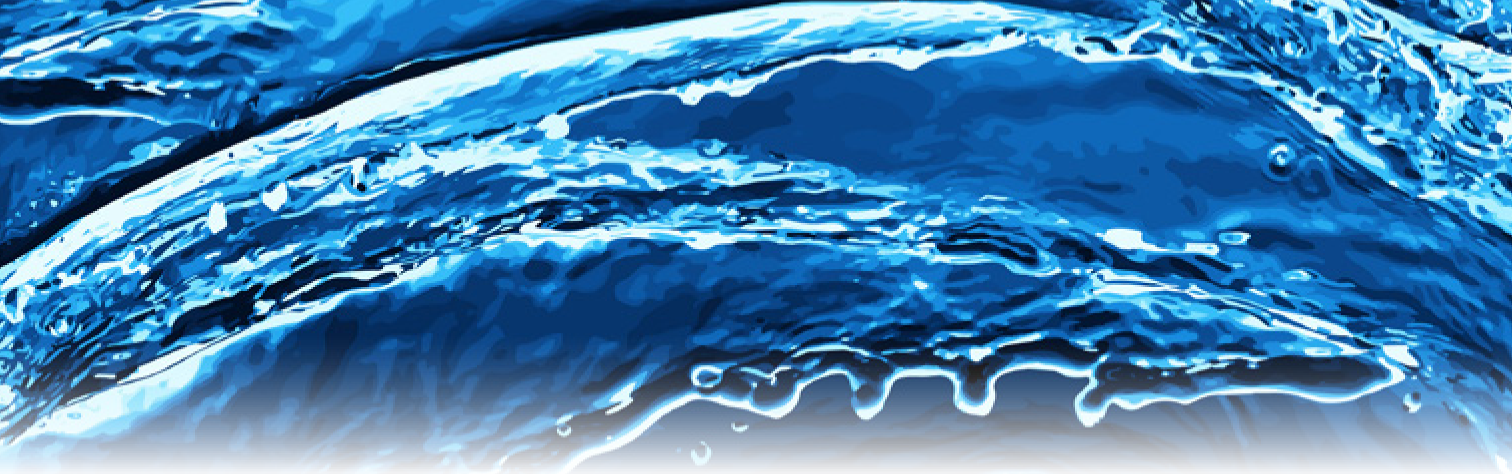

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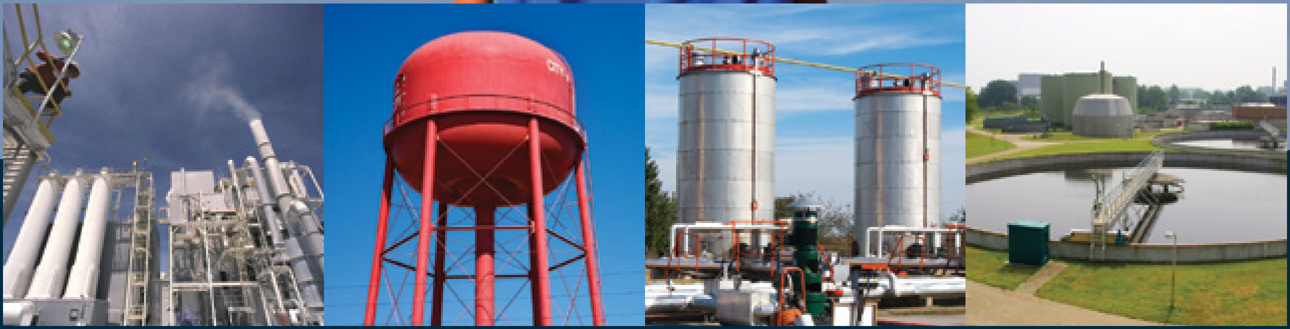

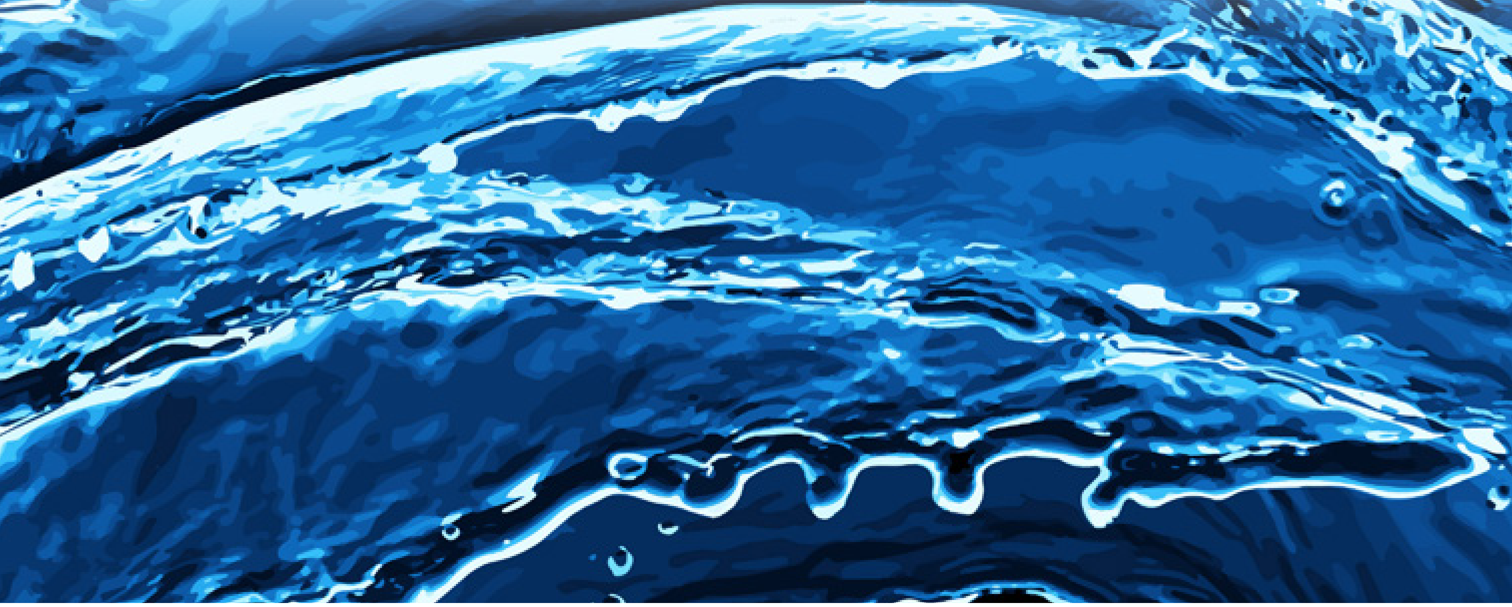

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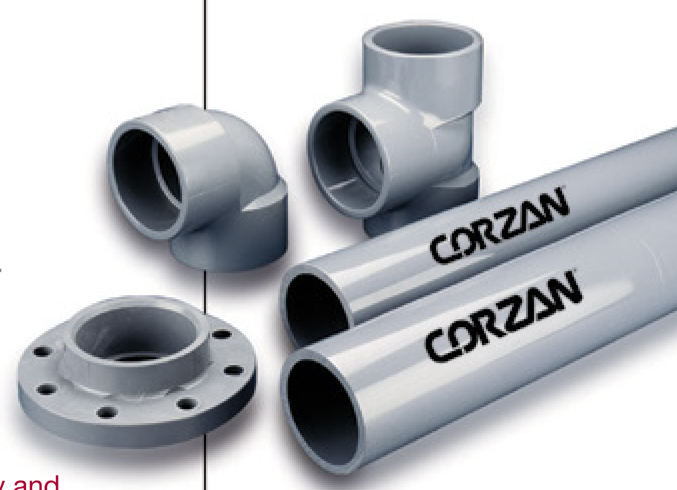

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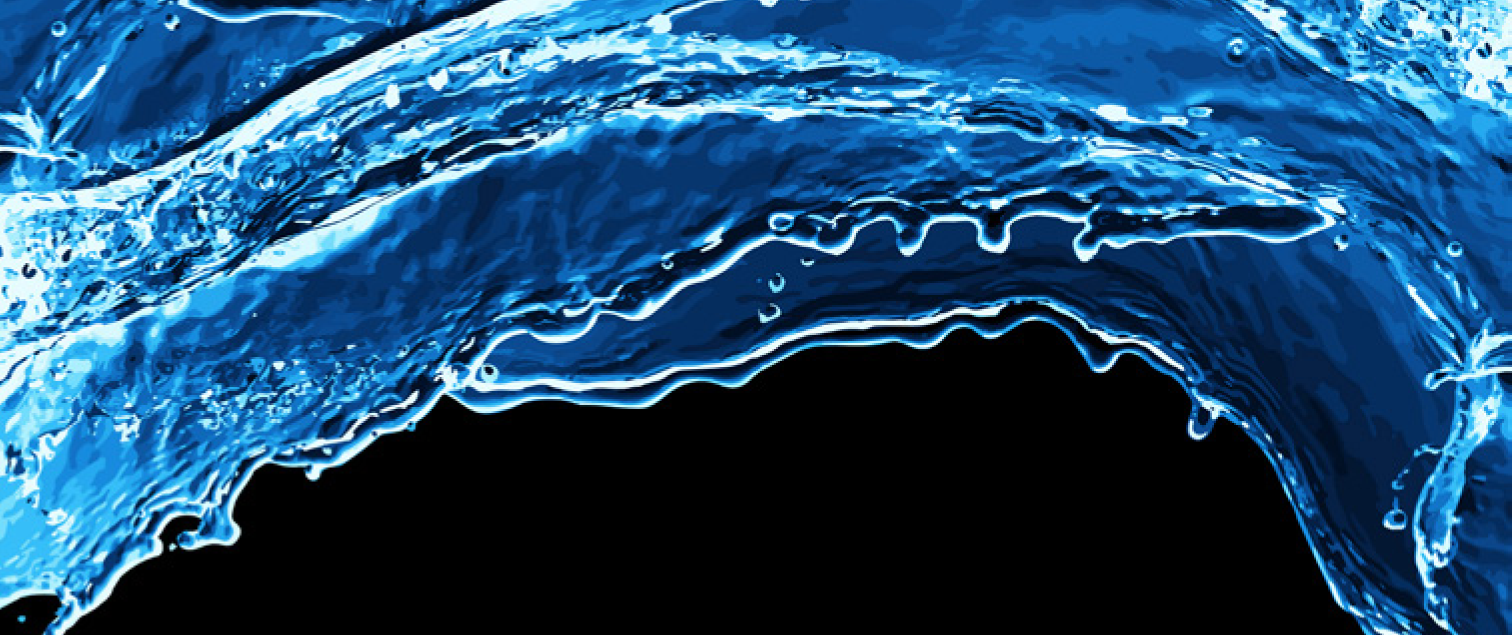


Master Metering Pumps

Understand when to use piston and diaphragm devices for precise liquid dosing

By Amin Almasi, rotating equipment consultant

SOME PROCESSES require dosing a precise volume of liquid into another flow stream in a specified time period. A metering (or dosing) pump usually handles the task. The term "metering pump" refers to the service rather than the particular kind of pump used. These pumps are not suitable for injection of gases; however, they can inject a liquid into a gas stream.

Metering pumps typically must supply practically constant flow rates of liquids (when averaged over time) within a wide range of discharge (outlet) pressures. Manufacturers provide each of their models of metering pumps with a maximum discharge pressure rating. Because the pumps are positive displacement devices, they usually can generate required discharge pressure if the drivers provide enough power. Of course, selection also must ensure the pressure and temperature ratings and wetted pump materials are compatible with the application and type of liquid being pumped. Most metering pumps have a pump head and an electric motor (driver). The liquid goes through the pump head, entering through an inlet line and leaving through an outlet line.

This article focuses on piston and diaphragm pumps and presents practical guidelines on the selection and operation of these metering pumps in chemical processes.

THE BASICS

A metering pump is a positive-displacement dosing device with the ability to vary capacity manually or automatically, as process conditions require. It features a high level of repetitive accuracy and can pump a wide range of liquids, including acids, bases, corrosive fluids, viscous materials and slurries. The particular fluid often can pose challenges for engineering, fabrication, commissioning and operation.

Metering pumps generally handle applications demanding high accuracy but relatively low flow rates; they usually are medium- or high-pressure pumps. A computer, microprocessor or flow-proportioning device commonly controls the pump.

Reciprocating motion (often from a piston) usually creates the pumping action. The piston either directly contacts the process fluid or moves (via air or hydraulic fluid) a diaphragm between it and the fluid.

During the suction stroke, the piston moves out, creating a vacuum that pulls liquid into the pump cavity past an inlet check valve. During the discharge stroke, the inlet valve closes and the piston moves in, pushing liquid through a now-open outlet check valve. These alternating suction and discharge strokes repeat over and over to meter and deliver the liquid. Changing the stroke length or adjusting the cycle frequency varies the flow.

Other types of metering pumps, such as peristaltic and bellows ones, find use in special applications. In peristaltic pumps, motor-driven rollers travel along flexible tubing, compressing it to push forward a liquid inside. Bellows pumps move a bellows back and forth to displace liquid. However, piston and diaphragm pumps handle the bulk of metering duties, and so this article focuses on them.

PISTON PUMPS

These positive-displacement devices can be designed to pump at practically constant flow rates (averaged over time) against a wide range of discharge pressures. Such pumps produce pressures to 700 Barg; special types can achieve pressure above 1,000 Barg. Figure 1 shows a single-acting piston pump.

Generally in such pumps, a piston (sometimes called a

PISTON PUMP

Figure 1. A small gearbox powered by an electric motor drives this single-acting plunger pump. *Source: Grosvenor Pumps.*

DIAPHRAGM PUMP

Figure 2. This single-acting diaphragm pump uses corrosion-resistant plastics for wetted parts. *Source: Grosvenor Pumps.*

plunger), typically cylindrical, goes in and out of a correspondingly shaped chamber in the pump head. Packing around the piston or a doughnut-shaped seal with a toroid-shaped sphincter-like spring inside that compresses the seal around the piston usually holds the fluid pressure when the piston slides in and out and makes the pump leak-tight. The packing or seals can wear out after prolonged use but can be replaced. The potential for wear and subsequent leaks makes piston pumps a bad choice for abrasive fluids.

A single-piston pump (Figure 1) delivers liquid to the outlet only during the discharge stroke. If the piston's suction and discharge strokes occur at the same speed, liquid is metered out half the time the pump is working; so, the overall metering rate averaged over time equals half the average flow rate during the discharge stroke. Some single-piston pumps feature a constant slow piston motion for discharge and a quick retract motion for refilling the pump head. For such devices, the overall metering rate practically equals the pumping rate during the discharge stroke.

DIAPHRAGM PUMPS

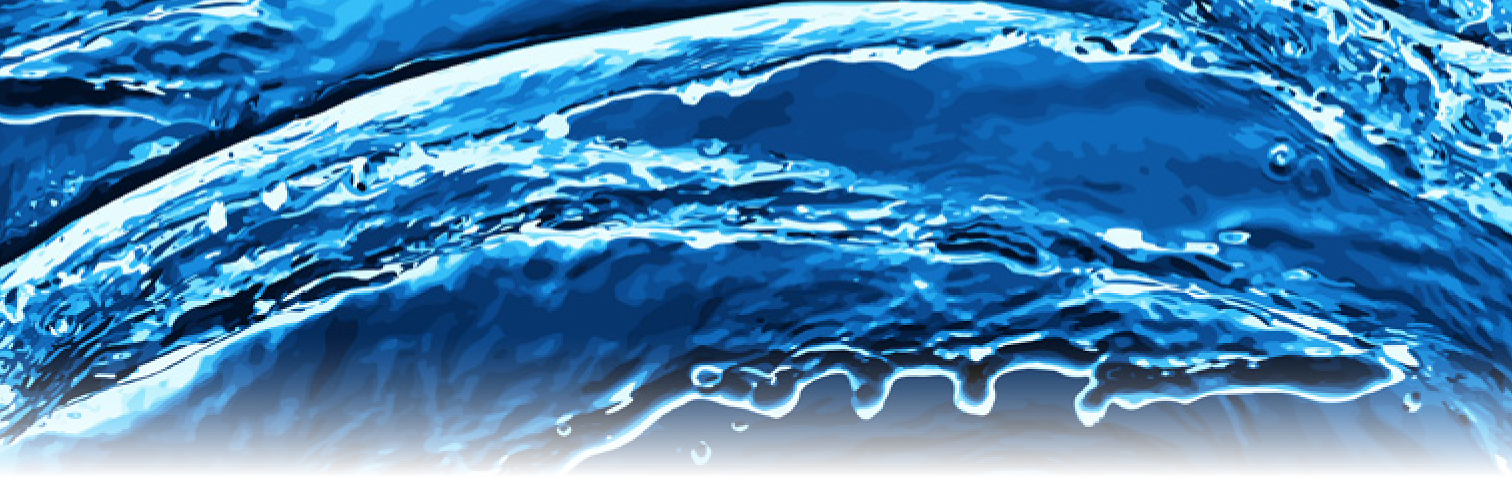
These pumps use reciprocating movement to pulse a flexible membrane — usually made of rubber or a fluoropolymer or other thermoplastic — to displace liquid with each stroke. The liquid doesn't penetrate through the diaphragm. Diaphragm pumps usually possess good suction lift characteristics. The devices produce pressures to 100 Barg; special variants can achieve higher pressures. These pumps usually require no seals; this suits them for handling abrasives and slurries. In addition, they are a good choice for dangerous, toxic or noxious liquids because they obviate issues of leakage through seals or packing. They also have good self-priming capabilities and dry-running characteristics. Some units boast efficiencies that reach as high as around 97%.

Diaphragm pumps often are electric motor driven (such as the one shown in Figure 2) but pneumatic- and hydraulic-powered units also are available. The pumps can be categorized by what's on each side of the membrane:

• *Process fluid on one side and compressed air or hydraulic fluid on the other.* Such air-operated or hydraulic pumps can be used in areas where electrical devices aren't suitable or would be very expensive because of explosion-proof or electrical-area-classification requirements; in other words, they are popular for many applications to avoid area classification problems or intermittent electric power availability issues. They are more compact and lighter than other designs.

• *Process fluid on one side and ambient air on the other.* Diaphragm flexing occurs due to the action of a crank, geared motor drive, lever or other mechanism. These pumps usually are more energy efficient than other designs. One reason is because the drive system doesn't require expensive compressed air or hydraulic oil. In addition, they can be tailored to the needs of the specific application.

Such pumps most often are electro-mechanical double-acting designs. In these, the integral metal core of each membrane is completely covered by the membrane material on its fluid pumping side, minimizing the possibility of fluid contamination. The smooth mechanically controlled linear drive of the membranes can ensure low-shear transfer at precisely controlled rates even when viscosity, pressure or other operating param-



eters change. A variable frequency drive can enable easy adjustment of flow rates. An external electrical control device such as a pressure switch can limit maximum discharge pressure if necessary.

• *Process fluid on both sides.* These pumps employ one or more unsealed diaphragms. Flexing of the diaphragm(s) causes the volume to change. These devices rarely are used.

OPERATING ISSUES

Often, a metering pump can exceed its pressure rating if it continues running after a downstream valve closes or line blockage occurs. For this reason, it is good practice to place a pressure relief valve ahead of the valve to prevent over-pressuring the tubing or piping line. The relief valve setting should be below the maximum pressure rating of the tubing, piping or downstream component with the lowest rating.

Gas bubbles entering a pump head can cause problems. The compression motion compresses the gas but doesn't necessarily drive it out of the pump head. In such cases, the pump may stop discharging liquid even though mechanically it's going through the motions — in reality, it's just repeatedly compressing and decompressing the bubbles. Preventing this type of "vapor lock" often calls for degassing of some solvents and other liquids before pumping.

If the outlet pressure is lower than the inlet pressure and remains that way in spite of the pumping, then this pressure difference opens both check valves simultaneously; liquid flows through the pump head uncontrollably. This can happen whether or not the pump is running. Placing a correctly rated positive-pressure-differential check valve downstream of the pump avoids the issue. Such a valve only will open if the minimum rated pressure differential across the valve is exceeded, which is a possibility with most high-pressure metering pumps.

Valves are a common source of problems; diaphragms top the issues for that type of pump. Metering pumps usually require maintenance to valves and diaphragms approximately every six months to one year.

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Nix Nozzle Nightmares

Don't forget to check nozzle locations when altering towers

By Andrew Sloley, Contributing Editor

MODIFYING THE internal layout of vessels can prompt unexpected problems. For example, after one plant switched the existing trays in a steam stripper from one-pass to two-pass in a quest for higher capacity, the tower didn't work correctly. Several different problems seemed to occur as operators changed operating pressures as well as steam and product rates in an attempt to make the unit work.

In general, at rates equal to the flow capacity of a single-pass tray, the system would work if steam flow rates weren't too high. In contrast, at high liquid rates and high steam rates, the tower would flood. Achievable capacity was roughly 70% of the rate before the modifications, not the 130% intended by the project — which, quite correctly, was considered a failure.

Two-pass liquid trays increase tray capacity by splitting the liquid flow in half. Reduced liquid rates on each tray section decrease weir loading, diminish downcomer pressure losses and cut tray pressure drop. Yet, in this case, the modifications failed to deliver even the same capacity.

Preliminary evaluation of the unit operation didn't clearly identify any reason for the capacity loss. Review of the tray design showed the trays should have worked. The fact they didn't indicates two main areas to check: 1) whether process conditions significantly differ from those expected; and 2) whether the trays as installed aren't what they should have been. Troubleshooting equipment configurations can be difficult on an operating unit. Unless the unit is shut down and physically inspected, what's in the column may remain uncertain.

Figure 1 shows both the original and revamped bottom section of the column. Pay specific attention to the steam injection. Field inspection revealed that, while the trays had been changed, the external piping hadn't been modified. The steam nozzle was putting the steam into the downcomer on one side of the tower.

Steam entering the downcomer reduced its capacity, causing liquid to back up onto the tray above. At rates below about 70% of capacity, the downcomer had enough volume to still allow for vapor/liquid disengaging. At higher rates, the tower flooded.

The revamped unit actually suffered two problems due to nozzles. The second stemmed from the liquid feed nozzle also not being modified or relocated. All the liquid feed was entering on one side of the tower.

Either problem could prompt flooding of the tower. However, only the steam-nozzle problem was seen because it caused the tower to flood first.

So, an effective solution requires further work both at the tower liquid feed (top of the tower) and the tower vapor feed (bottom of the tower).

I have observed other issues with nozzles, including having:

- a feed nozzle in the center downcomer when trays are switched from one-pass to two-pass. This occurs if the nozzle is rotated 90° from the tray alignment line;
- liquid-level measurement nozzles in unusable locations because of changes in internal baffles or collectors; and
- non-usable nozzles after installing strip-lining inside the tower and not cutting holes in the lining for the nozzles.

When modifying vessel internal arrangements, ensure that external feed, product and instrumentation connections end up in the correct locations.

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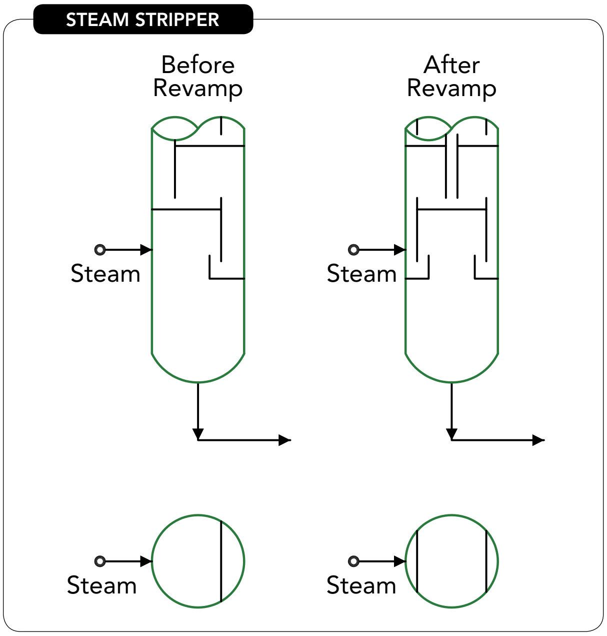

Figure 1. Revamp, which involved switching from one-pass to two-pass trays, cut capacity instead of increasing it.

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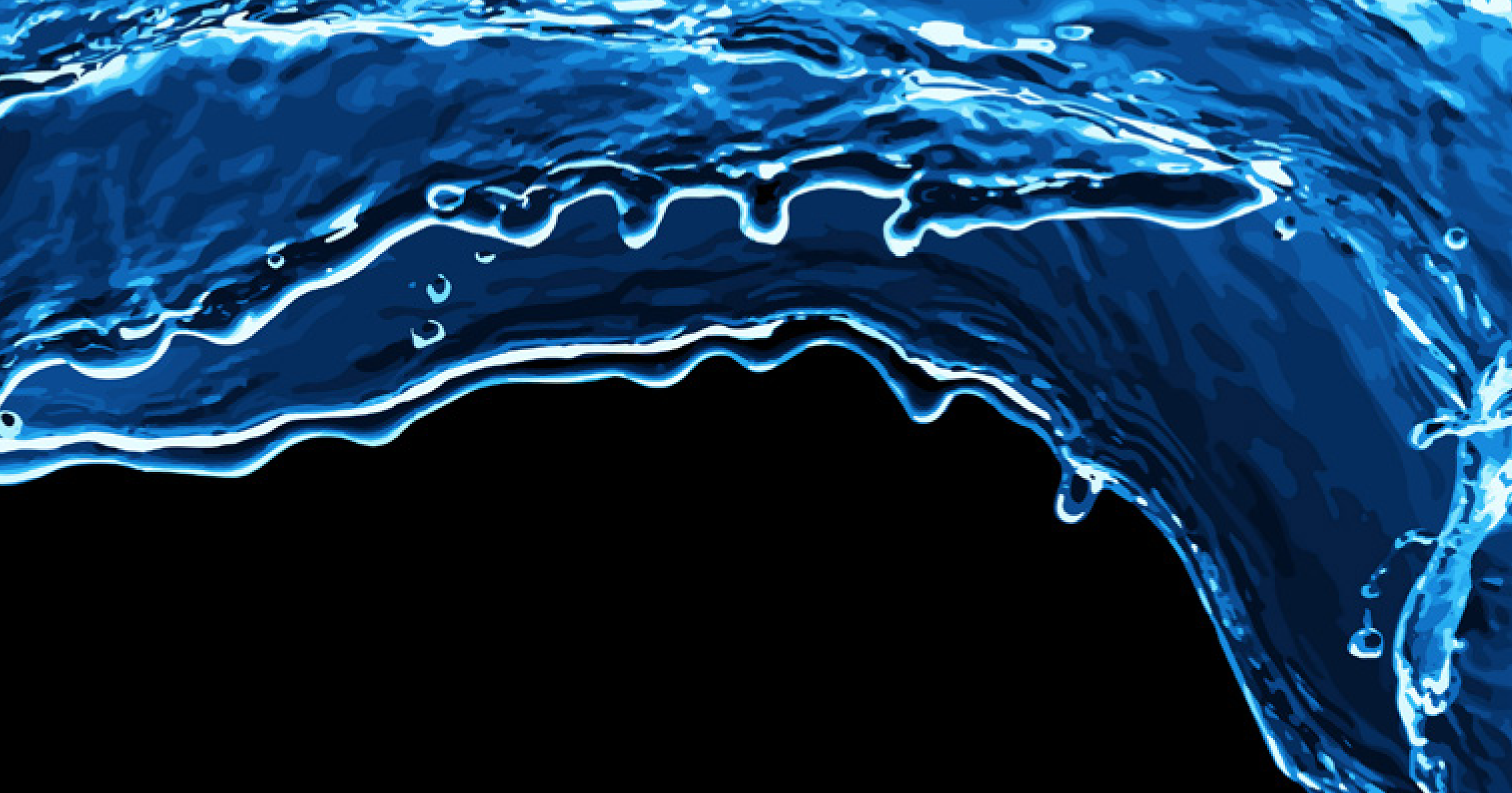


Carefully Consider Sidestripper Control

Analysis of three possible options provides important insights

By Andrew Sloley, Contributing Editor

IN "PONDER Parallel Paths," (http://goo.gl/TUKlXV) we examined how pressure balance can control maximum flow in sidedraw systems. Now, let's look at the objectives of sidedraw systems and how the main control approaches compare.

Sidedraw systems have two major objectives:

1. Draw a product at a specified condition. This may be a rate or a product purity or specification of some type. The draw rate may be set independently or reset by the operating system to meet a purity or performance specification.

2. Protect the equipment involved.

Figure 1 shows three sidedraw systems, A, B and C. In each, the draw rate is directly set on flow control. The major equipment protection step is maintaining a liquid level to safeguard the product pump. (A system without a pump still would need the upstream liquid level to provide a seal to prevent vapor entering the downstream product.)

Do all three systems meet the two major objectives?

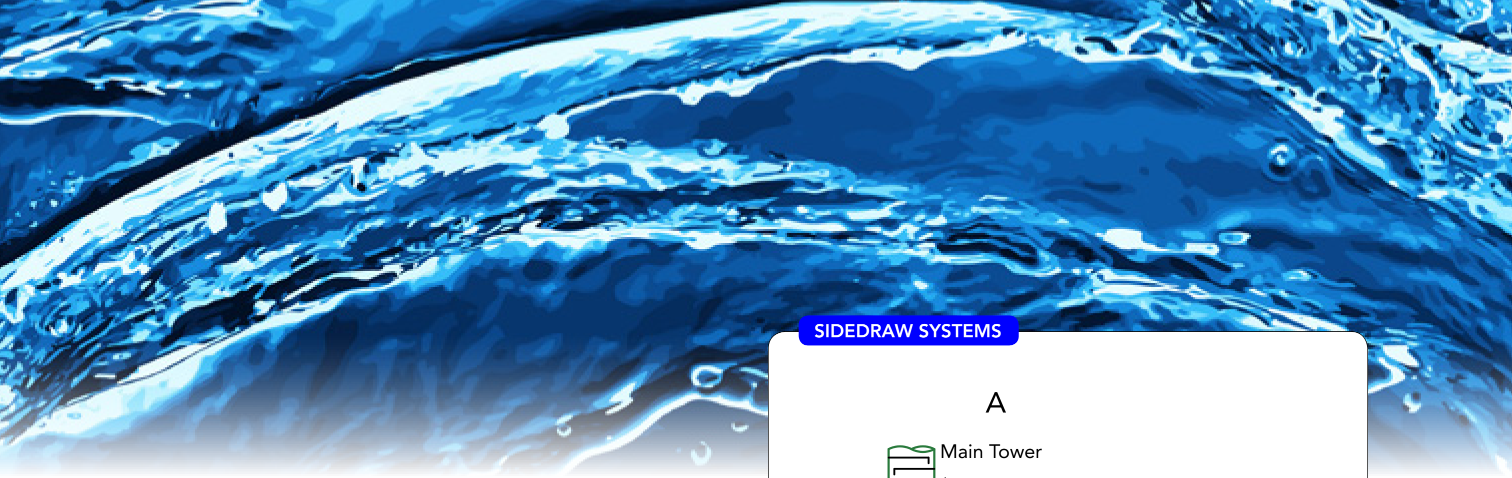
System A maintains a level protecting the pump by manipulating the final product rate — by directly varying the bottoms product rate.

System B maintains a level protecting the pump by manipulating the feed rate to the sidestripper — by varying the liquid draw from the main tower to the sidestripper.

System C maintains a level protecting the pump by manipulating the final product rate as in System B — but by using a cascade from level to flow. (This does not change the overall logic of the system.) The target product rate is approximated by controlling the feed rate into the sidestripper. This system assumes a roughly constant ratio of bottoms product to feed rate.

All three systems seem to meet the objectives of meeting a fixed product rate and protecting the bottoms pump. However, System C has two defects. First, the product rate is only an approximation; Systems A and B directly control the bottoms product rate to a specified value. Second, in System C, the feed line to the sidestripper uses an orifice plate as a flow measurement device. The orifice plate imposes a pressure drop in the system. As discussed last month, this pressure drop reduces the system draw capacity. If elevations suffice, this may not be important. Nevertheless, treat System C as a marginal option.

Systems A and B present an interesting choice. A review of my previous columns and articles would show that I highly favor System B, as do other authors. However, from a technical perspective, System A has a slight advantage. This raises two questions: "Why is System B



shown so often?” and “Why is System A superior?”

Let’s keep in mind that Systems A and B both work and are used extensively. A plant should standardize on one option or the other — i.e., every sidedraw should use the same control configuration. Keeping everything alike vastly simplifies operator understanding and helps avoids errors.

Now back to the open questions.

The reason authors so favor System B is simple. It draws up into a simpler sketch. No lines cross each other and the drawing is compact. Because the approach works and is widely used, it appears in article illustrations unless some specific point in the discussion requires a different system.

System A is technically superior — but not under normal control conditions where both systems meet the overall objectives. However, under abnormal conditions, control behavior can vary. Perhaps the most important difference is the response to a steam control valve failing open. In many units, if the valve fails open the steam rate will flood the sidestripper. One of the consequences of flooding is that liquid stays on the trays and doesn’t reach the tower bottoms.

In System B, the resultant drop in bottoms level opens the feed valve to the sidestripper. So, despite the trays remaining flooded and little (if any) extra liquid likely reaching the tower bottoms, the bottoms rate remains constant. The bottoms liquid level will continue to drop. Starving the pump of liquid is very possible.

In contrast, when the level of the sidestripper in System A drops, the flow out immediately decreases. This helps keep liquid on the pump suction. Eventually, the flow rate will drop to zero, but System A gives operations staff more time to respond to the pump than if level is completely lost.

Control systems must meet required process objectives. In selecting the approach to use for an operating unit, always consider steady state, dynamic and abnormal operating characteristics of the system.

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SIDEDRAW SYSTEMS

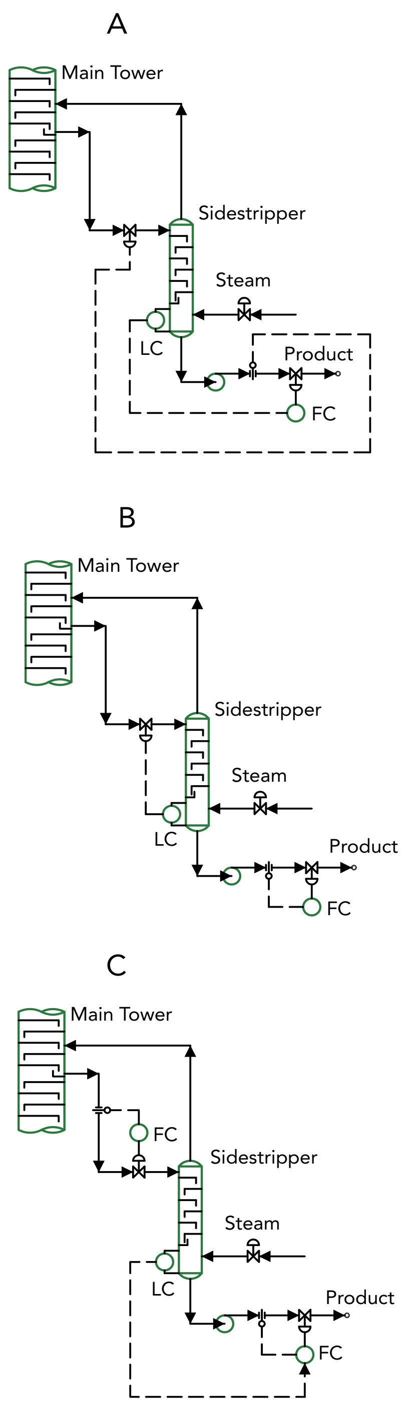

Figure 1. System A provides better product pump protection in the event of tray flooding.


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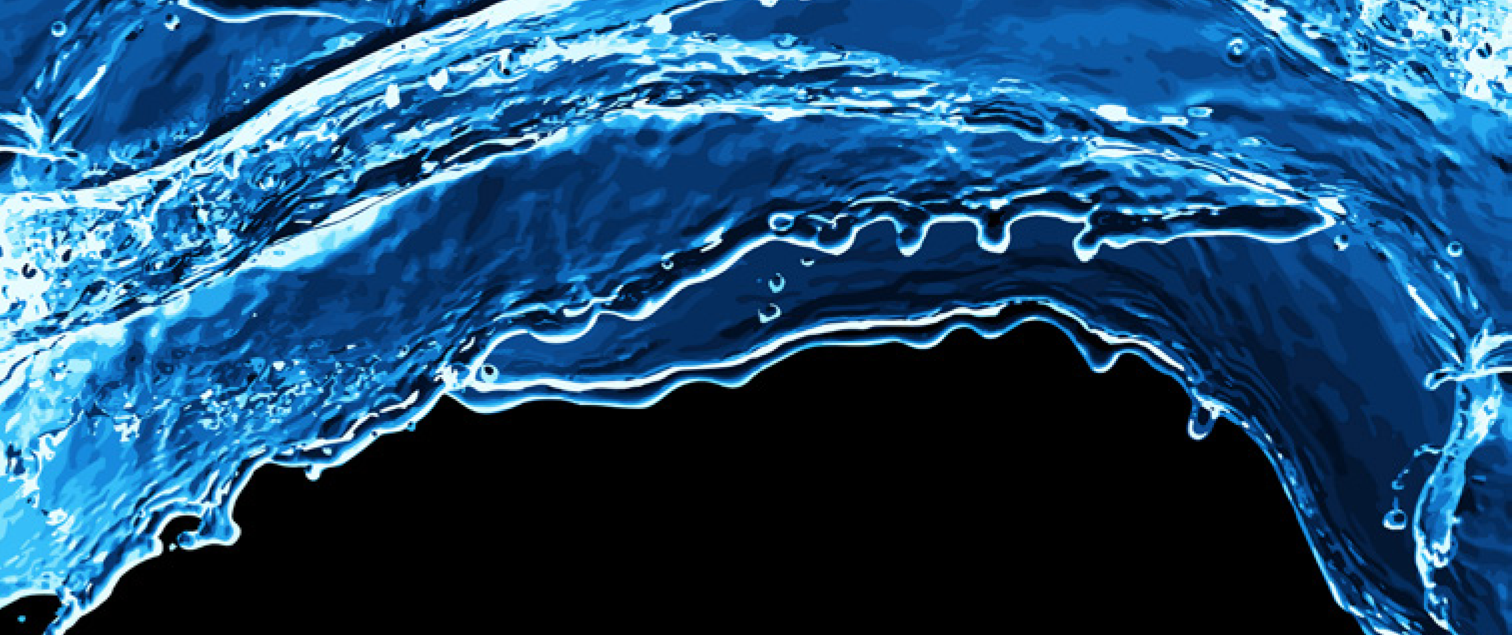

Case Study: Press Fittings Speed Up Plant Build

A producer of specialty lubricants speeds pipe installation using press-fitting technology

By Viega

TEXAS REFINERY Corp. (TRC), Fort Worth, Texas, has done something that hasn't been done in the U.S. for the past 25 years — it built a lubrication plant.

Established in 1922, the family-owned business produces specialty lubricants and protective coatings, such as oils, grease, gear lubricants, cleaners and sealants. TRC products are used to help protect equipment and a company's capital investments in industries that include manufacturing, agriculture, waste management, drilling, mining and steel mills. When TRC was ready for expansion, it built a new facility in Mansfield, Texas.

"In the early planning stages, TRC knew this plant needed to be special," says Dennis Parks, executive vice president at TRC. "TRC wanted a plant so special that other companies would model their future production facilities after this state-of-the-art factory."

PIPE-FITTING TECHNOLOGY

The facility represents TRC's investment in the future, which is why every attention to detail was important to the company. Working with A&G Piping, a mechanical contractor out of Fort Worth, TRC built the facility from the ground up in 2015. In turn, A&G Piping chose to work with Viega, which specializes in pipe-fitting tech-

Figure 1. Texas Refinery Corp.'s new lubrication plant includes Viega pipe fixtures for compressed air and potable water systems.

Figure 2. A&G Piping used Viega's MegaPress for the plant's compressed air system.

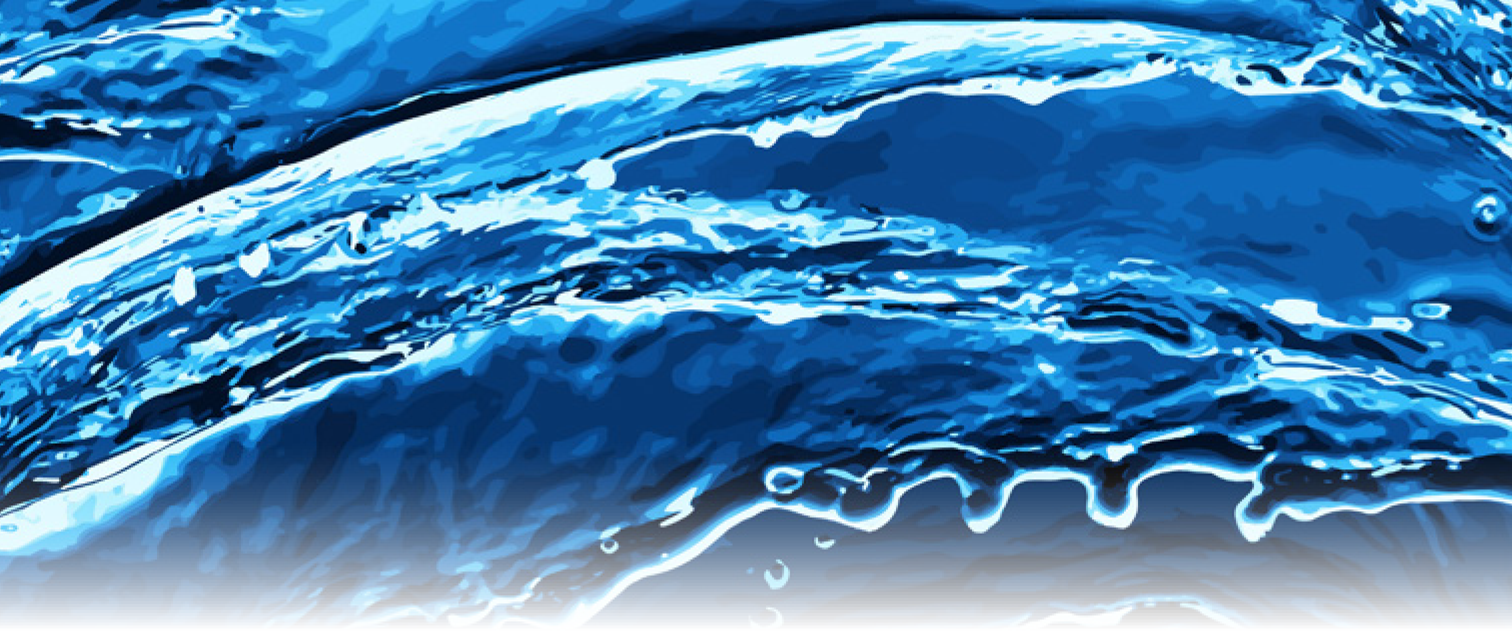

Figure 3. Using press-fitting technology saved an estimated 30% installation time over soldering.

Figure 4. Viega's MegaPress doesn't require much installation training and results in huge labor savings, said the piping contractor.

nology. A&G has used Viega's products for more than a decade and knew those products were the right solution for TRC's factory.

"I've used all the Viega products," says Tracy Auen, owner of A&G Piping. "They save a lot of labor time. You can cut in on a line where a valve is not holding and not worry about sweating it. It's a much simpler installation process."

QUICKER INSTALLATION

Auen installed the Viega MegaPress in ½ to 2 in. for compressed air and Viega ProPress for copper in ½ to 1½ in. for potable water. He estimates he saved 30% installation time over soldering. One of the best features of Viega fittings, according to Auen, is their quality.

"When we know we're getting Viega fittings — regardless of whether it's the stainless, copper or in the case of the refinery, carbon steel — we hardly ever have any issues with the quality of your workmanship," Auen said.

Auen was introduced to Viega ProPress for stainless in 2003 when he did some work at a local brewery and still recommends it to his colleagues, stating that "even if you've never done it before — and change is not easy, even I'm a creature of habit — just give it a shot."

PRESS-FITTING SAVES LABOR

"The cost saving on labor is huge with Viega MegaPress," Auen says. "Being able to install it even if the line is live is a big benefit. It's a simple product to install—it doesn't take years of training. The Viega sales rep can come out and do a training class on the proper steps for pressing, and it's literally that easy. It simplifies the skill level to install, but you don't sacrifice on the final quality."

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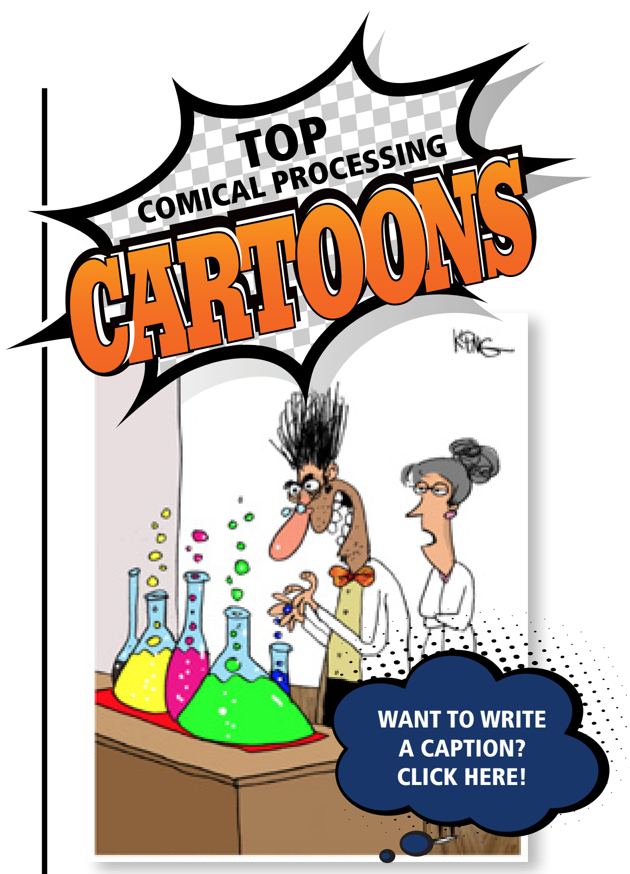

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