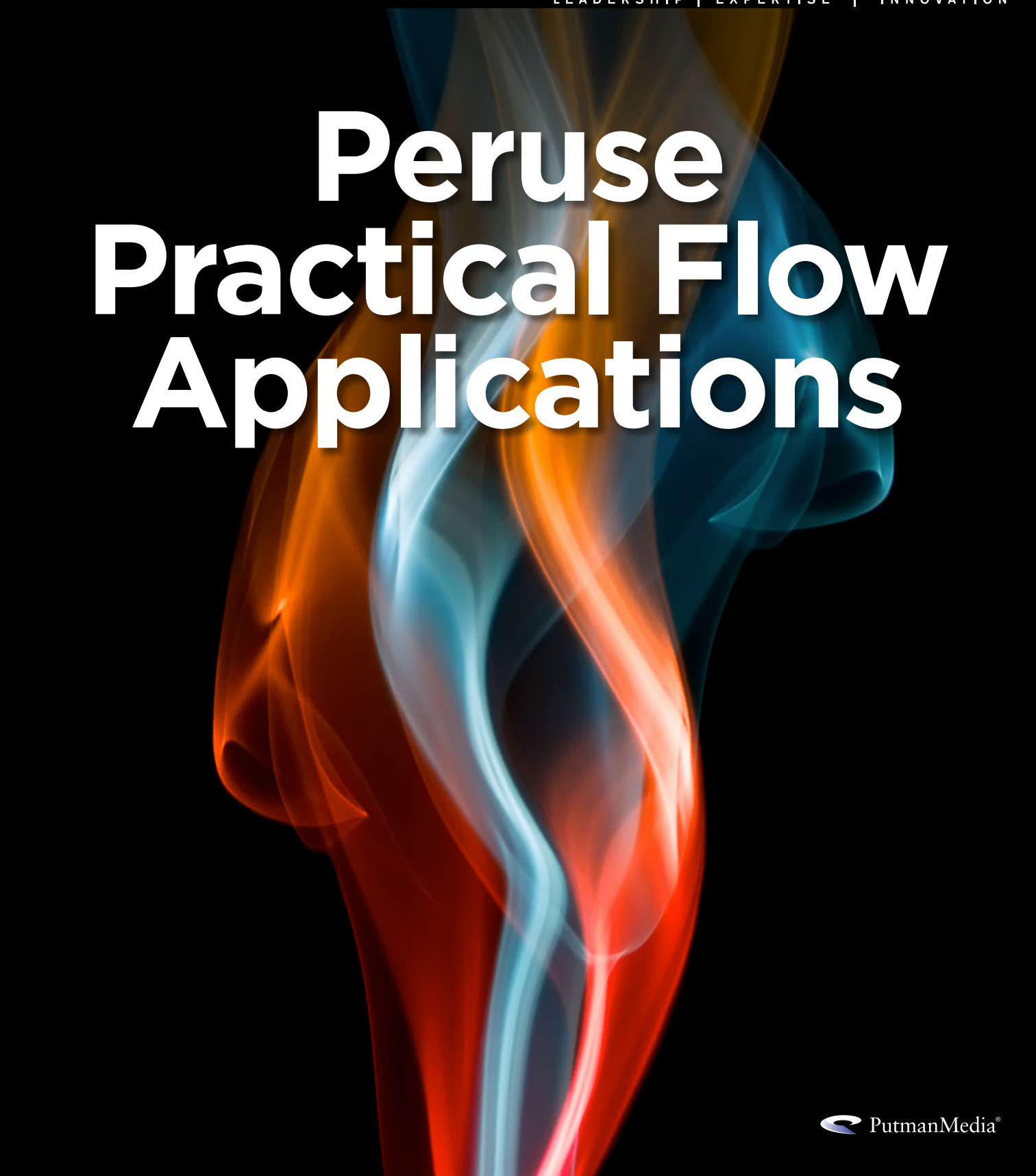
CHEMICAL PROCESSING
LEADERSHIP | EXPERTISE | INNOVATION

Peruse Practical Flow Applications



PutmanMedia®

ABB FSS450 Swirl flowmeters

The simple solution to complex flow problems.

ABB's new FSS450 swirl flowmeter features a unique design that requires minimal upstream and downstream piping requirements, which lowers installation costs. It is ideal for the chemical industry with multi-SIL certifications, on-board diagnostics and through-the-glass interface. Discover flow measurement made easy. **www.abb.com/flow**

TABLE OF CONTENTS

PRODUCT FOCUS

PROCESS ANALYTICS WITH CLAMP-ON ULTRASONIC TECHNOLOGY

Analyzer measures concentration, density and mass flow rates in real-time

The ultrasonic clamp-on process analyzer PIOX S is used to measure concentration, density and mass flow rates of a liquid in real-time by determining the acoustic velocity of the medium.

PIOX S transfers the practical advantages of clamp-on ultrasonic technology to process analytical applications. Because the transducers are mounted on the — safe — outside of the pipe, they are not subject to any wear and tear by the medium flowing inside. Moreover, as there is no need to open the pipe for installation, mounting and initial operation can usually be done during ongoing operation. Non-invasive process analytics are suitable for almost all pipe sizes and materials — whether it's steel, plastic, glass or special materials with inline or outer coatings, in a nominal size range of ¼ in. to 20 ft, for temperatures up to 750°F as well as for hazardous areas. The transducers and transmitters also are available in FM-certified designs.

The analyzer is said to be ideal for materials and processes that demand the highest levels of safety and reliability, e.g. in the case of corrosive media like strong acids or alkalis or even toxic compounds.

Flexim | 888-852-7473 | www.flexim.com/us/piox-s

Viega MegaPress® Stainless

Faster connections keep processes flowing

viega.us/mpstainless

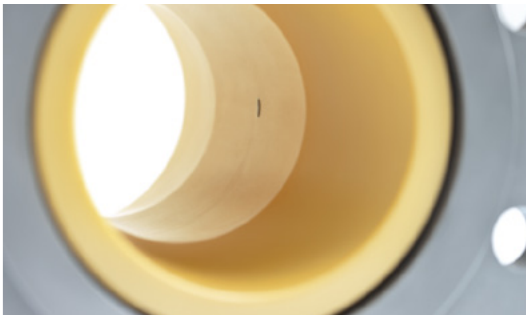
A solution to protect profitability

When piping systems need maintenance or repair, production may have to go offline during the time-consuming welding or threading process. There is a solution to cut downtime and revenue loss – Viega MegaPress fittings for IPS stainless steel pipe. One person can safely install a MegaPress fitting in 7 seconds or less. In just a fraction of the time, production is back online, with connections that meet the highest standards for strength and reliability. **Viega. Connected in quality.**

For more information, call 800-976-9819 or visit viega.us/mpstainless

viega

AD INDEX



fact

Accurate, reliable and durable flow measurement in chemical processes

OPTIFLUX 5000 series – technology driven by KROHNE

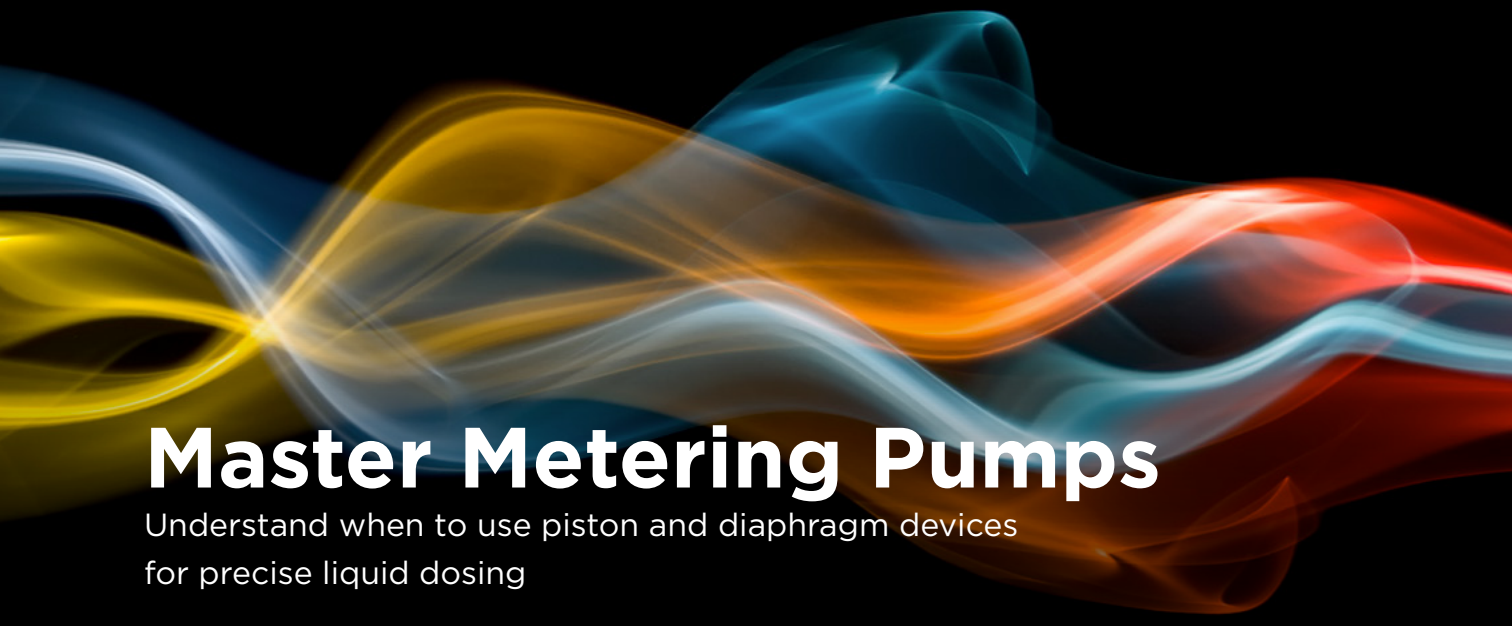
- Electromagnetic flowmeters with ceramic measuring tube for corrosive and abrasive fluids and slurries
- Vacuum resistance, form stability with under or overpressure, diffusion tight
- Leak proof with fused-in Cermet electrodes
- –40...+180 °C/–40...+356 °F, DN15...300/1/2...12", thermal shock resistant
- Hazardous area approved
- Virtual reference option: no need for grounding rings

ceramic
durability

KROHNE
measure the facts

products solutions services

More facts about the OPTIFLUX 5000: www.us.krohne.com/optiflux5000



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 practi-

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

cally 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 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 PUMP

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

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 ad-

dition, 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 electromechanical 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 parameters 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.

AMIN ALMASI is a rotating equipment consultant based in Sydney, Australia. E-mail him at amin.almasi@ymail.com

TRICOR
Coriolis Technology

Visit us online
www.tricorflow.com

FLOW ACCURACY & DEPENDABILITY

In the challenging, often complex chemical processing environment, it is important to feel confident that your instrumentation is operating at peak levels and will maintain high accuracy and repeatability. At TRICOR, we've taken the design of our TCM line of Coriolis meters to a whole new level utilizing cutting-edge technologies.

- **All-welded Construction** – All wetted components were engineered to comply with NACE standards and provide the highest resistance to corrosion from harsh chemicals.
- **Best-in-Class Density Measurement** – High accuracy and repeatability (.1% / .05%) and excellent resolution (10,000 Hz).
- **Easy Installation & Setup** – We can pre-program with your process parameters and reporting preferences.
- **Exceptional Value** – All-in-one instrument measuring mass flow, density & temperature.
- **Hazardous Area Certified** – ATEX, IECEx, CSA (US & Canada), TR (EAC).
- **Wide Range of Flow Rates** – Meters handle flows as low as 5 g/min (0.011 lb/min) to as high as 230,000 kg/hr (8450 lbs/min).

414.574.4300 | sales@aw-lake.com | 2440 W. Corporate Preserve Dr. #600, Oak Creek, WI 53154

Successfully Ground Your Electromagnetic Flow Meters

Unique virtual reference method helps address grounding challenges in EMFs used in harsh applications.

By Joe Incontri, KROHNE

In certain applications, conventional grounding of electromagnetic flow meters (EMFs) can pose special challenges. This article illustrates those challenges and sheds light on a unique solution that is especially suitable for problematic applications, some of which are found in desalination facilities. An example of a successful chemical application is provided.

For many decades, EMFs have been the first choice for measuring the volumetric flow of electrically conductive liquids. This is true for many industries such as chemical, pharmaceutical, food, beverage and throughout the water/wastewater industry.

The basis of the measuring principle is Faraday's Law of Induction, wherein an induced voltage at the electrodes is proportional to the velocity of a conductive fluid moving within a magnetic field. The inner wall of the measuring tube must be electrically isolated and only the electrodes are in contact with the fluid. Thus, most EMF measuring tubes are lined with hard rubber or other elastomers, or in cases where the fluids are extremely corrosive, they can be made entirely of ceramic.

GROUNDING

Like all electrical equipment, EMFs must be grounded in accordance with safety regulations for protective grounding or potential equalization. EMF grounding ensures primary protection against electric shock. In the event of a ground fault, there is no hazardous voltage transferred to the conductive parts of the device. However, most important for the measurement, proper

grounding provides a fixed reference potential; this is crucial because EMF signal voltage is typically about a millivolt or less. The EMF signal converter can only process such small sensed signals most efficiently when there is minimal difference between the induced voltage of the medium and the reference potential at the converter. In other words, the better the grounding, the better the flow measurement.

The three classical methods to ensure solid grounding are detailed below. In addition, the newest virtual reference method which eliminates the need for grounding the fluid also is discussed.

1. Grounding in electrically conductive pipes. This is the simplest case for grounding. In electrically conductive pipes (steel or stainless steel) the liquid is in direct contact with the metal and therefore has the same potential as the grounded pipe. The signal voltage on the electrodes thus has a fixed reference potential and no additional fluid grounding mechanisms are required for EMF use.

2. Grounding rings for non-conductive pipes. For ceramic, plastic or concrete and internally coated steel pipes, the fluid is brought to a known, fixed potential by using metal grounding rings. For maximum effectiveness, we recommend one on the inlet and outlet of the flow meter. Each ring is in conductive contact with the fluid and grounded with the sensor.

When assembling the pipeline to the meter's flanges, gaskets are necessary to limit any leak potential. The installed grounding rings and gaskets must not disturb the flow profile since this may affect meter performance. This technically reliable method has been proven for many decades in countless applications. However, higher grounding ring costs apply when special materials are needed for chemically aggressive media. One example is sea water inflow in desalination facilities where large pipe sizes are required and stainless steel grounding rings are not suitable.

Stray currents can travel via the grounding rings and the grounding cable where persistent and significant electrical potential exists between the fluid and ground. In time, those grounding rings will deteriorate as a result of the electrochemical reactions with the fluid.

3. Grounding with grounding electrodes. Some vendors will provide EMFs with a single grounding electrode situated at the inlet side of the meter. It is in direct contact with the sensor housing and is connected to the functional earth (FE) point of the EMF sensor. This additional electrode is often much less costly than equivalent grounding rings but they provide much less surface area so their performance is less effective for a variety of reasons.

Grounding electrodes can be more readily destroyed than rings by electrolytic action

in the presence of electrical potential differences. The resulting fluid leak path around the electrode would lead to the eventual destruction of the complete EMF thereby requiring its replacement while affecting the process. Similarly, abrasive solids in horizontal pipelines can quickly destroy these grounding electrodes through erosion. Deposits on the grounding electrode can inhibit the basic fluid grounding function, thus also inhibiting measuring performance. In the case of large EMFs equipped with grounding electrodes, significant deviations also occur when an EMF calibrated in an electrically conductive pipeline is used in an isolated pipeline application.

ALTERNATIVE TO CLASSICAL GROUNDING: VIRTUAL REFERENCE

In certain applications, conventional grounding methods of EMFs pose problems. For example, in lines with cathodic corrosion protection or in galvanization plants, a voltage is present between the electrodes and the earth. In desalination plants any metal in contact with the chemically aggressive fluid, including grounding rings or electrodes, are usually made of expensive materials. These can add up to very high costs where pipe sizes above 6 in. are concerned.

Krohne's unique and effective solution to this problem is called "virtual reference" or sometimes "virtual grounding" With virtual reference, the EMF sensor can be installed in any type of pipeline without grounding rings or electrodes. The converter's input amplifier evaluates the fluid's electrical potential at the measuring electrodes and a patented method creates an offsetting voltage to eliminate the induced electrical noise. This voltage is used as the reference potential for flow signal processing.

This method has several advantages: For one, no additional fluid grounding devices are necessary. This should not be underestimated; faulty grounding is the most common cause of error for an operating EMF. The elimination of grounding rings and the simpler installation of the EMFs results in lower overall costs. Unlike the use of grounding electrodes or rings, there is no risk of electrolytic destruction when there are potential differences in the system. Stray currents cannot flow from the product through grounding paths. Ungrounded use is also possible where voltage and current are applied to the pipes for electrolytic or galvanic treatment.

Virtual reference is available for sensor diameters above ¼ inch and for fluid conductivity at or above 200 µS/cm.

VIRTUAL REFERENCE APPLICATION

Krohne patented this method for the virtual referencing of EMFs in 1998 and is the only manufacturer using this method in its flow

meters. The following example illustrates an application in which virtually grounded EMFs are proven in practice.

Andritz, a technology company based in Austria, uses Krohne Optiflux 4300 in sizes of DN10 to 300 (3/8- to 12-in.) EMFs with virtual reference. The instruments are used in acid treatment processes such as stainless steel pickling, for example. Here, the flow of mixed acids, consisting of hydrofluoric acid, nitric acid and water, is measured. The process operates at 90°C (194°F) and a pressure of 3 bars (43 psi), with the acid flowing at a velocity of 1.5 m/s (5 ft/s).

Helmut Platzer, automation engineer at Andritz, summarizes some of the benefits: "Without this virtual reference, grounding rings would have to be used. As these rings must be made of different materials for different media, it would be easy to confuse them during installation. Hence, there will most likely be problems as the chemical resistance is uncertain. At the same time, these grounding rings can be very expensive — so not needing them results in a significant cost reduction."

Switching from a built-in reference electrode to a virtual electrode was justified due to the easy technical feasibility. Andritz uses small sized pipes where a reference electrode can't be mounted.

"The principle of virtual reference was performing very well right from the first instrument. There aren't even problems on difficult applications such as the mixing two acids with different temperatures right before the EMF," says Platzer. The use of Optiflux EMFs with virtual reference means considerably simplified work for Andritz when installing the devices and, in many areas it saves cost while minimizing leak potential.

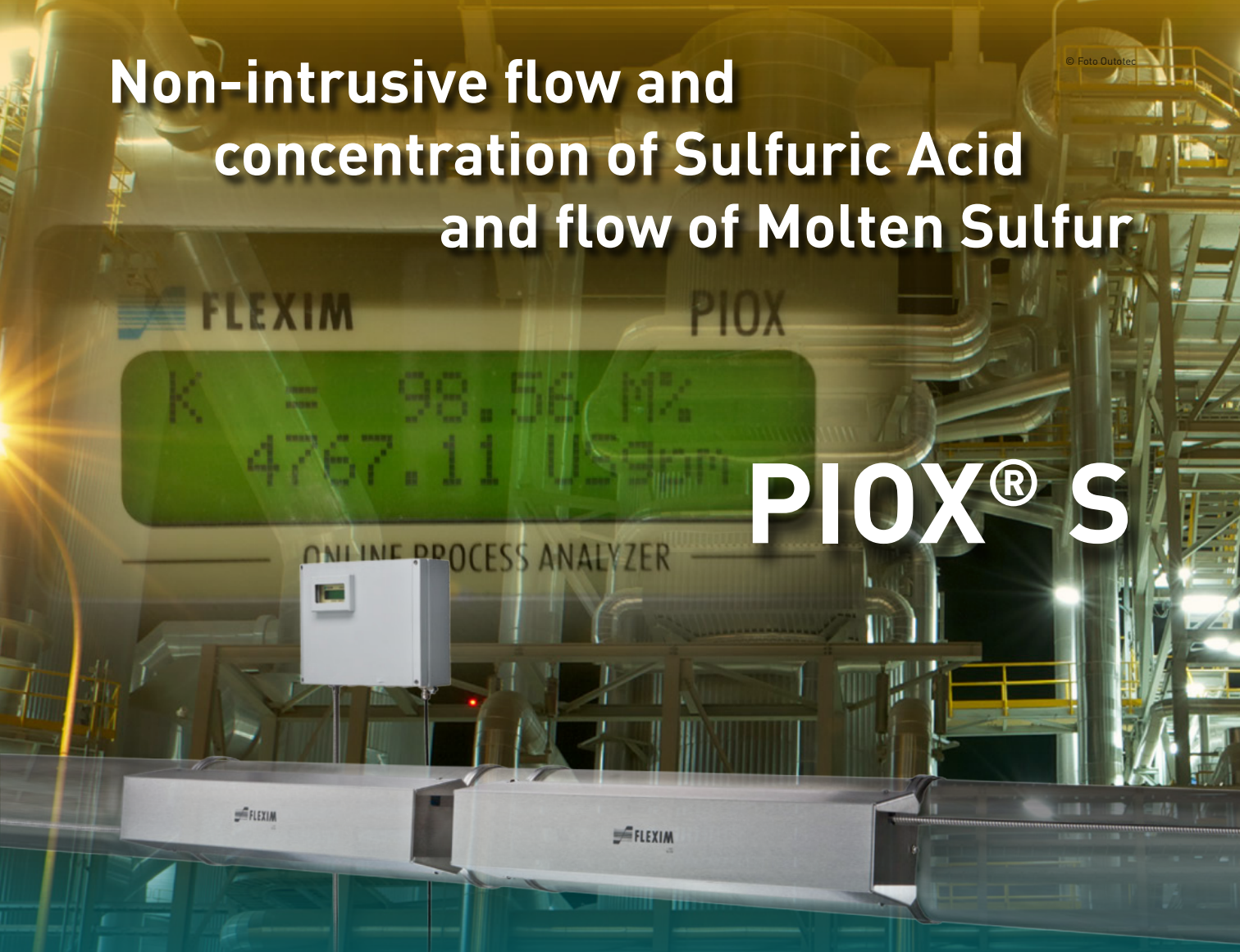
As shown in this example, the EMFs with virtual reference perform reliably even in harsh conditions. When the conditions mentioned regarding the diameter and conductivity of the product are fulfilled, the EMFs can be installed in all systems where classical grounding is a challenge.

VIRTUAL REFERENCE FOR DESALINATION

Krohne also has deployed the virtual reference option on a large number of EMFs installed in desalination plants. The special grounding ring or electrode materials needed for seawater were not required thus reducing the capital outlay and improving long term performance in galvanically protected pipes.

JOE INCONTRI is director of marketing for KROHNE, Inc. He can be reached at j.incontri@krohne.com.

Non-intrusive flow and concentration of Sulfuric Acid and flow of Molten Sulfur



PIOX® S

- No piping and valving
- 100% clamp-on
- No media contact - No risk of leaks
- No process Shut-Downs for installation
- No bypass needed
- For hazardous area locations (FM approved)
- Monitor your Total Sulfur Consumption
- Increase your Plant Up-Time
- Balance your Processes

PIOX® S - the evolution of flow and concentration measurement in sulphuric acid production.

PIOX® S already convinced many North American and some of the largest sulfuric acid plants in the world for use in their process control tasks.

FLEXIM

www.piox-s.com

www.flexim.com

Contact us for a free trial measurement!

Oil Recycling Company Presses On

Pipe press helps speed installation and reduce costs at new oil recycling facility

By Kristen White, Viega

Sustainability businesses are booming in Ohio. From energy to oil, companies are making their mark in the renewable resources industry. One such company is Valicor, who recycles oil, light bulbs, batteries, oily wastewater, plastic, cardboard, paper, ballasts, electronics, inks and more.

Every year, some of the largest companies in North America — including Honda, Ford and Harley Davidson — rely on Valicor to treat over 200 million gallons of wastewater. Most wastewater is treated at one of Valicor's eight centralized waste treatment (CWT) facilities located in Ohio, Alabama, Missouri and West Virginia (Figure 1).

Valicor also helps customers treat wastewater streams in-line with manufacturing processes by designing, building and servicing industrial oil recovery solutions. One of the people

OIL RECYCLING PROCESS
Figure 1. Valicor uses its eight waste treatment facilities to recycle oil and wastewater.

PIPE INSTALLATION
Figure 2. Thousands of feet of pipe, with a variety of flanges, tees and 90-degree elbows, were installed over the course of four months.

responsible for overseeing new builds and remodels for Valicor is Steve Hayes, project manager for Valicor. Valicor asked Hayes to work on a new oil recycling facility in Middletown, Ohio.

In 2016, Valicor recovered more than 36 million gallons of oil. That's a lot of oil for one company to process in one year. Even with multiple facilities in the mix, Hayes knew he needed to look for a solution that would speed up the building process.

The process fluids Valicor uses to process the oil have varying pH levels, so finding a product that could withstand those changes was important.

"I had been looking for something that could withstand the full spectrum of pH levels and was reading on the Internet, and that's how I found out about Viega," Hayes said.

"When we process fluids to clean them up it can be from a 1 pH to a 10, so we always use the 316 stainless and that will withstand the difference in pH levels," he explained. "It also has to be able to withstand temperatures of 180°F, so that's why we don't use plastic."

The best option for Vali-

"I would say we probably cut our [installation] time in half."

— Steve Hayes, project manager for Valicor

cor was to choose Viega's ProPress for 316 stainless steel. Thousands of feet of pipe, with a variety of flanges, tees and 90-degree elbows, were installed over the course of four months (Figure 2). Out of that, Hayes said they spent half as much time pressing as they did welding.

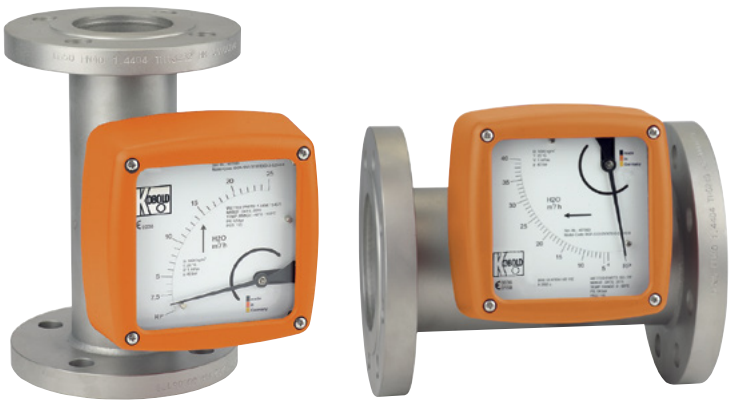
STAINLESS STEEL PIPE FITTINGS
Figure 3. Viega's ProPress for 316 stainless steel cut pipe installation time in half at Valicor.

"We used Viega ProPress in sizes ranging from two to four inches and it's really pretty easy to install," Hayes said. "I would say we probably cut our time in half."

According to the Viega sales representative for that region, this was one of the larger Viega jobs in the area. Although the rep's support of the project wasn't needed much, Hayes said he knows Viega will be there if he needs them "He was great. I got his card and he told me I could call him anytime day or night. I haven't had to call him yet, but I might sometime just to see if he was serious," Hayes joked. "But that's how more companies should be. If you have something you should stand behind it." ■

KRISTEN WHITE is content marketing editor at Viega. She can be reached at kristen.white@viega.us.

KOBOLD



RUGGED, RELIABLE, RESISTANT

BGN-P / BGF-P

PTFE-LINED ARMORED VARIABLE AREA FLOWMETERS

- Ideal for Difficult Operating Conditions
- Measuring Tubes: PTFE-Lined Stainless Steel
- Direct Reading Scales Calibrated for Media Viscosity, Density, Operating Pressure and Temperature
- BGN-P Ranges: 0.022...0.22 GPM to 24.2...242 GPM
- BGF-P Ranges: 0.044...0.44 GPM to 26.4...264 GPM Line Sizes: BGN-P up to 4", BGF-P up to 3"
- Connections: 150/300 ANSI Flanges
- Analog Output, HART®, Profibus®-PA, Foundation Fieldbus®, Totalizers
- Max. Temp: 257 °F, Max. Pressure: 230 PSIG
- Stainless Steel or Aluminum Housings
- Percent, Range, or Dual Scales
- Inductive Limit Switches, Micro-Switches, and NAMUR Switches
- Liquid Accuracy: ± 2% of Full Scale

HART COMMUNICATION FOUNDATION

Fieldbus

PROFIBUS

SIL

View Our Full Line of Innovative Instrumentation at www.koboldusa.com, or Call 1-800-998-1020

Flow | Level | Pressure | Temp

ADDITIONAL RESOURCES

EHANDBOOKS

Check out our vast library of past eHandbooks that offer a wealth of information on a single topic, aimed at providing best practices, key trends, developments and successful applications to help make your facilities as efficient, safe, environmentally friendly and economically competitive as possible.

UPCOMING AND ON DEMAND WEBINARS

Tap into expert knowledge. Chemical Processing editors and industry experts delve into hot topics challenging the chemical processing industry today while providing insights and practical guidance. Each of these free webinars feature a live Q&A session and lasts 60 minutes.

WHITE PAPERS

Check out our library of white papers covering myriad topics and offering valuable insight into products and solutions important to chemical processing professionals. From automation to fluid handling, separations technologies and utilities, this white paper library has it all.

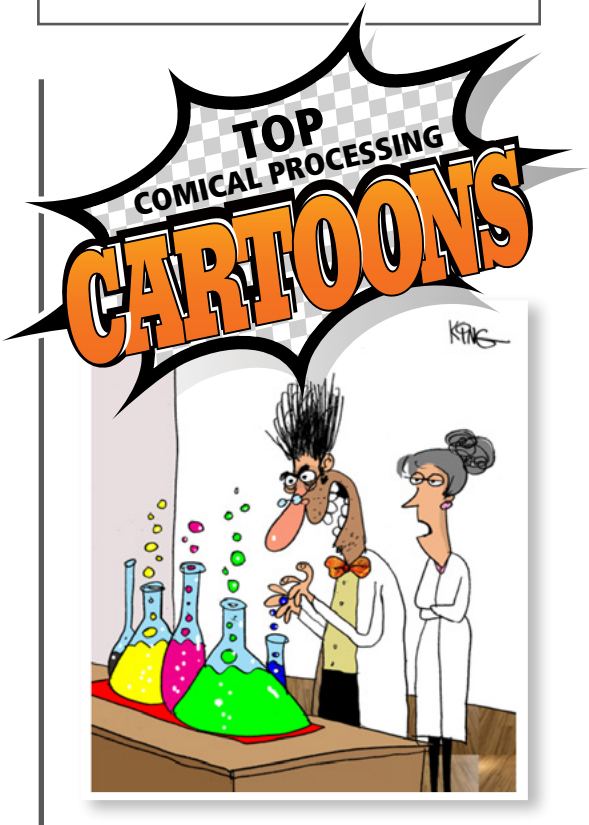
MINUTE CLINIC

Chemical Processing's Minute Clinic podcast series is designed to tackle one critical issue at a time — giving you hard-hitting information in just minutes.

ASK THE EXPERTS

Have a question on a technical issue that needs to be addressed? Visit our Ask the Experts forum. Covering topics from combustion to steam systems, our roster of leading subject matter experts, as well as other forum members, can help you tackle plant issues.

JOIN US ON SOCIAL MEDIA!



Visit the lighter side, featuring drawings by award-winning cartoonist Jerry King. Click on an image and you will arrive at a page with the winning caption and all submissions for that particular cartoon.