CHEMICAL PROCESSING

Achieve Better Flow

Start
Meeting and exceeding industry standards with every installation

For more than 115 years, Viega has been the global leader in pipe joining technology. On land or at sea, our press fitting systems can be joined without soldering, making us the clear choice for new and existing piping applications.

With three choices in sealing elements, Viega systems can be used in gas, compressed air, potable water, flammable fluids or hydronic applications. Viega’s press technology is available in multiple materials, and connections can be made in less than seven seconds, saving up to 60% on installation. Find peace of mind on the job with Viega products that include the Smart Connect® feature, allowing installers to easily identify unpressed connections during pressure testing.

For more information, call 800-976-9819 or visit www.viega.us
# Table of Contents

**Watch Out for Two-Phase Flow**  
7  
Process performance can suffer dramatically when a liquid flashes unexpectedly

**Nix Nozzle Nuisances**  
10  
Avoid flow problems by considering the impact of inlet losses

**Case Study: Speed Pipe Installation**  
13  
Pipe-joining system eliminates need to weld or thread connections

---

## Flow Meters Increase On-Site Efficiency

Series of flow meters measures five variables with one instrument

**THE NEXT-GENERATION** iSeries vortex mass flow meters, InnovaMass 240i and 241i, are designed for precise flow energy management in steam, compressed air, natural gas and water applications. Powered by Raptor II OS, a robust operating system, the device measures five process variables with one instrument, offering end users greater flow measurement precision to reduce energy costs and increase productivity.

The flow meter features flow energy calculations for AGA8 natural gas, steam enthalpy, thermal energy/BTU; a Raptor II OS microprocessor that’s 10x faster to run robust software applications; and FloPro software application that improves point-velocity accuracy for insertion version. A Raptor II OS Flow Engine and MassBalance sensor technology extend the range down to Reynolds numbers well below 5,000. Easy-to-use field diagnostics, validation, and adjustment through onboard Smart Interface Portal (SIP) increase efficiency in the field.

The SIP software allows end-users quick access to field validation and meter configuration. Access ValidCal Diagnostics through the SIP or meter LCD display to automatically check the meter’s firmware and hardware and report faults to the factory for immediate repair. MeterTuning from the SIP or local display allows field adjustments for the low flow cut off and vortex coefficient Ck. Through the SIP, InnovaMass’ firmware can also be updated or repaired in-situ (in-the field), saving time and money.

---

Sierra Instruments • 800-866-0200 • www.sierrainstruments.com

From Sierra’s beginning over forty years ago, Founder Dr. John G. Olin was driven by his vision to design the world’s most accurate thermal mass flow meter. Two revolutionary technologies, QuadraTherm® and qTherm®, made his vision a reality.

QuadraTherm Sensor
This revolutionary new four-sensor design isolates forced convection (the critical variable for measuring gas mass flow rate) by neutralizing unwanted heat-transfer components, like sensor stem conduction, one of the major causes of false flow reading inaccuracies.

qTherm Brain
qTherm is a proprietary algorithm set that uses QuadraTherm sensor inputs to solve the First Law of Thermodynamics (Heat Energy In = Heat Energy Out) for thermal dispersion technology. Accuracy never before possible is the remarkable result!

Accuracy: +/- 0.5% of Reading
Multivariable: Mass flow rate, temperature & pressure
Revolutionary QuadraTherm® four-sensor design
DrySense™ no-drift sensor with lifetime warranty
qTherm™ living, learning “Brain” manages all inputs
Dial-A-Pipe™: Change pipe size
Dial-A-Gas™: Change gas type
qMix™ Gas Mixing Software: Create and upload new gas compositions in the field
qTherm Gas Library: 18 gases & mixtures (growing & improving)
Digital Communications Solutions: HART, Profibus DP, MODBUS, RTU, Foundation Fieldbus
Approvals: ATEX, IECEx, CE, cFMus

sierrainstruments.com
North America / 800.866.0200
Europe / +31 72 5071400
Asia-Pacific / +8621 5879 8521/22
Ad Index

Viega 2
www.viega.us

Sierra Instruments 4
www.sierrainstruments.com

Krohne 6
us.krohne.com

Lubrizol 9
www.corzancpvc.com

TRICOR Coriolis Technology 12
www.tricorflow.com
Do you need flow measurement with online density compensation?
Available now with OPTISWIRL 4200 from KROHNE!

Featuring integrated pressure and temperature sensors, the new OPTISWIRL 4200 vortex flowmeter provides online density compensation for all types of gas and steam. The OPTISWIRL 4200 even masters fluctuating operating conditions with effortless precision and helps to significantly reduce installation costs. It’s the smart choice for auxiliary and supply processes in a broad range of applications.

Developed for use in continuous volume flow measurements in safety-related applications, the OPTISWIRL 4200 is in full compliance with the IEC 61508 SIL2 safety standard. Units can be easily switched from non-SIL mode to SIL mode without the need to call out a service technician.

Minimising downtime is critical for your business. That’s why the OPTISWIRL 4200 provides redundant data storage of all calibration and configuration data in the display memory and the electronics module – transferring data to replacement modules is a snap.

When efficiency and flexibility matter most, the OPTISWIRL 4200 is the definitive choice.

- Technology driven by KROHNE.

Email: info@krohne.com    Tel: 800-FLOWING    Web: us.krohne.com
Watch Out for Two-Phase Flow

Process performance can suffer dramatically when a liquid flashes unexpectedly

By Andrew Sloley, Contributing Editor

**TWO-PHASE FLOW** can present challenges. The greatest problems occur when two-phase flow shows up unexpectedly. Elevation changes with equilibrium liquids can lead to such situations. We’ll look at a case where uphill piping caused major difficulties.

Proper pressure balance can make a liquid flow uphill in a pipe. However, starting with an equilibrium liquid can cause flashing when elevation changes. The increased volume boosts pressure drop. The resulting flow may either be much lower than expected or cause severe mechanical problems from surging. Proper consideration of intermediate conditions in fluid flow can avoid these problems.

At the site in question, a drum supplies refrigerant to multiple exchangers. The plant added a new service to the existing system (Figure 1a). After commissioning, the new service received only 75% of the required duty.

The design of the new service, like that of many refrigerant exchangers, called for a fully flooded condition on the refrigerant side. Field investigation showed that the level control valve on the refrigerant supply always is fully open. The exchanger doesn’t have independent level taps. A neutron backscatter device monitors refrigerant flow.
and indicated that roughly one-third of the tube bundle actually is above the refrigerant level.

Field investigation continued with a series of pressure readings along the flow loop to the new exchanger. Based on flow rates, the pressure drop in the refrigerant return loop was as expected. However, the pressure drop in the refrigerant supply loop was much higher than expected. The immediate thought was that heat gain through the piping was causing vaporization in the refrigerant line. Inspection showed the new line was well insulated and not likely to have significant heat gain.

While inspecting the line to check the condition of its insulation, the engineer noticed that the new service was at a markedly higher elevation than most of the existing refrigerant exchangers. Review of the design of the new piping showed that elevation changes weren’t considered in system hydraulics. The supply drum provided enough head to overcome friction losses but not substantial elevation changes. The height change caused significant vaporization. Even a small percent of vaporization dramatically increased pressure drop.

To get refrigerant to the new exchanger required either changing a sizable amount of piping or keeping the liquid at a pressure above its bubble point. The latter called for either pumping the refrigerant to a higher pressure or cooling it to a lower temperature.

Adding rotating, reciprocating or other machinery with moving parts, even small units, costs a surprisingly large amount after final installation has been completed. So, instead, the plant installed a small subcooler. A slipstream of refrigerant provides cooling for the stream going to the new exchanger. The net result is that refrigerant going there enters the supply line at 30 psi over the saturation pressure. The subcooling eliminates the pressure drop problem. Desired capacity was immediately achieved.

Other situations when two-phase flow can unexpectedly occur include: heat gain into cold systems; flashing across orifice plates or other head meters; mixing dissimilar streams; retrograde condensation through the two-phase region; continuing reactions in lines; internal flows in physically large equipment; and leaks. To a large extent, process analysis can identify all these potential problems, except leaks, before they are created. Remember to check intermediate flow conditions — these may be important — as well as piping inlet and outlet conditions. If you don’t check for them, you risk unpleasant surprises. Proper analysis beforehand can head off such problems.

Leaks tend to be more of a troubleshooting issue. Don’t forget to think about the impact of low-pressure fluid leaking into high-pressure systems. Consider, e.g., leaks into a vacuum system, process/process leaks, or process/utility leaks. Even small amounts of extra volume can create major pressure drop problems.

ANDREW SLOLEY, Contributing Editor
ASloley@putman.net
Introducing Corzan® HP, creating piping systems with better

CORROSION RESISTANCE
AND HIGH-TEMPERATURE PERFORMANCE
for transmission of CHEMICAL FLUIDS,
all made with LUBRIZOL TECHNOLOGY
TO GIVE YOU MORE INSIDE.™

Corzan HP is a high-pressure, high-temperature, high-impact-strength piping system engineered with Lubrizol’s specially formulated chlorinated polyvinyl chloride (CPVC) compounds that meet the ASTM D1784 certification for 24448 cell class. It’s the only pipe that meets ASTM F441 material classification 4120-06, with a pressure rating 25% higher than standard CPVC at 180°F (82°C).

Choose Corzan HP for Chemical Processing, Semiconductor & Electronics, Water Treatment, Industrial Manufacturing, Mining and Power Generation applications.

See how the details on the inside make all the difference on the outside. Call a piping systems consultant at 1.216.447.7397 or visit corzancpvc.com to learn more.
PLANTS OFTEN must move fluid from a large vessel into a pipe. For pressurized systems this rarely creates problems. However, for systems in which static head sets the available head even the small inlet losses from nozzles can restrict flow. Therefore, it’s important to understand flow resistance coefficients ($k$) in your system to check low head flows.

The classic nozzle entrance shape is a flush connection with a $k = 0.5$. But other shapes abound, e.g.: angled flush, projecting, flush cone, flush bellmouth and projecting bellmouth (Figure 1), as well as screens and perforated plates. When limited by head available from gravity these complex pipe entrances can dramatically change system capacity. The $k$ of these shapes are hard to find. So, here’s a selection of the more useful.

Pressure drop through an outlet pipe is evaluated in height of the flowing fluid ($h$). The standard equation is:

$$ h = k \left( \frac{v^2}{2g} \right) $$

where $v$ is the velocity of the fluid and $g$ is acceleration due to gravity.

Converting this to a dimensional equation gives the two forms commonly used:

$$ h = 522 \left( \frac{kg^2/d^4}{d^4} \right) = 0.00259 \left( \frac{Q^2/d^4}{d^4} \right) $$

where $q$ is flow in ft.$^3$/sec., $Q$ is flow in gal./min., $d$ is diameter in in. and $h$ is height in ft.

If you know $k$, you can easily calculate head losses for piping entrances.

I. E. Idelchik’s “Handbook of Hydraulic Resistance” provides $k$ values. Unfortunately, working with that book poses challenges. The text was complex to begin with — garbled translation coupled with missing subscripts in some equations and use of the wrong symbols in others require the reader to take extreme care.

It’s not 100% clear from the text but Idelchik seems to have force-fitted his curves to meet theoretical boundary-limit conditions for known special flow cases. This leads to some apparent contradictions in $k$ values that aren’t immediately obvious in the published $k$ graphs. Despite these problems Idelchik is still the best one-stop reference for $k$. (Checking published values in supposedly authoritative sources deserves a future column.)

For angled flush entrances:

$$ k = 0.5 + 0.3 \cos \theta + 0.2 \cos^2 \theta $$

Figure 2 graphs $k$ for bellmouth or rounded entrances. The boundary limit for a bellmouth entrance is a radius-to-diameter (R/D) ratio of zero, which equates to a sharp-edge entrance. “Crane Technical Paper 410 — Flow of Fluids through Valves, Fittings and Pipe” only provides a value ($k = 0.78$) for a sharp-edge entrance for a freestanding or projected entrance. In comparison, Idelchik gives the entire curve but with a 1.0 value for a sharp-edge entrance. Its $k$ values are higher for the freestanding entrance because they’ve been force-fit to boundary conditions of an infinitely thin pipe. Crane’s

---

**COMMON ENTRANCE SHAPES**

![Diagram of pipe entrances](image-url)

Figure 1. Each of these types of entrance provide a different flow resistance.

---

Nix Nozzle Nuisances

Avoid flow problems by considering the impact of inlet losses

By Andrew Sloley, Contributing Editor

---

**COMMON ENTRANCE SHAPES**

- Flush
- Projecting
- Bellmouth (rounded)
- Angled flush
- Flush cone (countersunk)
- Projecting bellmouth

---

**COMMON ENTRANCE SHAPES**

- Flush
- Projecting
- Bellmouth (rounded)
- Angled flush
- Flush cone (countersunk)
- Projecting bellmouth

Figure 1. Each of these types of entrance provide a different flow resistance.
values stem from experiments with relatively thick commercial pipe; the thick pipe entrance reduces the effect of inlet losses. The Crane tables also show an unexpectedly low $k$ when $R/D = 0.02$.

Figure 3 shows $k$ for flush conical or countersunk entrances. Here, you must specify both the cone’s angle and length/diameter ($L/D$) ratio. Flow resistance approaches a minimum between 40° and 60° depending on the relative depth of the cone.

Another common entrance uses a perforated plate (generally with sharp-edge holes) as a screen or anti-vortex device. To evaluate this we must know the fraction open area of the plate compared to the downstream pipe:

$$f = \frac{\text{flow area open in plate}}{\text{flow area open in downstream pipe}}$$

For turbulent flow:

$$k \approx \left(\frac{1.707 - f}{f}\right)^2$$

For rounded entrances into plates we must know the fraction open area ratio plus the radius of curvature of the opening and the opening diameter. From the radius and opening diameter we calculate a resistance loss correction factor $k'$:

$$k' = 0.03 + 0.47 \times 10^{-7.7(R/D)_{open}}$$

$$k = \left[1 + (k')^{0.5} - f\right]^2$$

We can estimate $k$ for cast shapes with noncircular or complex openings using the equations here by substituting hydraulic diameter ($D_{hydraulic}$) for diameter:

$$D_{hydraulic} = \frac{4 \times \text{flow area of opening}}{\text{wetted perimeter of opening}}$$

These curves and equations enable estimating losses for many of the more common shapes of piping entrances. For extremely complex flow configurations as well as laminar and transition flow regimes, go to the standard references to find what you need. But double-check the assumptions behind the values and understand how they apply to your situation.

ANDREW SLOLEY, Contributing Editor
ASloley@putman.net
The highly skilled engineering professionals at TRICOR Coriolis Technology have vast experience within the Chemical and Petrochemical industries and understand their unique demands. We have successfully applied flow measurement solutions to a wide variety of chemical applications.
VIP PLUMBING of Cleveland, Ohio, used press fittings to make water- and air-tight connections when installing a stainless system at Royal Chemical’s Macedonia, Ohio plant. VIP installed approximately 3,000 ft of 316 stainless steel pipe for use with chemical processing equipment.

VIP Plumbing specializes in residential and commercial service, new construction and remodeling throughout northeastern Ohio. The ability to easily press stainless steel opened the door for VIP to install new chemical transport lines for Royal Chemical. The company had worked with Royal Chemical to install plumbing for a new bathroom as well as water and gas lines at its Twinsburg location. When Royal Chemical wanted to replace existing process piping for chemical transport between its storage tanks and mixing tanks...
with stainless steel pipe, as well as add additional processing lines to its facility, VIP was able to offer quick, flameless installation using Viega ProPress.

Viega ProPress uses press fittings to make water- and air-tight connections. The system comprises stainless steel pipe, valves and fittings in sizes up to 4 in. It takes less than seven seconds to make a pressed connection, compared to more than an hour for some threaded and welded connections. Its Smart Connect feature helps installers easily identify unpressed connections.

“If Royal Chemical had wanted welded stainless steel, we wouldn’t have been the ones to do the installation. VIP Plumbing would not have even submitted a bid on the project if it had to be welded,” says Paul Episcopo, president of VIP Plumbing. “By using pressing to join the piping, the labor was cut at least in half. Royal Chemical didn’t have to shut down its operation and it was easier to get the pressing tool into smaller spaces where welding would not have been an option.”

The process line installation at Royal Chemical was the first project where VIP used Viega ProPress for stainless. The company previously had rented the pressing tool for various copper tubing installation projects to increase time savings or use in environments where water couldn’t be shut off for long periods of time.

“For this project, purchasing the pressing tool was a good investment for us and it’s also opened up our capabilities to include work on stainless steel systems,” explains Episcopo. “It’s convenient now that we have the tool — we have done other projects with pressing and we can use the same tool on multiple kinds of pipe.”

MATERIALS MATTER
VIP installed 2-in. to 2½-in. Viega 316 stainless steel lines for five mixing tanks and used approximately 130 fittings including tees, 90º and 45º fittings, couplings and 12 three-piece ball valves which are a new addition to the Viega ProPress for stainless product line. The valve features a three-piece construction with a full-port ball that can be removed for repair and maintenance.
without removing the press ends from the system. It also features an ISO pad for actuation.

“The original valve that we installed on the nitric acid line didn’t work correctly. Our Viega rep introduced us to the new three-piece ball valve that worked perfectly,” says Rocky Iammarino, the plumber who performed the work at Royal Chemical. “The three-piece ball valve was perfect for the corrosive chemicals, like the nitric acid. It can be locked and if any of them ever need to be fixed, the valves won’t have to be taken out.”

For the installation, VIP used a combination of fittings with the standard EPDM sealing element and the FKM sealing element for increased resistance against corrosive chemicals.

“Because Royal Chemical transports caustic chemical through the lines, we knew that they needed fittings with highly chemical-resistant sealing elements,” says Episcopo. “We worked with our Viega representative to make sure that the sealing elements were approved for use with the specific chemicals used on those lines.”

**FLAMELESS INSTALLATION**

Viega ProPress for stainless proved to be ideal for Royal Chemical’s needs due to the chemical resistance of the materials, as well as the safety and time-savings the flameless aspect of the system offered.

“By using Viega ProPress on this project, we kept Royal Chemical from having to shut down for long periods of time and avoided the need for hot permits that would have been required if the pipe had been installed with welding,” notes Episcopo.

During the first phase of the installation, Iammarino installed support brackets and five new lines to replace the original welded stainless steel lines as well as sagging PVC lines. In other phases of the project, approximately 12 lines were installed.

“With all of the supports in place, installing the stainless steel piping is extremely quick,” says Iammarino. “We could work around everyone at Royal Chemical and they were able to keep their facility running during the entire process. With the caustic chemicals, a welding installation was out of the question, and threading the pipe would have been much less flexible and more time-consuming.”

“Royal Chemical looked into a variety of different materials for their lines. Since the plant is composed of primarily stainless steel for its other systems, it was an easy decision to select 316-grade stainless pipe and fittings for the new lines,” Iammarino adds. “Even though it was our first time using Viega ProPress on stainless pipe, we had used it on other pipe material and knew how it worked.”

“The security against leaks that the system provides is extremely important with chemical transporting,” notes Iammarino. “I was alerted to a fitting that hadn’t been pressed yet with the Smart Connect feature that ensures no fitting is left unpressed, and after that fitting was pressed, we pressure tested the lines and there weren’t any leaks.”

The flameless pipe-joining system allowed VIP to not only complete the installation of the chemical transport lines but also established the company’s capabilities in the industrial market. “We are looking forward to getting involved with additional commercial and industrial projects that involve stainless and may not have been in our repertoire prior to our experience with Viega ProPress for stainless,” says Episcopo.

**VIEGA**, headquartered in Wichita, Kan., manufactures press technology that provides an alternative to traditional pipe joining methods such as soldering, welding and grooving. For more information, visit www.Viega.us or call 800-976-9819.
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.

NEW!! 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.