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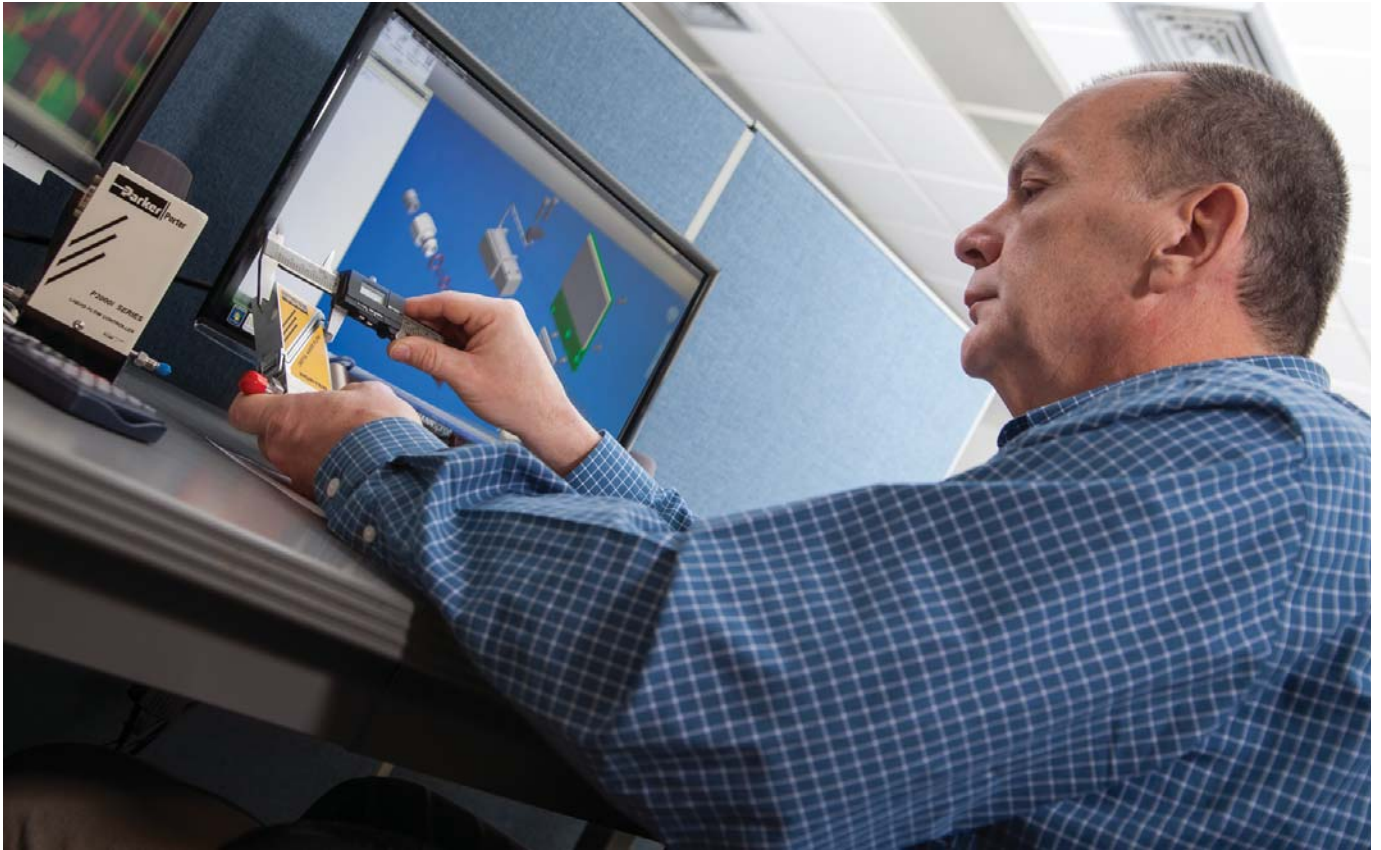
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Leaks Don't Lie

Treat them as calls for action against the underlying problem

Dirk Willard, Contributing Editor

ON AUGUST 6, 2012, firemen and a work crew were investigating a leak in the light-gas-oil side-cut line of the crude atmospheric tower at Chevron's Richmond, Calif., refinery. An operator suggested shutting down the unit for repairs but was over-ruled. Firemen were instructed to pinpoint the leak under the insulation, which they proceeded to do — with a fire hook. The firemen smashed a hole in the thinned pipe and then blasted the pipe with cold water to break loose the insulation. The pipe burst and 640°F oil spilled and ignited. This accident nearly incinerated a fireman and has cost Chevron \$12 million so far.

Chevron had been replacing this corroded line and others connected to it but, obviously, not fast enough. Leaks were evident. During an inspection after the accident, Cal-OSHA found nine clamps to stop leaks.

Unfortunately, Chevron isn't alone in such misfortune. On December 7, 2009, a high-pressure reactor at NDK Crystal's plant in Belvedere, Ill., ruptured, killing a truck driver 650 feet away. In this case, nearby reactors had leaked before — in 2003, 2006 and 2009. NDK was convinced that a protective coating formed inside the 8-in.-thick reactor walls protected these vessels.

NDK never qualified this "theory" or inspected vessel interiors. Neither the state of Illinois nor the company's insurer challenged the theory, though. Illinois granted NDK a waiver from complying with the ASME code: the thickness of the wall made inspection and fabrication problematic. The Belvedere site remains closed.

What links these two accidents together? Leaks provided adequate warning that something was very wrong.

So, what's the best way to approach a leak? Obviously, the first line of defense is vigorous inspection. Chevron, to its credit, did that; NDK did not. (The fatal 2010 fire and explosion at Tesoro's Anacortes, Wash., refinery also was linked to poor inspection.)

Second, always evaluate whether to continue operating once a leak is detected. Who at Chevron and NDK decided to keep the units running?

Chevron had more warning, but slapping a clamp on a leak is a common practice at most refineries. Chevron had used clamps before, building confidence that this approach was sound. (For more on the perils of stopgap repairs, see "Fear Ad Hoc Fixes," www.ChemicalProcessing.com/articles/2013/operational-safety-and-maintenance-fear-ad-hoc-fixes/.) Let's

RELATED CONTENT ON CHEMICALPROCESSING.COM

"Prepare to Clamp Down Tighter on Leaks," www.ChemicalProcessing.com/articles/2010/098/

"Plants Look Harder for Leaks," www.ChemicalProcessing.com/articles/2012/plants-look-harder-for-leaks/

hope regulators and operating companies are doing some soul-searching to understand the risks of temporary solutions.

Now, imagine you were the maintenance manager at Richmond assigned to seal the leak. Assume you can't shut down the refinery, because that's normally the case. Perhaps operations can do something such as cut the tower rate, or cool or heat the tower temporarily to reduce the side draw. Ask. Work out a cooperative plan.

Start by reviewing the work done recently and in the past on the pipe and vessel: look at the inspection reports, marked-up isometrics, hazard and operability studies, etc. Talk with the inspectors and include them in the preparation. *You now know this pipe is fragile.* The process and instrumentation drawings don't show isolation valves; besides, even if they did, you don't know when these valves were operated last.

So, you have a delicate pipe and must remove the insulation to inspect it. How will you pull the insulation off without endangering your crew? Involve them in developing the job plan. What is your backup plan if the leak gets worse? How will the crew egress? What other equipment will be affected? What will you do if

insulation removal doesn't expose the leak point? Who is qualified to do the job? Consider how the crew's actions could affect their safety and the success of job. Finish the draft and review it. Ask the inspectors to look over the job plan, too.

Ideally, you should have written a template for this plan months ahead as a maintenance standard operating procedure. This is a common practice at Dow Chemical and elsewhere.

Before work begins, brief your crew: no heroics, and no deviations from the plan. Establish a rapport with operations — what are they expected to do to support the crew? If the job goes sour, what will operations do to shut down the tower and reduce pipe flow? Do they have enough people to quickly isolate the tower? Are refinery safety and communications people in the loop on the work? Are nearby units aware of and prepared for what's going on? What about contractors and others off the refinery radio network? ●

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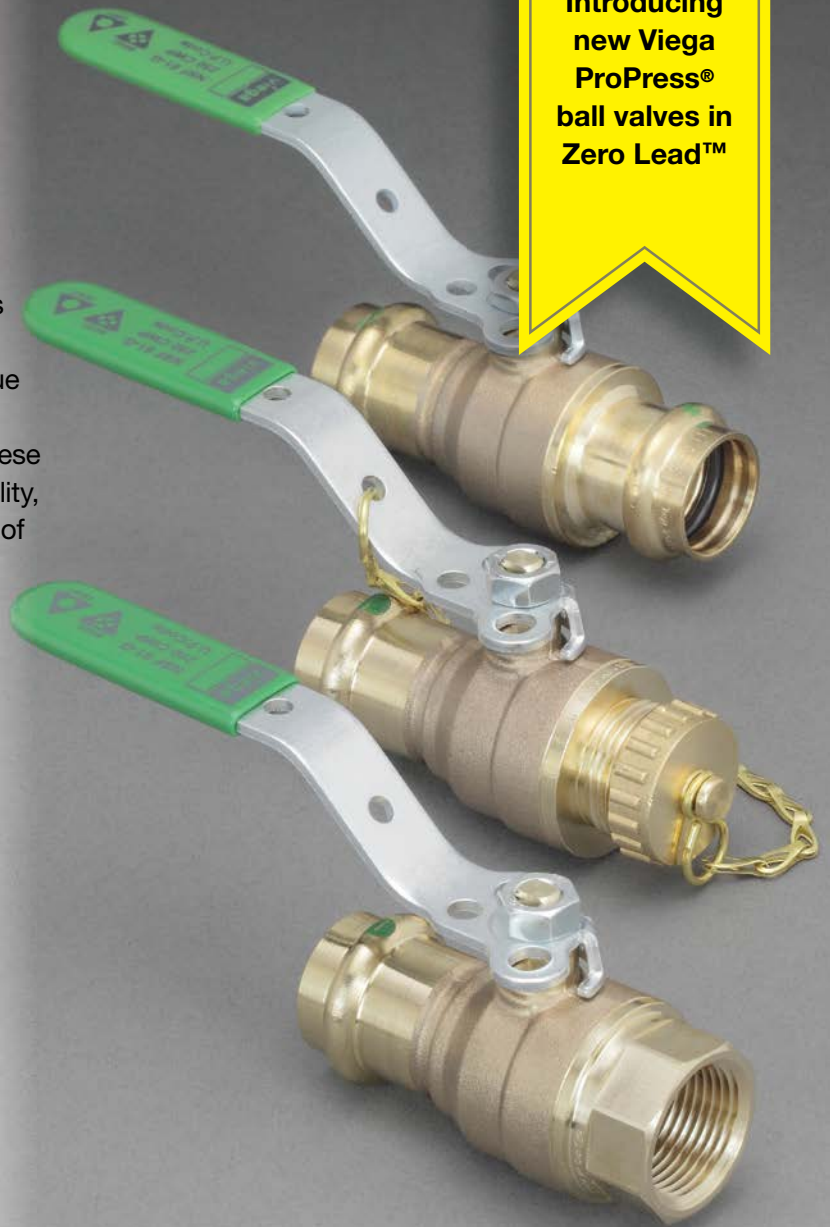
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Consider VFDs for Centrifugal Pumps

Such drives may provide energy savings and avoid operating problems

Andrew Sloley, Contributing Editor

VARIABLE FREQUENCY drives (VFDs) offer a useful control option for the motors of many types of reciprocating and centrifugal equipment. For instance, VFDs can deal with centrifugal-pump suction recirculation problems; running at lower speed can help reduce damage and operating difficulties.

To understand how to apply VFDs effectively, you must know the characteristics of the system and the equipment. So, let's look at a general procedure that can serve as a good starting point for evaluating specific cases — realizing, of course, that it can't cover every possibility.

To evaluate a VFD application, we need the following:

- system information on pressure drop versus flow;
- pump performance curves for the existing impeller;
- pump performance curves for the maximum impeller; and
- pump inlet eye dimensions.

Ideally, the performance curves should include pump head, pump efficiency and net positive suction head (NPSH) required versus flow rate. Pump heads and efficiencies at various speeds are useful.

Often, only incomplete information is available. So, you may need to extrapolate to fill in missing information.

ANALYSIS PROCEDURE

A VFD evaluation involves multiple steps, each looking at a specific item. Below are the basic steps. (Some cases won't need every step while others may require additional ones. The information available and needed as well as the number of cases to be evaluated determine what must be done.)

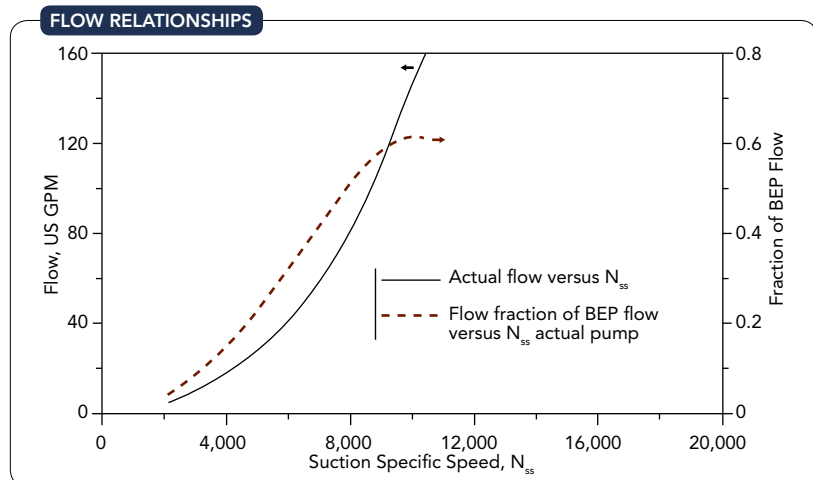


Figure 1. Combined plot shows both flow and fraction of BEP flow versus N_{ss} .

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1. Define the system curve.
2. Examine the pump curve for the existing impeller at fixed speed.
3. Plot a flow rate versus speed curve for the installed impeller.
4. Determine the best efficiency point (BEP) flow rate versus speed for the maximum impeller.
5. Examine NPSH versus flow rate.
6. Plot flow rate versus suction specific speed (N_{ss}) for using the VFD to control.
7. Define operating fraction of BEP flow versus N_{ss} .
8. Compare the operating flow fraction versus N_{ss} to good practice.
9. Evaluate pump suction energy to determine the NPSH margin.
10. Check power available.
11. If the results of operating flow fraction versus N_{ss} and pump suction energy evaluation are unacceptable, assess alternative solutions.

The system curve plots the required differential head versus flow rate. The system curve includes both static head requirements for elevation and pressure change and dynamic head requirements from pressure drop.

Most often, only a pump curve at a single fixed speed is available. This typically is a nominal 1,800 or 3,600 rpm for 60-Hz motors and 1,500 or 3,000 rpm for 50-Hz motors. (In such cases, you can generate curves for other speeds by using the affinity law: pump head varies as the square of pump speed.)

Plotting the pump curve for fixed-speed operation shows how much savings a VFD might provide. If the pump curve and system curve don't intersect at a higher flow than for the given pump, the pump is too small. A VFD can help here by raising the pump's operating speed to a higher-than-standard rpm so the pump curve and system curve intersect at the desired

flow rate — but at the expense of higher power requirements.

Evaluating pump performance requires a BEP versus speed curve for the maximum diameter impeller. BEP flow typically varies linearly with both pump diameter and speed.

An NPSH curve also is necessary. If only available at one point, NPSH can be extrapolated based on the flow rate squared. However, this will underestimate NPSH requirements at low flow rates. So, it's always best to use an actual NPSH curve.

Based on pump speed versus flow, plot a curve of N_{ss} versus flow [1]. Also plot a curve of fraction of BEP flow (at that speed for the maximum impeller). Figure 1 shows an example plot of flow versus N_{ss} and fraction of BEP flow versus N_{ss} .

Good practice suggests a maximum N_{ss} of roughly 8,500 for a turndown of 50% on a centrifugal pump. Consult ANSI/HI 9.6.3-2012 [2], which is the most commonly accepted good-practice definition for flow flexibility on centrifugal pumps, to get an idea of the reasonable operating range of a specific pump with a VFD.

Suction energy [3] is another, more recent, measure of suitability for running at low liquid rates. So, compare the pump performance to suction energy values. The lower the suction energy, the more likely the pump will operate successfully.

The pump efficiency curve varies with the percent of BEP. Use the efficiency curve to compute power. At very low turndowns, savings might not be as great as expected. When operating above standard speeds, power consumption may be very high.

If the VFD analysis shows problems may persist, consider changing either the process or adding additional features to protect the pump from low flow [4]. ●

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Mining Operations Unearth Big Benefits

Piping made of high-performance plastic provides unmatched performance and longevity

By Jorge Solorio, Lubrizol Advanced Materials, Inc.

CORROSION IS the enemy of metallic piping systems everywhere. The slow deterioration of pipes by water, chemicals or other fluids spells the inevitable end of metallic systems across the globe. It's not a question of "will my pipes fail?" or even "when will my pipes fail?" but "how soon will my pipes fail?"

Due to this prevalence of corrosion, it's not uncommon for industrial facility maintenance managers to have low expectations of their piping systems. Lifespan expectancies of metallic pipes range anywhere from just a few months to around five years —necessitating frequent maintenance and replacement, driving up costs and becoming a major operational hassle.

The solution is Corzan HP industrial piping systems. Engineered with Lubrizol CPVC (chlorinated polyvinyl chloride) compounds, Corzan HP provides a high-pressure, high-impact, high-temperature-strength piping system. Lubrizol's CPVC technology gives Corzan unmatched corrosion resistance that eliminates pitting and scaling while providing superior life-cycle benefits.

Harsh chemicals flow through Corzan HP piping inside Grupo Mexico's copper refinery metallurgical complex in Nacozari Sonora, Mexico, on a daily basis. The plant's operations include copper refining and wire rod, precious metals and effluents treatments, and Luis Antonio Nuñez Acosta, the complex's maintenance manager, reports the performance of piping throughout has exceeded expectations.

"The refinery processes the anodic copper by electrolysis," says Acosta. "We have operated with Corzan HP industrial systems without interruption for 15 years, with mechanical integrity and free of maintenance."

BEYOND EXPECTATIONS

Mitigating corrosion and minimizing maintenance was a critical concern when Grupo Mexico built the Nacozari Sonora complex in 1997, which factored heavily into the

decision to utilize Corzan HP. The use of CPVC pipes was considered from the design phase of the plant in order to convey the highly corrosive fluids with a very low pH and at a temperature in the region of 65°C, all of which are important factors in the selection of material.

PVC was ruled out because of operational deficiencies such as rapid aging and a temperature limit of 60°C. The option of metallic piping — both carbon steel and stainless steel — also was ruled out because of the chemical and galvanic corrosion generated in the electrolytic process. It became clear to the plant's designers that Corzan HP industrial systems was the most viable option due to its high performance in conveying liquid chemicals at temperatures above 90°C, as well as its anti-corrosive qualities.

As the facility was built (Figure 1), Corzan HP was used for 80% of the piping installed throughout the plant, ranging from 1 in. to 16 in. The remaining 20% of the plant's system is made up of polypropylene piping. However, Grupo Mexico has made plans to convert that remaining 20% to Corzan HP because of consistent leaks that have plagued the thermo-fused joints of the polypropylene portion of the system. Polypropylene is a softer material than CPVC, and in applications like this one, trouble can arise due to the material's expansion and contraction. Additionally, as polypropylene gets hotter (whether due to sun exposure or heat conditions inside the facility in which the material is being used), its joints run into trouble. By comparison, Corzan HP pipe and fittings are joined using a solvent welding process, which molecularly fuses the material, ensuring that leaks won't be a problem in the long run.

Corzan HP has also helped the facility stack up additional operational savings with its constant surface roughness of C=150 on the Hazen-Williams equation, providing lower friction loss than commonly used pipes.

"The advantages we found in using Corzan HP are due to the fact that the maintenance is virtually nil," Acosta notes.

GRUPO MEXICO SITE



Figure 1. Corzan HP Industrial Piping Systems was used for 80% of the piping installed throughout Grupo Mexico's Nacozari Sonora complex. The company has made plans to convert the remaining 20% to Corzan HP.

“Other factors that contribute are the significant reduction in scaling (a roughness coefficient of the smooth inner surface) and resistance to internal and external corrosion.”

And so far, it's been 15 maintenance-free years.

CORROSION AND OTHER PROBLEMS

While corrosion issues may be the most prominent failing of metallic pipes inside a chemical processing plant, mining facility, etc., it's not the only issue that can hurt the performance of an industrial piping system.

Rigidity of pipes in these sorts of facilities is necessary and important in the reduction of sediment buildup, which can drastically shorten lifespans. Metallic pipes are prone to sagging, causing increased sediment to rest at the bottom, hindering performance and necessitating early replacement. The rigidity in Corzan HP pipes helps to alleviate these issues.


Preventing leaks is a high priority for mining and chemical facilities as well. Miguel Avalos, engineer, general and

projects director ATIC Asesoría Técnica y Control, S.A. de C.V. for First Majestic Silver Corp.'s Del Toro plant in Zacatecas, Mexico, said that the goal of a Corzan HP installation at the facility was to achieve zero leaks, zero scaling and zero sediment buildup.

Reagents aren't cheap; leak prevention presents a significant cost savings for the company. The plant installed more than 7 km of Corzan HP CPVC piping and estimates that the investment would be recovered in less than one year.

This cost savings can be attributed to a number of factors. The maintenance of a metal reagent piping system is expensive — and pipes must be frequently replaced in their entirety due to their susceptibility to corrosion and scaling. Acids and other corrosive chemicals cause constant wear and tear on the system, which requires high maintenance costs in order to prevent leaks.

“We installed the Corzan HP CPVC system to convey reagents, including the sodium cyanide used in extracting gold and silver,” Avalos says. The extraction process is con-



ducted by introducing cyanide to the ore, which causes the gold to oxidize and dissolve in the presence of air and water.

This process, called cyanidation, can be highly corrosive to metallic pipes. The process consists of slowly passing a diluted cyanide solution through piles of crushed, ground or agglomerated gold ore. This must be done on an impervious surface that allows the collection of the resulting gold-cyanide solution. As the gold- and silver-enriched impervious surface reaches the impervious floor, it is poured into a storage pond, which then feeds a piping circuit that precipitates the gold and silver from the cyanide.

All of this is handled without issue by the plant's Corzan HP piping system. In addition to the sodium cyanide, the facility's Corzan HP pipes are used to convey copper sulphate as an activating agent in the concentration by the floating of lead foam, zinc, cobalt and gold. All that makes for a tough job that Corzan HP pipe and fittings can handle for years.

Corzan HP also enables automatic reagent dosing at the Del Toro plant, helping to create additional efficiencies. Due to its high mechanical properties, Avalos will be installing

14-in. diameter Corzan HP pipes in the mine's laboratories. In conjunction with the system's valves, the pipes are used in the scrubber for the extraction of hot gases and dust at temperatures greater than 70°C.

"We decided to replace the metal pipes with Corzan HP because it offers numerous benefits," says Avalos. "High resistance to the ambient temperature and UV light, it never corrodes and prevents scaling and sedimentation. We have already installed almost 7 km of Corzan HP pipes in diameters ranging from 1 in. to 14 in."

COST BENEFITS OF HIGH-PERFORMANCE CPVC PIPES

Maintenance managers and other decision makers have two costs to consider when deciding on a new chemical piping system, no matter the application: cost of maintenance and cost of installation.

When replacing a piping system, losses attributable to a facility's downtime during a retrofit or installation can be far more expensive than the installation itself. For this reason, it's of great importance to limit the amount of downtime in order to keep production at a maximum.

THE LUBRIZOL ADVANTAGE

Corzan HP is a member of the Corzan Industrial Systems family of CPVC pipe, fittings and process components that were originally engineered to simplify system design, maintenance and repair with one reliable material solution. Whether 24-in. diameter piping systems, pump/filtration systems or air pollution control systems are needed, Lubrizol can provide a proven, corrosion-resistant solution for the entire process.

Choosing Corzan HP also means receiving access to the full support of the Lubrizol CPVC team, from design to installation. Lubrizol offers its expertise on CPVC piping solutions throughout all segments of the industrial market, from mining and refining applications, to power generation, gas extraction and beyond.

A piping solution from Lubrizol CPVC also means access to the FBCTM System Compatible Program. Chemical compatibility of Corzan HP with ancillary products — meaning those products the pipes may come in contact with during an installation or otherwise — is important in order to ensure optimal, long-term performance of the system. This isn't to be confused with a list of products that Corzan HP can safely transport — this information can be found on our manufacturing partners' websites.

Corzan HP pipe and fittings are available globally through Lubrizol's list of manufacturers. Visit corzancpvc.com to find a manufacturer or to locate a Lubrizol CPVC piping systems consultant who can assist with specifications and design recommendations. To speak to a piping systems consultant, call 216-447-7397.

PIPING SYSTEM



Figure 2. Corzan HP Industrial Piping Systems, engineered with Lubrizol CPVC's superior compounds, provides high-pressure, high-impact, high-temperature-strength systems, offering a corrosion-resistant technology that eliminates pitting and scaling while providing superior lifecycle benefits.

Metallic systems are not the easiest to work with, particularly when dealing with large pipes as is so often the case inside industrial facilities. For instance, suitable iron pipes for such a facility would require heavy lifting equipment like forklifts and dollies, which drives up costs if renting such equipment is necessary. Additional safety concerns begin to come into play when dealing with heavy machinery.

Metallic piping also requires fusing and welding of joints and pipes, and doing so for pipes of this size requires a lot of energy, further driving up costs. It's a slower, often cumbersome process that can add up to more downtime than anticipated while an installation is performed.

Lubrizol's Corzan HP, by contrast, does away with each of these concerns, helping drive down costs both in the short and long term. Corzan HP pipes are much lighter weight than comparative metallic pipes, meaning

they don't require special equipment to lift and install. As well, the two-step solvent welding process used to join Corzan HP pipe and fittings offers a cleaner, safer and faster installation process without the need for hot welding equipment.

As such, the speed and ease of a Corzan HP installation can greatly reduce operational losses that can result from lengthy facility downtime; once a Corzan HP installation is established, as much as 300 m of Corzan HP piping can be installed within a single day. Combined with the lower price point of Corzan HP CPVC materials, it all adds up to significant cost savings for a facility.

PERFORMANCE BENEFITS

Corzan HP Schedule 40/80 piping system made from fully pressure-rated materials gives engineers and facility managers a solution that exceeds expectations. Other benefits include:

- Corzan HP piping meets ASTM F441 material classification 4120-06, with a pressure rating 25% higher than standard CPVC at 180°F (82°C).
- Drop impact strength is up to three times higher than that of standard CPVC piping material.
- Corzan HP offers the highest heat deflection temperature (HDT) of any CPVC piping compound.
- Fitting materials have improved creep resistance and an ability to withstand long-term, high-temperature hydrostatic pressure.

LOCATION CONCERNS AND ADDITIONAL USES

While Corzan HP excels as a piping choice for the transmission of chemical fluids, it can also become a part of an industrial facility's total piping system (Figure 2).

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Consider Ceramic in Electromagnetic Flow Meters

Material used for measuring tubes offers high performance, longevity and a host of other benefits

By Ralf Haut, KROHNE

THE CHEMICAL industry relies on tried and true measuring technology to measure the volume flow of electrically conductive media: well over 3 million electromagnetic flow meters (EMFs) are in use all over the world. The demands placed on devices when used in chemical plants are much more stringent than those in the water industry, for example. In addition to the electronics, the design and measuring tube material are crucial when it comes to determining whether the EMF is suitable for use in chemical processes. The following properties of the measuring tube material are particularly relevant:

- Corrosion resistance to aggressive media
- Form stability
- High resistance to thermal shock
- Vacuum resistance, form stability with under/over pressure
- Resistance to abrasion
- Diffusion tight
- Leakage immunity

Even if not normally the case, sometimes with certain tasks such as measuring nitric acid, several of these properties are required at the same time. The PFA and PTFE linings typically used for EMFs aren't adequate in this case as they are not acceptably resistant to diffusion. For this reason, EMFs with measuring tubes and measuring tube liners made out of ceramic materials have been available for decades for this type of application.

A variety of different device types exist featuring ceramic measuring tubes: in addition to their use with acids and bases in chemistry, the flowmeters used in bottling machines in the beverage industry are almost exclusively equipped with ceramic measuring tubes. This is where another of the ceramic properties comes into play: extraordinary low surface roughness means good hygienic suitability.

The OPTIFLUX process measuring devices used in the chemical industry (Fig 1) feature measuring tubes made of oxide ceramics with a base of aluminium oxide or zirconium oxide. The electrodes are mainly platinum but depending on the application, other materials (Hastelloy, titanium, tantalum) also are used. Variants without wetted metal electrodes, so-called capacitive EMFs, also are available.

MAKING CERAMIC MEASURING TUBES

To understand the special properties of ceramic measuring tubes, you must first understand their design: a measuring tube is a single rotation-symmetric piece from face to face. It's manufactured as if it were a cast piece. This holds true for nominal sizes up to DN 300, sizes above that are lined with ceramic plates.

The starting material for the measuring tubes is an aluminium oxide or zirconium oxide powder featuring special mineral quality (Figure 2) which



Figure 1. The OPTIFLUX 5300 electromagnetic flowmeter from KROHNE features a measuring tube made of oxide ceramic (flange version).



Figure 2. Oxide ceramic powder is poured into a mold.

is pressed into a cylindrical shape (Figure 3) under pressures $>1,000$ bars. The cylinder is then machined into the shape of the measuring tube (Figure 4). It is sintered above $1,700^{\circ}$ in an elaborate process (Figure 5), during which the ceramic shrinks to the pre-calculated size. The hardened measuring tube is now the desired basic size and any continued processing such as machining the outside diameter, end faces and inlet taper is only possible with a diamond-tipped tool (Figure 6). Following quality control (Figure 7), it is ready to be installed into the EMF.

This brief description doesn't come close to reflecting the extreme amount of effort and years of experience and expertise necessary to manufacture high-performance ceramic. For example, KROHNE and its partner FRIATEC, collaborated to create the fused-in-place cermet electrode.

When inserting the electrode containing precious metal into the ceramic measuring tube, the goal is to unite two different materials with as little gap as possible and in such a way as to ensure that temperature shocks cannot cause any damage. A leak at this position could mean a safety concern and increased costs, depending on the measured product. To begin with, two holes are made in the ceramic raw form and the electrode is inserted like a massive pin, the ceramic then shrinks during sintering. The result is a leak-free compound of two materials.

A cermet electrode is a composite component made up of ceramic and metal, in this case platinum. Two of these electrodes

are already integrated into each green body. During the fusing process, the ceramic portion of the electrode bonds to the surrounding ceramic while the platinum is embedded as regards thermal and electrical properties. The result is a homogenous ceramic fusion zone with no potential gap (i.e. no leakage point) between the measuring tube and the electrode (Figure 8, Figure 9).

CERAMIC BENEFITS

The long-term stability (i.e. accuracy over many measuring cycles) of the measuring tube is achieved thanks to the form stability of the ceramic. Plastic coatings, on the other hand, are malleable, exhibit vacuum sensitivity and are not as resistant to wear.

KROHNE, in cooperation with the PTB (National Metrology Institute), investigated the long-term stability of the ceramic devices. The devices tested for the food and beverage industry were subjected to a total of 600 simulated Cleaning-In-Process (CIP) cleaning cycles, one after the other, followed by another 60 sterilizations with hot steam (SIP) (extreme temperature change). That corresponds to a device life of approximately 4–5 years in average operation. The tests showed that the ceramic devices had an average deviation of only 0.05% compared to the tests in



Figure 3. The powder is placed under high pressure and compressed into a cylinder.

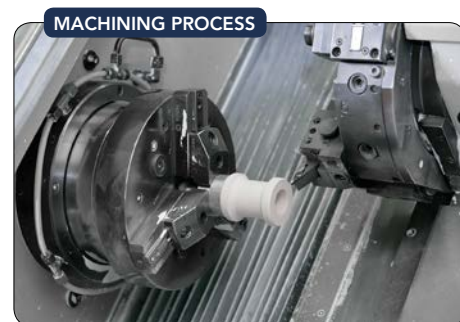


Figure 4. The shape of the measuring tube is mechanically carved out.



Figure 5. The ceramic is sintered in the kiln.



Figure 6. A diamond-tipped tool is used to machine the outside diameter, end faces and inlet taper to complete the final finishing touches of the hardened measuring tube.



Figure 7. A helium leak test is performed to ensure quality control of the finished measuring tube.

new condition and also featured stable repeatability at various flow rates (Figure 10). The average deviation compared to the new condition was 8 times higher with measuring tubes with plastic liners.

High geometric stability is one of the reasons the OP-TIFLUX 5300 is often used as a reference device/Master-Meter in flow measurement plants in national institutions, measurement offices, nationally recognized testing bodies and notified bodies. Sterilization with hot steam (SIP) exceeds the temperature changes of over 100 K commonly found in processes in the chemical industry. Thanks to the adaptation of the thermal expansion properties of the measuring tube and cermet electrode, the material bond easily withstands this stress.

Burst tests proved that the measuring tubes with just 2mm wall thickness could withstand over 600 bar, and those with 4mm more than 1,000 bar internal pressure — a result of the consistent application of the finite element method (FEM). Checking the break lines after the break tests showed no specific nucleation site for the formation of cracks, neither near the fused-in-place electrodes nor in the rest of the measuring tube.

Additional material testing procedures included tensile and compression tests as well as corrosion tests. Tensile load tests showed strength close to the value of steel. The high compression strength is one of the properties of this ceramic. This helps ensure the measuring tubes are robust enough to withstand the mechanical loads placed on them during installation and operation in chemical plants.

An application example illustrates the abrasion resistance of the virtually diamond hard ceramic: the Dutch company NEDMAG Industries Mining and Manufacturing B.V. is Europe's leading manufacturer of ultrapure synthetic magnesite (DBM: dead burned

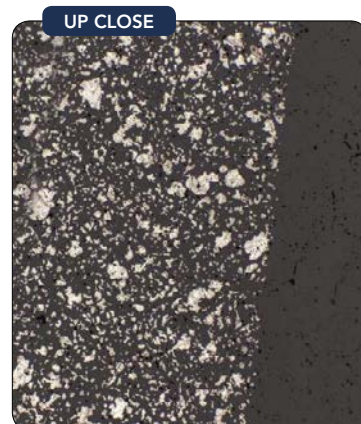


Figure 8. In the electron microscope shot of fused-in-place cermet electrode (left), the light points (platinum) are the only way to recognize that there are two different materials.

CERAMIC MEASURING TUBE



Figure 9. In this external shot of the finished ceramic measuring tube prior to installation into the EMF, the black dot represents the fused-in-place cermet electrode.

TEST RESULTS

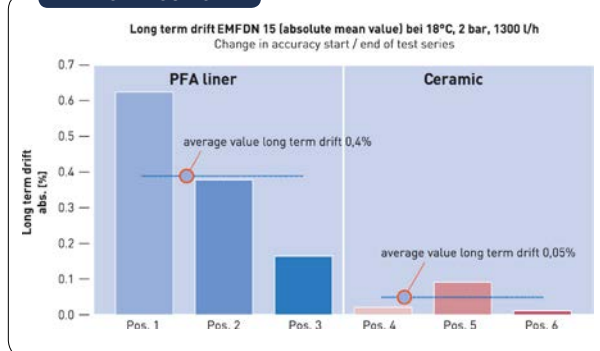


Figure 10. Test series shows accuracy changes and average deviation from new condition.

HEAVY DUTY APPLICATIONS



Figure 11. The OPTIFLUX 5300 measures highly abrasive magnesium hydroxide sludge.

magnesia). DBM is mainly used in fire-proof applications such as liners in blast furnaces. When producing DBM, magnesium hydroxide sludge with 53 % solid content also is created. To further process this extremely abrasive sludge, its flow rate must first be measured. Because a PFA or PTFE liner would fail in a short time in this case, the company opted to use an OPTIFLUX 5300 with ceramic measuring tube (Figure 11).

To combat corrosion, the requirements of the chemical industry are extremely high. To equip standard processes and new production routes, KROHNE offers a comprehensive list of corrosion resistant EMF devices using ceramic measuring tubes.

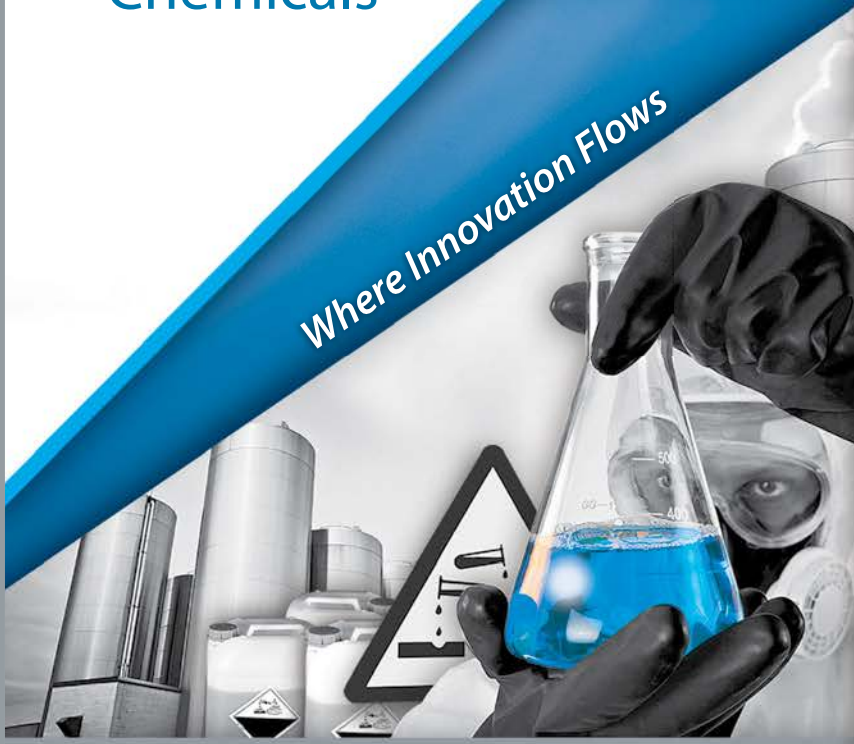
To further increase process reliability, EMFs with ceramic measuring tubes are available in both sandwich (DN25...100) and flange versions (DN15...300). The flange version of the OPTIFLUX 5300 uses shorter screws (less expansion upon heating), to offer a high degree of fire resistance to ensure dangerous products don't leak at connection points if a fire occurs. The flange version also features a Pressure Equipment Directive 97/23/EC with individual approval for zirconium oxide (FRIALIT FZM) and has design approval for DN 15 to DN 300 from TÜV Rheinland. This enables the chemical operator to use a ceramic EMF per the Pressure Equipment Directive. This means the operator doesn't have to run his own test and can reduce costs.

Electromagnetic flowmeters with ceramic measuring tubes boast high performance, particularly in the chemical industry. Thanks to the unique combination of material properties such as surface hardness and finish, mechanical strength, resistance to corrosion and temperature change, the operator benefits from the extreme accuracy and long-term stability as well as vacuum and diffusion resistance. The chemical industry's own requirements concerning process reliability, longevity and durability are well met. ●

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