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Flow eHandbook

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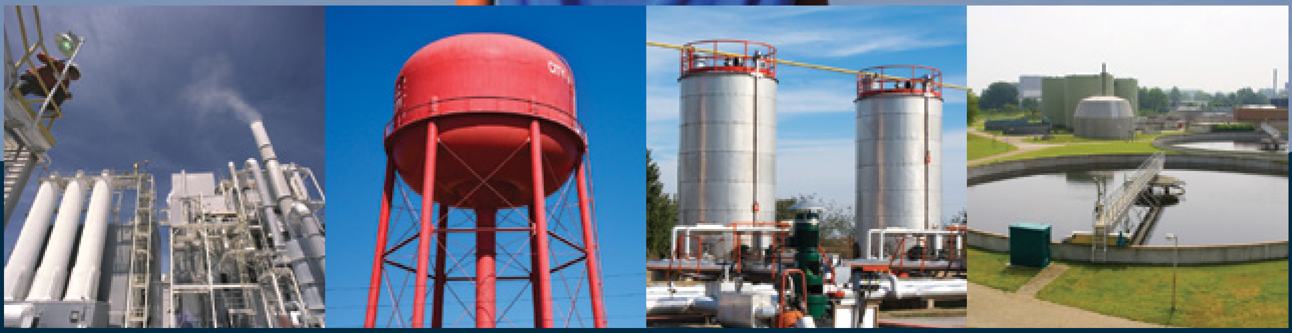

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Defeat a Double Whammy

Select the proper pump to handle low suction head and cavitation

By Andrew Sloley, Contributing Editor

AS SOON as I looked at the knockout drum, a sinking feeling took over. The plant was mystified by level trips from a compressor interstage knockout drum on a compressor system and complained the liquid pump on the drum "never seemed to work right." An inspection quickly led to identifying one problem with the system. The liquid drum was so close to the ground the clearance gave barely enough room for the isolation valve and an elbow to squeeze in under the vessel. The liquid height in the vessel was about 2 ft above the pump inlet nozzle.

The system originally was designed for a steady-state operation where the interstage pressure could force the liquids out with no pump. To save money, the interstage drums were placed a minimum height above grade. The bottom flanges were barely 18 in. above the concrete slab.

Intermittent loads in the compressor system caused fluctuating drum pressures. Some times the pressure in the drum dropped below the pressure of the liquid collection system for the interstage liquids. So, the plant decided to add a pump to ensure liquid could get out of the system. However, the net positive suction head available for the pump was extremely low — less than 18 in.

The plant was most familiar and comfortable with centrifugal pumps and installed one to remove the liquids. The pump suffered continual problems and often stopped working. On some occasions no liquid at all seemed to get to the pump. The pump had lost prime.

The changing system loads on the compressor were one reason for this. When the compressor gas load decreased, the interstage pressure dropped. Liquid in the drum started to vaporize when the pressure fell, causing the feed to the pump to contain vapor bubbles.

So, the pump had to contend with two issues. First, very little head was available to get liquid into the pump. Second, vapor intermittently formed in the liquid.

The final analysis was that the pump must meet three requirements: operate at low suction head available; tolerate some vapor in the feed; and be robust enough to survive (with reasonable reliability) some amount of damage due to vapor bubble collapse.

This led us to investigate four types of positive-displacement pumps: reciprocating; regenerative turbine; vane; and gear.

We quickly vetoed reciprocating pumps for two reasons. First, acceleration effects on the net positive inlet pressure (NPIP) would be large. Second, vapor in the pump would cause problems with pistons and valves.

Regenerative turbine, vane and gear pumps had a huge advantage for this service. They all could provide smooth flow characteristics, and allowed flow control by using variable frequency motors to regulate capacity.

CAPACITY CURVE

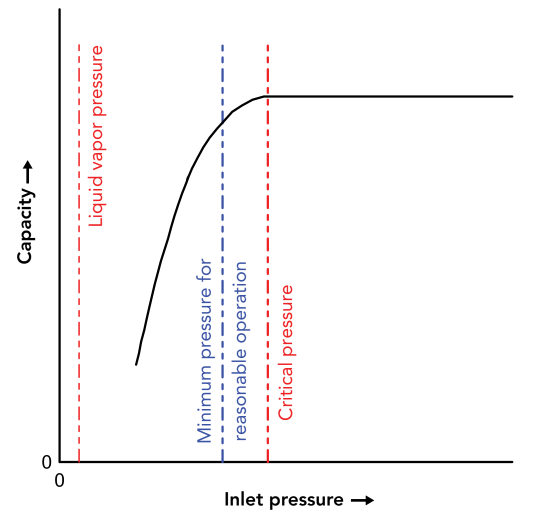

Figure 1. A gear pump's capacity falls sharply when vaporization starts in the feed.

We opted for a gear pump. One key reason was that a physically robust unit could be found for a reasonable price. (For details on such pumps, see: "Get Up to Speed on Gear Pumps," http://goo.gl/pucWme.)

Gear pumps also are self-priming. They can pull all the way down into a vacuum if required. They can tolerate bubbles in the feed. These benefits come with some costs, though. Figure 1 shows the typical shape of a gear pump's capacity/suction-pressure curve. As vaporization starts in the feed (suction pressure drops below NPIP), capacity drops. So, coping with varying system pressure requires changing operating speed to maintain the same capacity. A flow controller based on pump speed may need some tuning to handle unstable feed conditions.

In addition, pumping vapor remains a severe service. The most difficult operation is when the vapor bubbles in the feed collapse completely. The cavitation shock wave can create severe damage. Even though a gear pump is more damage resistant than a centrifugal unit, damage will occur. Fortunately, the much slower speed of the gear pump decreases the damage.

No pump can fully avoid problems at low suction heads. However, if you can't change the process, pick a pump that can reduce problems to a tolerable level.

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Pick The Proper Flow Meter

Consider a wide range of factors to determine the optimal choice

By Brian Kettner, Badger Meter

FLOW MEASUREMENT is a critical aspect of chemical processing. The effectiveness of operations depends upon accurate data on flow measurement, as does maintaining compliance with regulations. In addition, a greater emphasis on sustainability is driving more manufacturers to closely monitor the consumption of precious resources and the byproducts generated in the process. At some sites, another crucial concern is custody transfer, with increasing energy costs spurring the need for improved fiscal metering of high-value products.

So, in this article, we'll look at the key criteria in flow meter selection and go over some pointers for picking the most appropriate device.

COMMON CHOICES

Let's start by reviewing the most frequently used measurement technologies and their advantages and disadvantages:

Coriolis. These meters contain a vibrating tube in which a fluid flow causes changes in frequency, phase shift or amplitude. Circuitry in the devices then converts this signal into an output that's strictly proportional to the actual mass flow rate — in contrast to thermal mass flow meters, which depend upon the physical properties of the fluid.

One of the most important features of a Coriolis flow meter (Figure 1) is its ability to directly measure fluid mass with a very high degree of accuracy over a wide range of temperatures. Its unobstructed open-flow design is suitable for viscous non-conductive fluids that are difficult to measure with other technologies. With no internal moving parts, a Coriolis meter requires a minimum amount of attention once installed. However, such devices sometimes are considered too sophisticated, expensive or unwieldy for certain applications.

Differential pressure (DP). These meters measure the pressure differential across the meter and extract the square root. They have a primary element that causes a change in kinetic energy, creating DP in the pipe, and a secondary element that measures the DP and provides a signal or read-out converted to the actual flow value.

DP meters are versatile instruments that employ a proven well-understood measuring technology not requiring moving parts in the flow stream. Viscosity changes don't affect the devices greatly. However, they have a history of limited accuracy and turndown, as well as complex installation requirements.

Electromagnetic. Such meters employ Faraday's law of electromagnetic induction, whereby a conductor moving through a magnetic field induces

CORIOLIS METER

Figure 1. Such meters can directly measure mass flow with very high accuracy over a wide range of temperatures.

ELECTROMAGNETIC METER

Figure 2. These devices can monitor virtually any conductive fluid or slurry found at a plant.

voltage. The liquid acts as the conductor, with energized coils outside the flow tube creating the magnetic field. The produced voltage is directly proportional to the flow rate.

An electromagnetic meter (Figure 2) will measure virtually any conductive fluid or slurry, including process water and wastewater. The devices provide low pressure drop, high accuracy, large turndown ratio and excellent repeatability. The meters have no moving parts or flow obstructions, and are relatively unaffected by viscosity, temperature and pressure when correctly specified. The meters tend to be heavy in larger sizes and may be prohibitively expensive for some purposes.

Thermal mass. These meters utilize a heated sensing element isolated from the fluid flow path. The flow stream conducts heat away from the sensing element, with the rate directly proportional to the mass flow rate. The meter's electronics package provides a linear output directly proportional to mass flow.

Thermal mass meters have a relatively low purchase price. They are designed to work with clean gases of known heat capacity, as well as some low-pressure gases not dense enough for Coriolis meters to measure. The main disadvantage of thermal technology is low-to-medium accuracy, although suppliers have improved the capabilities of these meters in recent years.

Turbine. Such meters contain a freely suspended rotor whose vanes rotate at a rate proportional to flow velocity. A sensor/transmitter detects the rotational rate of the rotor; the faster the fluid moves, the more pulses that are generated. The transmitter processes the pulse signal to determine the flow of the fluid in either forward or reverse direction.

Turbine meters incorporate a time-tested measuring principle, and are known for high accuracy, wide turndown and repeatable measurements. They produce a high-resolution pulse-rate output signal proportional to fluid velocity and, hence, to volumetric flow rate. Turbine meters are limited to clean fluids only. Use of ceramic journal bearings largely has addressed bearing wear — a common concern with this type of device. As a mechanical meter, turbines require periodic recalibration and service.

Impeller. Often used in large-diameter water distribution systems, these devices insert a paddle wheel perpendicularly into a process stream. The number of rotations of the paddle wheel is directly proportional to the velocity of the process.

The advantages of impeller meters include direct volumetric flow measurement (often with visual indication), universal mounting, fast response with good repeatability, and relatively low cost. However, their performance suffers in applications with low fluid velocity; the meters also are sensitive to flow profile. They suit clean, low-viscosity media.

Ultrasonic. There are two types of ultrasonic meters: transit time and Doppler. Both will detect and measure bidirectional flow rates without invading the flow stream. They can handle all types of corrosive liquids as well as gases, and are insensitive to changes in temperature, viscosity,

Figure 3. Clamp-on version can prove valuable for troubleshooting a wide range of flow issues.

density or pressure. A clamp-on unit (Figure 3) is ideal for troubleshooting, diagnostics and leak detection.

Ultrasonic meters have no moving or wetted parts, suffer no pressure loss, offer a large turndown ratio, and provide maintenance-free operation — important advantages over conventional mechanical meters. However, the precision of these meters becomes much less dependable at low flow rates. Unknown internal piping variables can shift the flow signal and create inaccuracies.

Variable area. These meters are inferential measurement devices consisting of two main components: a tapered metering tube and a float that rides within the tube. The float position — a balance of upward flow and float weight — is a linear function of flow rate. Operators can take direct readings based on the float position within transparent glass and plastic tubes.

Simple, inexpensive and reliable, variable area meters are appropriate for many applications. However, they must be calibrated for viscous liquids and compressed gases. Furthermore, they offer limited turndown and relatively low accuracy.

Vortex. Such meters make use of a principle called the von Kármán effect, whereby flow will alternately generate vortices when passing by a bluff body (a piece of material with a broad flat front that extends vertically into the flow stream). Flow velocity is proportional to the frequency of the vortices. Flow rate is calculated by multiplying the area of the pipe by the velocity of the flow.

Vortex meters have no moving parts that are subject to wear and, thus, don't require regular maintenance. However, they only can measure clean liquids. The devices are particularly well suited for measuring gas emissions produced by wastewater. Vortex meters may introduce pressure drop due to their obstructions in the flow path.

Oval gear. These meters utilize a positive displacement (PD) design, whereby fluid enters the inlet port and then passes through the metering chamber before exiting through the outlet port. Inside the chamber, the fluid forces the internal gears to rotate. Each rotation of the gears displaces a specific volume of fluid. As

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the gears rotate, a magnet on each end of the gear passes a reed switch, which sends pulses that a microprocessor translates into a flow rate shown on an LED display.

The latest breed of oval gear meters directly measures actual volume. It features a wide flow range, minimal pressure drop and extended viscosity range. This design offers easy installation and high accuracy, and measures high-temperature, viscous and caustic liquids with simple calibration.

Nutating disc. Most commonly used in water metering applications, these devices have a disc attached to a sphere mounted inside a spherical chamber. As fluid flows through the chamber, the disc and sphere unit wobble or "nutate." This effect causes a pin, mounted on the sphere perpendicular to the disc, to rock. Each revolution of the pin indicates a fixed volume of liquid has passed. Meters with aluminum or bronze discs can monitor hot oil and chemicals.

Nutating disc meters have a reputation for high accuracy and repeatability. However, viscosities below their designated threshold adversely affect performance.

KEY SELECTION FACTORS

In a typical plant, fluid characteristics (number of phases, viscosity, turbidity, etc.), flow profile (laminar, transitional or turbulent), flow range and accuracy requirements all are important considerations in determining the right flow meter for a particular measurement task. Additional considerations such as mechanical restrictions and output-connectivity options may impact the choice.

For process operations, the key factors in meter selection include:

Process media. Whether the fluid is liquid, gas or multiphase influences the suitability of a particular device for the service. Different flow meters are designed to operate best with certain fluids and under specific operating conditions. That's why understanding the limitations of each style of instrument is important.

Measurement type. Do you need a mass or volumetric flow measurement? While volumetric readings are convertible into mass measurements given an accurate density, volumetric measuring devices like variable-area and turbine meters can't distinguish density-altering temperature or pressure changes. So, mass flow measurement would require additional sensors for these parameters and a flow computer to compensate for the variations in these process conditions. Thermal mass flow meters are virtually insensitive to variations in temperature or pressure.

Flow rate information. A crucial aspect of selection is determining if continuous or totalized flow rate data are needed. A typical continuous flow measurement system consists of a primary flow device, flow sensor, transmitter, flow recorder and totalizer.

Desired accuracy. The difference between on- and off-specification product often depends upon flow meter accuracy. This is specified in percentage of actual reading, calibrated span or full scale. It normally is stated at minimum, normal and maximum flow rates. You must clearly understand these requirements to get a meter with acceptable performance over its full range.

Application environment. A meter can face widely varying conditions in a plant. So, you must decide whether the low or high flow range is most important for a metering application; this information will help in sizing the correct instrument for the job. Pressure and temperature conditions are equally important process parameters. You also should consider pressure drop in flow measurement devices, especially with high-viscosity fluids. In addition, viscosity and density may fluctuate due to a physical or temperature change in the process fluid.

Fluid characteristics. You must pick a meter compatible with the fluid and operating conditions. Many plants handle abrasive or corrosive fluids that may move under aerated, pulsating, swirling or reverse-flow conditions. Thick and coarse materials can clog or damage internal meter components — hindering accuracy and resulting in frequent downtime and repair.

Installation requirements. Planning a flow meter installation starts with knowing the line size, pipe direction, material of construction and flange-pressure rating. You also must identify possible complications due to equipment accessibility, valves, regulators and available straight-pipe-run lengths. Nearly all flow meters require a run of straight pipe before and after their mounting location. Where this isn't possible, you can use a flow conditioner to isolate liquid flow disturbances from the flow meter while minimizing the pressure drop across the conditioner.

Power availability. Pneumatic instrumentation once was used in most applications in hazardous areas to obviate bringing in a power source that might cause an explosion. Today's installations normally call for intrinsically safe instruments; these rely on safety barriers that limit current to eliminate any potential spark. Another option is to employ fiber optics. Turbine flow meters offer an advantage in environments where a power source isn't available because they don't require external power to provide a local rate/total indicator display for a field application; the devices instead rely on a battery-powered indicator. Solar-powered systems also may make sense in remote areas without power.

Necessary approvals. Plants must comply with relevant standards and regulations for the use of flow measurement equipment in hazardous locations. These include: FM Class 1 Division 1, Groups A, B, C and D; and FM Class 1, Zone 1 AEx d (ia) ia/IIC/T3-T6. Standards such as the Measuring Instruments Directive in the European Union apply to fiscal- and custody-transfer metering for liquids and gases. In terms of environmental emissions, industrial flow meters must meet the Electromagnetic Compatibility Standards EN55011:1992 and EN61326-1:1997.

Output/Indication. You must decide whether measurement data are needed locally or remotely. For sending data for remote indication, the transmission can be analog, digital or shared. The choice of a digital communications protocol such as HART, Foundation Fieldbus or Modbus also figures into this decision. In a large plant, flow readings typically go to an automation system for use for process control and optimization.

OTHER IMPORTANT ISSUES

Higher accuracies and broader capabilities in flow meters cost more. So, determine what you actually need. Evaluate process conditions, including flow rates, pressure and temperature, and operating ranges to find a meter suited to the specific application. Sacrificing features for cost savings or opting for a lower-priced alternative that would be applied outside of its capabilities are false economies.

All meters are affected to some extent by the medium they are monitoring and the way they are installed. Consequently, their performance in real-world conditions often will differ from that in the reference conditions under which they were calibrated. For the lowest uncertainty of measurement, PD meters generally are the best option. Electromagnetic meters provide for the widest flow range while turbine meters usually are the best choice for the highest short-term repeatability. Despite their high initial cost, Coriolis meters are ideal for measuring particularly viscous substances and wherever readings of mass rather than volume are required.

You always should examine long-term ownership costs. A flow meter with a low purchase price may be very expensive to maintain. Alternatively, a meter with a high purchase price may need very little service. Lower purchase price doesn't always represent better value.

Generally speaking, flow meters with few or no moving parts require less attention than more-complex instruments. Meters incorporating multiple moving parts can malfunction due to dirt, grit or grime present in the process fluid. In addition, impulse lines needed with some meters can plug or corrode, and units with flow dividers and pipe bends sometimes suffer from abrasive-media wear and blockages. Changes in temperature also affect the internal dimensions of the meter and require compensation.

The need to recalibrate a flow meter depends upon how well the instrument fits a particular application. If the application is critical, check meter accuracy at frequent intervals. Otherwise, recalibration may not be necessary for years for non-critical applications and ones where conditions don't vary.

No matter the chosen flow-meter technology, overall system accuracy won't exceed that of the equipment used to perform the meter calibration. The most-precise flow calibration systems on the market employ a PD design. This type of calibrator, directly traceable to the U.S. National Institute of Standards and Technology via water draw validation, provides total accuracy of at least 0.05%.

CHOOSE CORRECTLY

Selecting the right flow meter can significantly impact operational and business performance. So, educate yourself about basic flow-measurement techniques and available meter options, and don't hesitate to consult with a knowledgeable instrumentation supplier in the early stages of a project. That will help you ensure a successful application once the equipment is installed. ●

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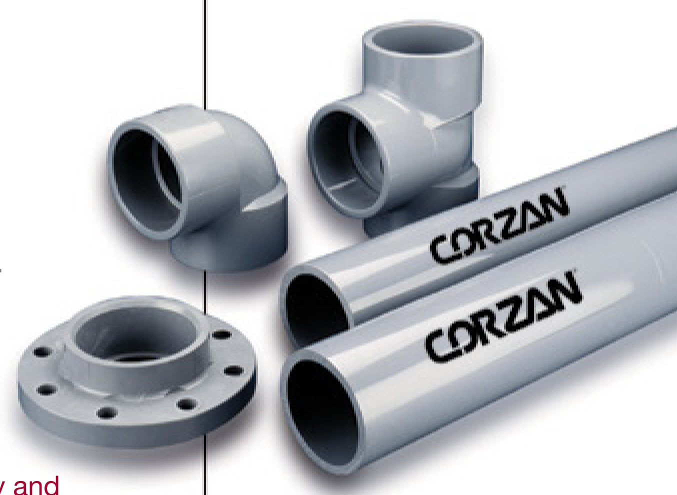

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Choose Rupture Discs Wisely

Selecting the correct pressure relief method and configuration depends on a variety of factors

By Paul Yanisko, Rembe Inc., and Dr.-Ing. Stefan H. Rüsenberg, Rembe GmbH

IN THE process industries, many operations are conducted at pressures above, or well-above, ambient. Applying appropriate design, engineering, fabricating, operating and maintenance methods helps to ensure system integrity and safety, reduce the potential for overpressure incidents and minimize the risk of asset damage and personal injury. Key considerations in achieving these objectives include determining a pressure control and pressure relief strategy and properly selecting, applying and implementing instrumentation, pressure relief devices or combinations of each.

Pressure control approaches typically use safety instrumented systems (SISs) that operate primarily to prevent a process-related overpressure scenario from developing. Such systems may be based on feed-forward or feedback control and usually require knowing about the potential overpressure scenarios and the somewhat well-characterized and well-established relationships between the overpressure cause and the resulting pressure rise. Successful implementation requires confidence in these relationships and trust that the pressure rise, once initiated, may be controlled within the overall system's design pressure. These are proactive pressure control systems.

Pressure relief systems typically use safety relief valves (SRVs), rupture discs (RDs) or combinations of each. These devices operate primarily by opening to relieve an overpressure situation that has developed in the process system. Their implementation requires knowledge of the process conditions at which the device must open to relieve the pressure that develops within the system, thereby preventing pressure-related asset damage and other potential consequences.

The key design parameters needed for proper device specification include the system's design pressure (or MAWP), the device's required set pressure and set temperature, the back pressure on the device's exhaust side and the required flow capacity. These devices offer a reactive means of pressure relief.

PRESSURE RELIEF METHODS

Pressure control and pressure relief methods each have their respective operating situations for which they tend to be preferred. Several methods are available to implement process RDs for pressure relief, and certain operations benefit from particular approaches (see Table 1).

When pressure relief systems are being considered for

RD APPROACHES AND RELATED CONSIDERATIONS

RD APPROACH	CONSIDER FOR THESE POTENTIAL OVERPRESSURE SCENARIOS	MAIN DRIVER	INSTEAD OF
Single RD	Well-controlled, noncorrosive process, vent to atmosphere, low frequency of overpressure	Cost	Single SRV
	Need for very fast response (e.g., runaway reaction, heat exchanger tube rupture)	Performance	Single SRV
RD → SRV	Corrosive or other substance that otherwise would require single SRV of high-alloy material	Cost	Single high-alloy SRV
	When emissions (fugitive or otherwise) must be minimized (e.g., processing toxics or strict emissions permits)	Performance and cost	Single SRV
	Adhesive or other process substance that otherwise may inhibit operation of a single SRV	Performance and cost	Single SRV
RD → RD	Discharge to a system or header with variable back pressure that otherwise may inhibit proper operation of a single RD or single SRV.	Performance	Single RD or single SRV
	When emissions (fugitive or otherwise) must be minimized to a greater degree than the RD/SRV approach will allow.	Performance	RD/SRV
SRV → RD	For overpressure of a noncorrosive-containing process into a header that also serves corrosive-containing processes	Performance and cost	Single-alloy SRV
RD = SRV	When sizing one device for all overpressure scenarios would result in much larger size and much higher cost	Cost	Single SRV
RD = RD	For redundancy when relief case requires high reliability and potential frequency is very low	Performance and Cost	RD = SRV

Table 1. Pressure control and pressure relief methods each have their respective operating situations for which they tend to be preferred.

overpressure protection, questions arise regarding which type of device to use and what its appropriate arrangement should be. They include whether an RD or SRV is the most appropriate device for the service, whether it is worthwhile to consider using both, and, if so, determining how they are arranged.

The answers will set the design approach. After the basic pressure relief approach has been established, the device can be selected and sized. Pressure relief system approaches and sizing methods are defined by ASME (ASME Boiler and Pressure Vessel Code, Section VIII) and API (API RP 520, Sizing, Selection, and Installation of Pressure-relieving Devices: Part I—Sizing and Selection and Part II—Installation). A good, practical summary of pressure relief system sizing recently was published entitled "Sizing Pressure-Relief Devices," by Daniel A. Crowl and Scott A. Tipler, https://goo.gl/CQ9oVc.

Rupture discs may be installed in several configurations that typically include:

- one rupture disc alone;
- a rupture disc upstream of, and in series with, a pressure relief valve;
- two rupture discs in series;
- a rupture disc downstream of, and in series with, a pressure relief valve;
- a rupture disc in parallel with a pressure relief valve; or
- two rupture discs in parallel.

CONFIGURATION CONSIDERATIONS

Choosing which configuration is appropriate depends on such factors as ease of the process' control, the process pressure's relative variability or stability, the existence and variability in back pressure on the relief discharge piping, the process substance's corrosiveness and toxicity, emissions requirements, the extent to which the process substance may plug a relief valve (or otherwise affect its reliable operation) and capital cost expectation.

As with most process equipment decisions, the appropriate configuration typically achieves the performance requirements and offers benefits at an acceptable cost. To determine appropriateness, consider each configuration, identify the key factors that favor it and look at some example processes or operations for which the approach may be applied.

One rupture disc alone. Using the RD alone (Figure 1) is a viable approach when the process pressure is relatively well-controlled or when it may rise rapidly (and therefore must be relieved rapidly). The installation requires the disc to be installed either between standard ANSI/ASME flanges (typical for very low-pressure applications) or in an assembly comprising the RD installed between vendor-supplied disc holders. This assembly then is installed between flanges. Disc holder use is typical for moderate-pressure applications and higher.

REVERSE-ACTING RUPTURE DISC

Figure 1. The use of an RD alone is a viable approach when the process pressure is relatively well-controlled or when it may rise rapidly (and therefore must be relieved rapidly).

This configuration may be desirable to protect a liquid water holding tank operating at low and relatively well-controlled pressure. In such a case the pressure is unlikely to rise to the disc burst pressure, special disc construction materials are not required, and the RD cost will be lower than the SRV cost. The low cost of the RD relative to an SRV likely will be the key factor driving its selection.

A single RD also may be considered for protection of runaway reactions such as those in the phenol-formaldehyde reaction system. Regardless of whether this system is acid-catalyzed (novolacs) or base-catalyzed (resoles), the potential for rapid runaway reaction, rapid pressure rise and overpressure is high. In the event of runaway for these reactions, the pressure rise may occur more rapidly than the time required for a SRV to open fully. Generally, SRVs open in hundreds (~300) of milliseconds (ms), while RDs open in a few (~5) ms. In this case the RD's fast response performance likely will be the critical factor driving its selection.

Rupture disc upstream of, and in series with, a pressure-relief valve. Using an RD upstream of, and in series with, an SRV can be considered for various scenarios, including concern about the possibility of plugging the SRV (and subsequent negative effects on its operation); when the processing environment requires pressure relief devices constructed of exotic, relatively expensive materials; or when leaks to the environment must be minimized as much as possible.

This approach requires the RD to be installed either between standard ASME/ANSI flanges (typically for low burst pressures) or between disc holders, which then are installed between flanges (typical for moderate burst pressure and higher). The SRV is installed downstream (on the discharge side) of the RD.

The connecting pipe between the RD and the SRV must be vented or monitored for pressure rise. These items ensure that pressure does not build up over time in the pipe space between the two devices. A telltale pressure gauge will indicate whether pressure is rising or has risen in the pipe space. The vent simply will prevent pressure rise in the space. Project-specific requirements will determine whether to use the telltale gauge or the vent.

The combined RD and SRV approach may be beneficial in corrosive acid service. In such cases, instrumentation and equipment fabricated from high-nickel-content alloys such as Inconel, Incolloy or Hastelloy typically are used because of their anti-corrosive properties. These alloys tend to be expensive relative to carbon or even stainless steels. One option is to use a single SRV constructed of a relatively expensive nickel alloy. An alternative to the single SRV approach is to use a SRV constructed of carbon or stainless steel and to install upstream of the valve a RD constructed of the high-nickel alloy.

When an exotic alloy is required as the construction material when the device is exposed directly to the corrosive process environment, using a high-alloy SRV alone typically is more expensive than using a high-alloy RD upstream of a SRV constructed of more conventional materials. In this case, the decision to use the high-alloy RD in combination with the SRV constructed of conventional materials is driven by its lower cost relative to the use of the single SRV constructed of high-alloy material.

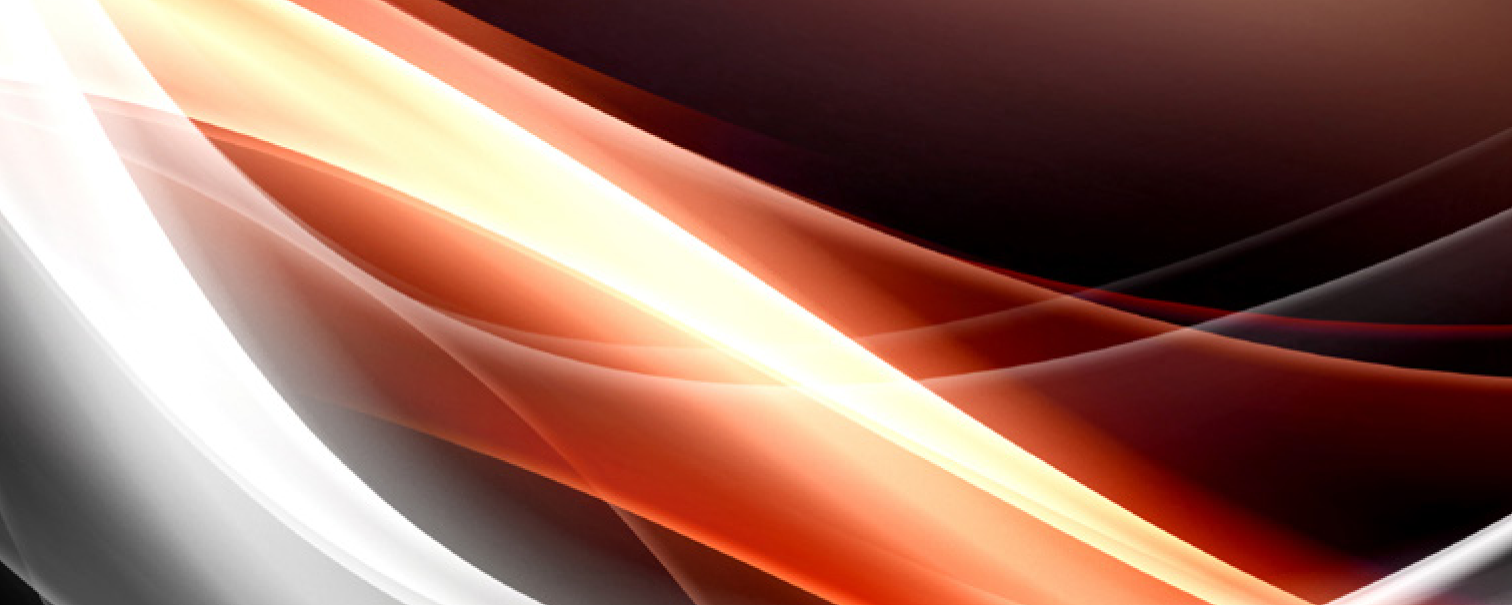
This approach also may be beneficial for operations that process toxic substances or in any instance for which emissions (fugitive or otherwise) must be minimized. For such an operation it is likely that pressure control and monitoring will be maximized to minimize the possibility of an overpressure incident.

COMBINATION DEVICE WITH RUPTURE DISC

Figure 2. This device allows plant personnel to conduct in-situ pressure tests without having to remove and reinstall the SRV.

One possibility for pressure relief is a single SRV. However, using an SRV always offers the risk that a leak, however small, will develop either over time because of relaxation of the spring mechanism or valve assembly or after first SRV response from incomplete reseating. A better alternative to improve leak tightness and reduce the possibility of emissions is to provide pressure relief via a RD on the upstream side of the SRV. The key factors driving this approach include the ability to minimize emissions while maintaining operability at minimal cost.

This type of installation requires that the RD be a non-fragmenting design. This prevents material release from the disc during bursting, which may affect the downstream SRV's operation negatively. Also, for this approach, RDs now are commercially available that allow in-situ SRV pressure testing (Figure 2). This enables plant maintenance teams to satisfy the SRV periodic pressure test requirement without the need to



remove and reinstall the SRV for testing. The associated test cost savings potentially are significant.

Two rupture discs in series. Using two RDs in series (one downstream of the other) is a consideration when there may be high pressure variability on the first RD's exhaust side (variable back pressure) that may affect proper operation negatively or when preventing leaks to the downstream side is critically important. Three configuration methods are available. They include installing each disc in its own flanges (for low-pressure applications), installing each disc in its own disc holder assembly (each assembly then is installed between its own flanges) or installing each disc in one "double-disc" holder (which then is installed between flanges) (Figure 3).

DOUBLE-DISC INSTALLATION

Figure 3. Using two rupture discs in series is suitable for installations with variable back pressure.

Two RDs in series may be a viable option to protect a system that is connected to an extensive header (a flare header, for example) on the disc assembly's exhaust side. Such cases offer the potential for high variability in the header pressure depending on, at a particular moment, which other lines are exhausting to it or the state of the flare's operation. Variable back pressure may affect negatively, or even prevent, the proper opening (bursting) of a single disc installation.

An RD operates on the basis of not only pressure on the upstream side, but, more specifically, pressure differential between the upstream and downstream side of the disc. Therefore, if an RD's burst pressure is "X" (let's say 100 psig) and it is protecting a system with a design pressure of the same "X" (100 psig) and if the back pressure may vary from 50 to 100 psig, it may be difficult to properly design or supply a disc that will open when it really must.

A double disc (in series) configuration allows the downstream disc to isolate the upstream disc from variable back pressure. This, in turn, allows the upstream disc to be designed and supplied for the required burst pressure at a single defined back pressure (typically atmospheric pressure achieved by venting the space between the discs to atmosphere by means of a small hole).

The downstream disc is rated for a forward burst pressure that is lower than the upstream disc (so that the downstream disc bursts when the upstream disc bursts), and for a backward pressure that is higher than the maximum possible back pressure (so that it does not burst in the reverse direction). In this situation, performance (the certainty of opening at the required burst pressure by decoupling from exposure to the variable back pressure) is the key factor driving the use of the in-series, dual-disc assembly.

The double disc in series also may be used when emissions to the downstream side are not desired. Such is the case for substances that are particularly toxic or have stringent emissions requirements. Examples include silane compounds or VOCs, which are regulated by the U.S. Environmental Protection Agency (EPA) or other state environmental agencies.

Using an SRV for operations processing such materials may be undesirable because of the probability that the SRV valve seat/opening may lose integrity over time (from spring relaxation) and allow leaks to the downstream side. In these circumstances, a double-disc in-series configuration may satisfy the process' leak and emission prevention needs. Given

this situation, it is the better leak-tight performance aspect of rupture discs, relative to safety relief valves, and even better leak tightness of double discs in series that drive the preference for this configuration.

Rupture disc downstream of, and in series with, a pressure relief valve. This arrangement is similar to the case of an RD upstream of, and in series with, an SRV Installing an RD downstream of a pressure relief valve is beneficial when the SRV must be protected or isolated from the downstream process fluids. This may be the case when the SRV discharge from a noncorrosive process is directed to a common header, which also serves corrosive processes. For noncorrosive process pressure relief, installing an RD fabricated from corrosion-resistant materials downstream of an SRV fabricated from common noncorrosion-resistant materials likely will allow cost savings overall and preserve the SRV's proper operating functionality.

Rupture disc in parallel with a pressure relief valve. Using an RD in parallel with an SRV may be considered when the combined cost of using both devices is less than the cost of using only one for all the possible overpressure scenarios or when the additional cost of redundant pressure relief is worth the reduced risk of asset damage and personal injury.

Each device may be installed on separate equipment nozzles or on branches from the same nozzle. In the first approach, one device can be sized for a particular set of relief scenarios and related relief capacity (and device diameter); the other device can be sized for another set of relief scenarios and related relief capacity (and device diameter). This arrangement may be desirable when, for example, the pressure relief device sized for the most probable pressure relief scenarios is smaller (and lower cost) than the pressure relief device sized for all of the possible scenarios.

A specific example is overpressure protection of shop-fabricated, high-pressure, cryogenic liquid storage tanks. These tanks typically are vacuum-jacketed to achieve low heat transfer to the environment. The potential overpressure scenarios include loss of control of the pressure build circuit (which drives the discharge of liquid from the tank) and vacuum loss in the insulating space. The required relief capacity of the former generally is lower than the required relief capacity of the latter.

It may be economical and operationally preferable to size an SRV for the loss of control of the pressure build circuit scenario and to size an RD for the vacuum loss scenario, rather than sizing a single pressure relief valve for both scenarios. The performance and cost of the combined devices in parallel are the factors that drive its preference versus the use of the single SRV.

Two rupture discs in parallel. This arrangement may be worthwhile to consider when overpressure relief requires high reliability and when the likely frequency of overpressure is low, or simply when high pressure relief area is required. Either arrangement may cost less than an installation consisting of an RD and SRV in parallel.

EVALUATE NEEDS AND BENEFITS

Pressure control methods and overpressure protection are key considerations in the process industries. Their successful implementation minimizes risk of asset damage and personal injury. RDs are non-reclosing pressure relief devices and are an important option to consider as a means of overpressure relief. They may be installed in several different arrangements either alone, in combination with another RD or in combination with a SRV. Each arrangement option offers desirable performance or cost for certain operating scenarios.

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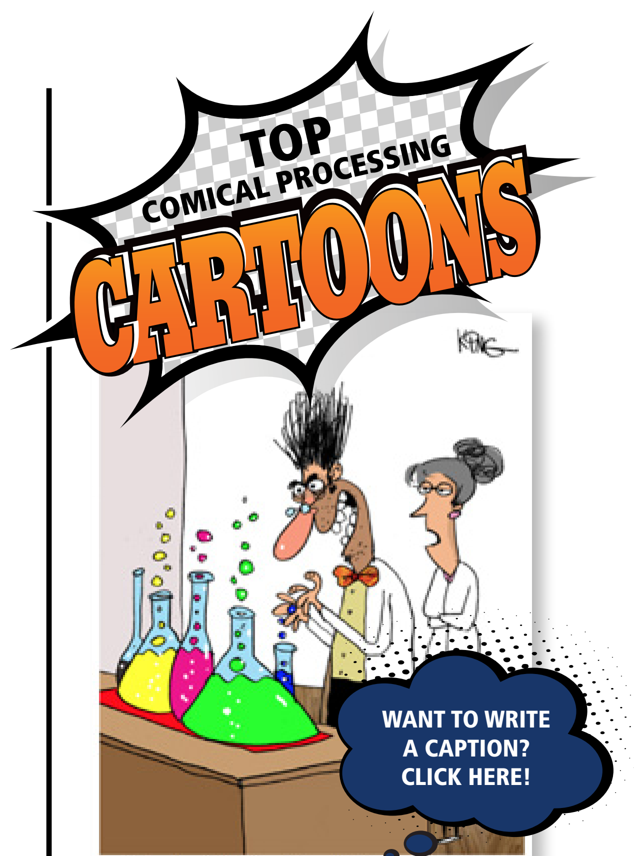

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