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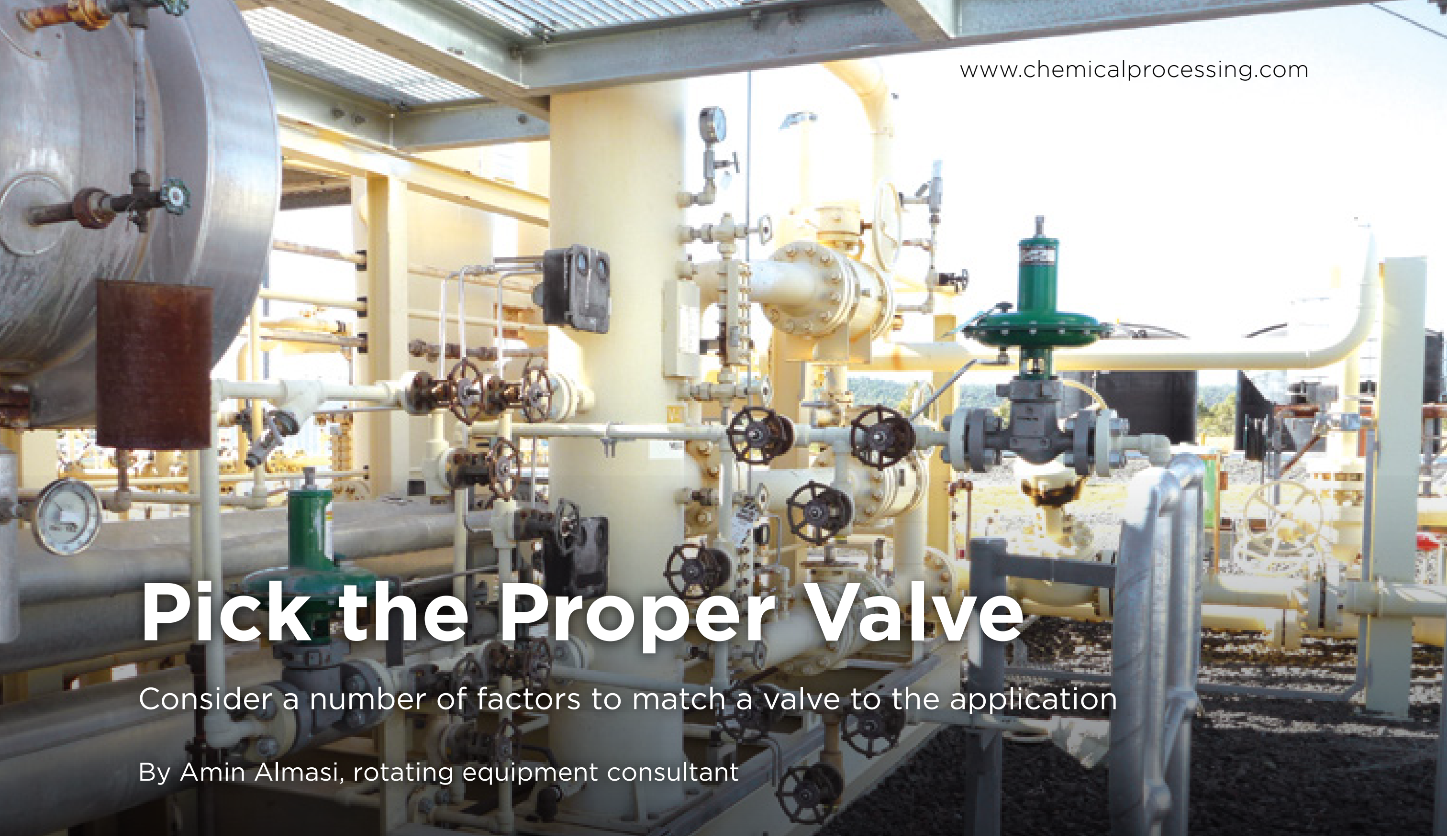

Pick the Proper Valve

Consider a number of factors to match a valve to the application

By Amin Almasi, rotating equipment consultant

Valves handle a wide variety of functions related to liquids and gases — turning flow on or off, controlling flow rate, and preventing reverse or back flow, as well as regulating and relieving pressure. Valves fall into two general classifications — linear (such as a gate valve) or rotary (such as a ball valve) — based on the action of the closure member. They also are categorized by their closure member's shape (e.g., gate, globe, butterfly, ball, plug and diaphragm). Selection primarily depends upon the application and the pressure and temperature conditions. In addition, certain services, such as those handling flammable materials, may require valves to be fire-safe or approved for fire protection use.

Some valves are actuated manually. Valves that are located remotely in a machinery package, require frequent operation or must automatically respond to equipment needs (such as to prevent surge in turbocompressors), or control system demands (such as to adjust flow rate) use a powered actuator.

VALVE COMPONENTS

The valve body houses all the internal working components of a valve and includes flanges or other hardware for joining the valve to the piping system. Inside the body, the closure element moves to adjust passage of fluid through the valve. To shut off flow, the element closes so that its mating surface presses against a seat that provides a surface capable of sealing against the flow. The seat usually is attached to the valve body. Most valves have a metal closure element sealing on a soft elastomeric seat; metal-seated valves may require as much as 50% more seat material. The distance the closure element travels from fully open to fully closed position is called its stroke.

A movable stem connects the valve's actuator to the closure element. The stem may go through a bonnet, which provides a leak-proof entrance to the body. However, many valves (such as plug and some ball designs) don't have bonnets.

The bonnet often is semi-permanently screwed into the valve body or bolted onto it (which is preferable for high performance valves); special valves feature other bonnet designs. Accessing internal parts of a valve, e.g., for maintenance, usually requires removing the bonnet.

A stuffing box (the interior area of the valve between the stem and the bonnet) contains packing to seal the stem to prevent leakage to the outside of the valve; a packing nut on the bonnet often keeps the packing in place.

In many valves, the bonnet has a backseat to seal the stem to avoid leakage into the packing when the valve is in its fully open position. A bushing on the stem provides the mating surface. Backseating is useful if the packing begins to leak and also prevents the stem from being ejected from the valve.

The particular fluid being handled impacts the operation of a valve. For instance, the operating torque necessary will depend upon the lubricity of the fluid; gases usually don't provide any lubrication while liquids may. Liquids carrying solids can clog clearances between the stem and other components. The fluid also may corrode internal parts over time, considerably increasing the torque needed — up to twice or more of that when new.

For fire safety, some valves may require secondary metal-to-metal seating. Another important consideration in some situations is fail-safe operation; this typically calls for a larger size actuator.

ACTUATOR ISSUES

The power source for a valve actuator should be capable of exceeding by an adequate margin the torque needed. In the case of throttling, determining the necessary torque may require a detailed analysis. The worst case involves providing the breakaway torque (usually the highest value). Valve-operating torque varies with closure member position. As a rough indication, the peak torque is required at breakaway, decreases to about 30% of breakaway in the half-open position and increases to about 90% of breakaway at closure.

The valve-operating torque depends upon the size and characteristics of the valve itself and the type of seat. A valve operating at full-rated pressure usually requires more operating torque than one operating at a lower pressure. The pressure differential typically varies throughout the valve's entire stroke.

Breakaway torque plus a proper margin generally is used to select actuators for on-off service. For quarter-turn valves requiring throttling, calculating the torque often is more complicated because additional torque is necessary to counterbalance the momentum of the flowing fluid; unbalanced forces generate "hydrodynamic torque." For smooth operation, the actuator torque output should significantly exceed the operating torque.

Torque requirements usually are lowest at ambient temperature. High and cryogenic temperatures necessitate greater operating torque. Fluid temperatures above 140°C may mandate a special operating and mounting assembly, often a stem extension. Even at ambient conditions, actuators located outdoors may require special considerations.

Another important factor is the cycling rate. Pneumatic and hydraulic actuators that cycle more than 30 times per hour are considered to have high operating rates. The same is true for electric actuators cycling more frequently than 10% of their duty cycle (say, operating for one cycle and resting for a time equivalent to nine cycles); such a situation calls for an extended-duty motor. Cycle speeds faster than one-half the standard cycle time demand particular care. A sudden physical shock associated with fast operating speed combined with rapid cycling rates can damage valve and actuator parts. Pneumatic actuators may need quick exhaust valves, special solenoids and larger actuators. Higher speeds are accomplished using different gearing devices, which may increase torque output, or via an electronic speed control, which will not affect torque output.

An often overlooked, but important consideration when designing piping systems and packages is stem orientation. A valve stem not aligned vertically may cause stem seal leakage or galling due to side thrusts induced by an overhung load on the actuator. The use of heavy-duty couplings and mounting brackets will minimize these problems.

Electric actuators frequently are chosen for valve operation. Either solenoid- or motor-operated, they usually are (relatively) large and heavy but often have the lowest total installed cost because electricity generally is readily available and the wiring and control instrumentation are relatively simple. Solenoid operation typically is limited to smaller lines. Motor-operated actuators tend to be bulky and slow, particularly when large gear reduction is used to increase torque — but their torque output is constant throughout their stroke and their response is more-or-less linear. Critical systems should have an emergency power supply because a power cut or a power system failure is a possibility.

The speed at which the valve closure member operates also is important. Relatively high rates are available — but exceeding the maximum specified speed will damage the seat and closure member. Gate and globe valves are torque-seating valves when closed. In the open direction, a limit switch often is provided to protect the seat against backseat over-tightening. Quarter-turn valves (such as ball valves) are position-limited open and closed because seating is based on position, not force. Electric motors don't stop instantaneously but coast to a stop. So, it may make sense to use a solenoid brake to prevent the motor from over-tightening the closure member; check with the valve manufacturer. Unless an emergency power source is available, don't use electric motors where cycling to a fully opened or fully closed position is necessary in the event of a power failure. Limit motor operators to moderate cycling functions; avoid them for services where severe cycling is necessary.

Pneumatic actuators handle a variety of valve applications and are well suited for services requiring frequent operation and fast response times. Depending upon the system selected, these air-driven devices usually operate in a range of 2–10 bar, with 4–6 bar most common. The compressed air supply should be a dedicated one and preferably supplied from an instrument air (known as IA) compressor package to ensure the air is clean and dry. Actuators come in two types: piston and diaphragm. The piston actuator usually is used for on-off operation. The piston stroke can be long, making it suitable for large valves. The diaphragm actuator is appropriate for modulating service but its short travel often limits the size of valve on which it can be used. Fail-safe operation typically depends upon either an internal spring or a secondary accumulator tank to provide the necessary power to cycle to an opened or closed position. The internal spring may cause the assembly to flex, which may be a problem for some installations. The accumulator tank is externally mounted, often on a nearby wall or column. Pneumatic actuators are (relatively) large in size and often need frequent maintenance because of air leakage over time (particularly for piston types) that also makes response time longer. There usually is a limitation on maximum valve differential pressure.

Hydraulic actuators are preferred for some special valves. These devices use hydraulic fluid (hydraulic oil) to produce torque and rely on special hydraulic pumps (usually positive displacement pumps, most often gear pumps). They can provide fast actuation; they also are suitable for modulating service. Hydraulic actuators can handle large valves with high pressure differentials and can tolerate frequent cycling. They generally have no fail-safe mode unless emergency electrical power is available. Stroke is easily adjustable in service.

FIRE-SAFE VALVES

By the nature of their service, some valves require a “fire-safe” designation. Basically, this means the valve shouldn’t melt in a fire or leak after a fire and the seat should close adequately. The standard used most frequently is API-607 (“Fire Test for Soft-Seated Quarter Turn Valves”). Valve makers often provide ratings for their products. Fire-safe valves usually must be tested to show they provide the necessary performance as far as, e.g., “minimum internal leakage,” “minimal external leakage” and “continued operability.”

A valve should offer acceptable seating prior to and after exposure to high temperatures (from fire, etc.) without depending on supplementary pressure from spring-loaded or other devices or a critical seal. The valve body design should minimize external leakage by using fire-resistant stem seals and avoiding large gasketed body joints. The valve should be operable despite fire damage; the body and actuator should resist harm from high temperatures.

VALVE RATINGS

A number of designations are used to indicate the pressure ratings of valves; these denote a valve’s ability to withstand pressure within a range of temperatures. Standard pressure ratings have been established to match ASME/ANSI ratings of flanges and fittings and are designated by class, conforming to ASME/ANSI B16.34 ratings. Two types of designation are “WSP,” which stands for working steam pressure, and “WOG” for (cold) water, oil and gases. When both ratings are provided, WSP is called the primary rating. When only one rating is given, the valve generally isn’t used for a service not covered by the rating. A class 300# rating indicates a valve with a working pressure of 300 psig. If a valve primarily is used for water service, a common designation is “WWP” or water working pressure, which rates the ability to handle cold (say, from 0°C to 30°C) water.

High temperatures require de-rating of the valve pressure. Likewise, high pressures mandate de-rating the temperature. The temperature limit of most metallic valves usually is based on the capabilities of the seat and interior trim materials. In general, valves used for utility services (such as in machinery packages) rarely are selected based on pressure drop through the valve but rather for their suitability for the application. Calculations typically aren’t needed because established equivalent lengths of pipe for each type of valve are sufficiently accurate to determine the approximate pressure drop through the valve.

In some situations, such as where pressure drop must be kept to a minimum, precisely

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determining the pressure drop through a valve is necessary. This usually is done using the standard measure of valve flow, i.e., the coefficient "C_v," which indicates the flow that will pass through a valve in the wide-open position with a certain pressure drop. The valve manufacturer determines this coefficient, typically via actual flow tests.

MAKING A SELECTION

The first factors to consider in choosing a valve are temperature and pressure. The valve body, trim and operating parts should be capable of withstanding the highest temperature expected during sustained normal and transient operating conditions. The valve should be rated for the highest transient pressure anticipated. Then, consider the degree of shutoff necessary. For utility applications (for instance, cooling water for a machinery package), allow for some minor (internal) leakage; completely eliminating such leakage is extremely costly. Bubble-tight valves are those that exhibit no visible leakage through the elastomeric seat of the valve for the duration of a test. Corrosion resistance also is important, and usually is affected by the nature, concentration and temperature of the fluid. Other crucial parameters are velocity of the fluid through the valve, the nature of its operation (e.g., on-off or modulating), whether a fire-safe version is needed, and fluid details (such as whether a gas, liquid or stream with some particulates). ■

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Quickly Estimate Reagent Addition Time

A simple equation suffices in many situations involving batch reactors

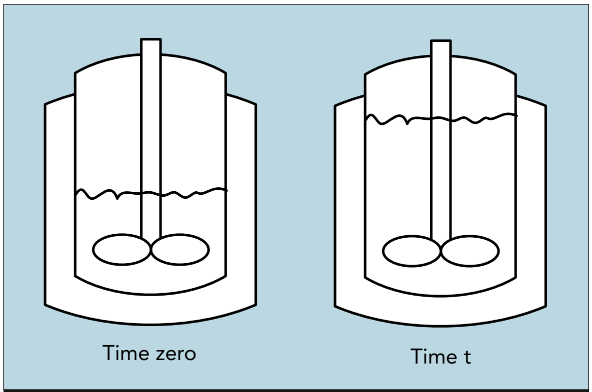
By Michael J. Gentilcore, Mallinckrodt Pharmaceutical, and Luigi Grippa, Libero Professionista

Batches often have a step in which a reagent chemical is added to a mixture being stirred and reacts immediately (with little accumulation) — with the rate of addition controlled by the ability to remove heat. A maximum temperature is specified with full cooling applied to the reactor's jacket. If the reagent chemical is dilute enough to cause a significant level change, then the wetted area for heat transfer will not remain constant.

When the reaction rate is much faster than the feed rate, the added reagent is immediately converted to product by spontaneous reaction with the substrate previously charged to the reactor. A negligible buildup of the reagent occurs in the reactor during the addition. The heat production rate is directly proportional to the feed rate of the reagent as limited by the heat transfer of the jacket. The reagent feed rate can be raised as the volume increases and provides more wetted area for heat transfer.

DERIVING THE EQUATION

For simplification, let's assume the liquid mixture in the reactor prior to addition is on the straight wall as shown in Figure



JACKETED REACTOR

Figure 1. Equation assumes that batch always is on the straight wall of vessel.

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"Quickly Estimate Batch Distillation Time," http://goo.gl/3je2cl

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1. For purposes of integration, let's also assume the heat of reaction (ΔH), liquid density (ρ), overall heat transfer coefficient (U) and temperature differential (ΔT) between the utility (jacket) and process (tank) remain constant.

This situation is the reverse of a batch distillation — for which the equations and their derivation have been published previously [1]. The solution is:

$$A_t/A_0 = e^{-t/\Theta} \quad (1)$$

$$\text{where } \Theta = \rho \times D \times \Delta H/(4U \times \Delta T) \quad (2)$$

The differences versus batch distillation are in the definition of the terms ρ, ΔH and ΔT. Let's discuss each of these.

Liquid density. In batch distillation, ρ is the density of the liquid in the vessel. For reagent addition, this term is the net weight added during the addition versus the observed volume change of the reaction mix. For the special case where the reagent and reaction mixture mix ideally with a zero volume change, the density equals that of the reagent.

Enthalpy change. In batch distillation, ΔH is the heat of vaporization of the evaporated solvent. For reagent addition, it is the heat of reaction expressed as unit of heat versus the net weight added. The heat of reaction must be calculated at the temperature of reaction and must include all enthalpy effects such as the sensible heat from a reagent below reaction temperature, heat of dilution, evaporative cooling when there is a byproduct off-gas and, of course, the chemical heat of reaction.

Temperature difference. The ΔT term is the same and constant for both batch distillation and reagent addition. Typically in batch distillation, steam is the heating medium and calculation of this term is straightforward because both the process and jacket are isothermal. In reagent addition, a liquid commonly is the coolant and the jacket supply and outlet temperature are unequal. In this case, the difference is determined by a log mean temperature calculation.

For a simple case of water flowing once through a jacket, the following relationships apply:

$$T_O = T_P + (T_S - T_P)/K \quad (3)$$

$$\text{where } K = \exp[(UA)/(WCp)] \quad (4)$$

Eq. 4 includes the wetted area (A). Under a rigorous analysis, the temperature difference is not constant. However, as an approximation, the log mean temperature difference can be calculated at both the

	Before Reaction		After Reaction			
	Liquid to be added	Liquid in reactor	Offgases		Reactor Contents	
	Sodium	Water	No. 1 (H_2)	No. 2 (Water)	Solute (NaOH)	Solvent (Water)
Weight, lb	1,683.5	6,610.3	73.8	14.2	2,928.9	5,276.9
Moles, lb-moles	73.2	366.9	36.6	0.8	73.2	292.9
Volume, gal	219.9	795.9			712.0	
T, °F	260.3	77.0	77.0	77.0	77.0	77.0
ΔH_f@ T, kcal/mole	1.357	-68.315	0.00	-57.796	-110.219	-68.315
ΔH_f @ T, BTU/lb	106.3	-6,831.7	0.0	-5,579.8	-4,964.6	-6,831.7
Enthalpy, kBTU	179.0	-45,159.4	0.0	-82.0	-14,540.7	-36,050.0
Density, lb/gal	7.66	8.31			11.53	
MW, lb/lb-mole	22.9898	18.01528	2.0158	18.01528	39.997	18.01528

HEAT AND MATERIAL BALANCE

Table 1. Sodium added to vessel causes a reaction.

lowest level (A_0) and highest level (A_t) in the integration. For practical problems, the observed disparity in temperature difference will be slight and the lower value can be used to provide a conservative estimate of addition time. An example will illustrate this.

Many reactors have heat/cool modules that enable the jacket inlet temperature to differ from the coolant supply temperature. In such cases, substitute equations that are available in Reference 2 for Eq. 3 and Eq. 4.

AN EXAMPLE

Molten sodium metal is added to water to make a sodium hydroxide solution — with the temperature controlled isothermally at 77°F during the addition. The reaction chemistry is:

$$\text{Na (liq.)} + \text{H}_2\text{O (liq.)} \rightarrow \text{NaOH (aq.)} + \tfrac{1}{2}\text{H}_2\text{ (gas)}$$

The reaction occurs in a vessel with a 5-ft outer diameter and a ¼-in.-thick shell, equipped with a bottom ASME F&D head. The straight wall holds 144.5 gal/ft of liquid height. The bottom head holds 73.9 gal. The straight side has a wetted area of 15.7 ft²/ft of liquid height. The outside surface area of the bottom head is 23.2 ft². Table 1 presents a heat and material balance for this reaction.

Let's now estimate the addition time, assuming an overall heat transfer coefficient of 80 BTU/hr/ft²/°F and 25,000 lb/hr of 41°F chilled water flow (Cp = 1) to the jacket.

Step 1. Calculate the liquid density, ρ.

Per Table 1, the change in volume is 712.0 - 795.9 = -83.9 gal = -11.2 ft^3. The change in weight is 2,928.9 + 5,276.9 - 6,610.3 = 1,595.5 lb. The liquid density for this reaction is 1,595.5 lb/(-11.2 ft^3) = -142.5 lb/ft^3. (Surprise! The density is a negative number because the total volume shrinks after the addition.)

Step 2. Calculate the heat of reaction.

Per Table 1, the heat liberated is the sum of the product enthalpies minus the sum of the reactant enthalpies, i.e., [0.0 + (-82.0) + (-14,540.7) + (-36,050.0)] - [179.0 + (-45,159.4)] = -5,692.3 kBTU. The net weight added to the reactor is 1,595.5 lb. (Surprise! It doesn't equal the weight of the sodium metal because of the evolution of hydrogen gas.) The heat of reaction is then -5,692.3 kBTU/1,595.5 lb = -3.568 kBTU/lb or -3,568 BTU/lb.

Step 3. Calculate the height on the straight wall.

Start of reaction:
(795.9 - 73.9)/144.5 = 5.00 ft
End of reaction:
(712.0 - 73.9)/144.5 = 4.42 ft

Step 4. Calculate wetted areas.
Start of reaction: 5.00×15.7 + 23.2 = 101.7 ft^2
End of reaction: 4.42×15.7 + 23.2 = 92.6 ft^2

Step 5. Calculate K factors. (See Eq. 4.)
Start of reaction:
K = exp (80×101.7)/(25,000×1) = 1.385
End of reaction:
K = exp (80×92.6)/(25,000×1) = 1.345

Step 6. Calculate jacket outlet temperatures.

NOMENCLATURE

A	area, ft2, m2
Cp	Coolant heat capacity, BTU/(lb×°F), J/(Kg×-°C)
D	Tank i nside diameter, ft, m
ΔH	Heat of reaction, BTU/lb, J/kg
K	Flow rate correction per Eq. 4, dimensionless
t	Temperature, °F, °C
ΔT	Temperature difference (jacket - process), °F, °C
T	Time, hr
U	Overall heat transfer coefficient, BTU/(hr×ft2×°F), W/(m2×-°C)
W	Coolant flow rate, lb/hr, kg/s
ρ	Liquid density, lb/ft3, kg/m3
Θ	Time constant per Eq. 2, hr

Subscripts

0	Time zero
f	Formation
t	Time t
S	Coolant supply (jacket inlet temperature)
O	Coolant return temperature (jacket outlet temperature)
P	Process temperature (reaction temperature)

REFERENCES

1. Gentilcore, M. J., "Quickly Estimate Batch Distillation Time," Chemical Processing (April, 2013), http://goo.gl/3je2cl.
2. Gentilcore, M. J., "Estimating Heating and Cooling Times for Batch Reactors," Chemical Engineering Progress (March 2000).

(See Eq 3.)

Start of reaction:

T_o = 77 + (41 - 77)/1.385 = 51.0°F

End of reaction:

T_o = 77 + (41 - 77)/1.345 = 50.2 °F

Step 7. Calculate ΔT.

Start of reaction: [(77 - 41) - (77 - 51.0)]/ln [(77 - 41)/(77 - 51.0)] = 30.7°F

End of reaction: [(77 - 41) - (77 - 50.2)]/ln [(77 - 41)/(77 - 50.2)] = 31.2°F

The two values differ by less than 2%. Per the integration assumptions, the temperature will be treated as constant — using the lower value, 30.7°F, in subsequent calculations to give a conservative estimate of the addition time.

Step 8. Calculate Φ. (See Eq 2.)

First, calculate the tank's inside diameter:

$5 - 2\times 1/4 \times 1/12 = 4.9583$ ft

Φ = [(-142.5)×4.9583×(-3,568)]/(4×80×30.7) = 256.6 hr

Step 9. Rearrange Eq. 1 to solve for time.

$t = -\Phi \ln(A_t/A_o)$

Step 10. Plug in values and calculate addition time.

-256.6×ln(92.6/101.7) = 24.1 hr ■

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Choose the Right Flow Measurement Technology

Answering a few key questions can determine the right device for a specific application

By Rich Lowrie, KROHNE, Inc.

Flow measurement instrumentation options abound, and the challenge of picking the right one for a particular application can be daunting. Many experienced plant personnel default to one they've used before — or perhaps count on a supplier to help them select among the available technologies.

Instead, start by getting answers to a few key questions about measurement specifics for your application. The answers will help determine the most important criteria to assess available choices for your circumstance, since many flow technologies may apply. Next, review how different flow measurement technologies work to determine which one fits your process needs best. Finally, compare the pluses and minuses of options in Table 1. Voilà — you're on the right path to successfully choosing a measurement device.

KNOW WHY YOU ARE MEASURING

Of all the questions to ask, the key one has to be, why is the measurement required? Is it to control or optimize the process, to meet state regulations, or for monitoring or indication? Or, is it as a safety safeguard or to warn of a process upset? For example, if your measurement

Technology	Price	Turndown	Accuracy	Installation Requirements	Notes	Products
Coriolis	$$$$	Based upon 1 bar pressure drop over device	.12% nominally of mass and mass flow	Depends on manufacturer, most have none	High viscosity low flow can cause some meters to have errors	Slurries, gases, chemicals, polymers, fuel oil, hydrocarbons
DP Measurement	$$$	Generally 10:1	Dependent upon the pressure device	10D upstream unobstructed. Requires secondary device to make measurement	Reynolds number influences pressure loss/maintenance of pressure device	Oil, water, hydrocarbons, gases, most any clean liquid or gas not affected by pressure drop
Magnetic Flow	$$	100:1 or better	.5% (nominally)	5D upstream and 3D downstream	Must be conductive fluid best above 2 FPS velocity	Water, acids, bases, chemical feed in WTP and WWTP, slurries
Positive Displacement	$$$$	20:1 or better	.15–.2%	None	Frequent calibrations, subject to slippage with lower viscosity fluids (process slippage through seals)	Crude oil, fuel oil, water, polymers, thick viscous fluids
Turbine Meters	$$$	20:1 or better	0.20%	10–20D upstream unobstructed	Frequent calibration required	Gases, water, fuel oils, air
Ultrasonic	$$ Clamp on $$$ Spool piece	100:1 or better	.3% nominally (non CT spool piece meters) 1–2% clamp on meters	5–10 upstream unobstructed 3–5 downstream	Flow profile and Reynolds dependent	Gases, water, fuel oils, air, chemicals, crude oill
Variable Area	$	10:1 generally	1% nominally	Flow from bottom to top on most models	No solids, low viscosity	Gases, water, chemicals, air, ozone, methane
Vortex	$$$	10:1 generally	1–2% nominally	20D upstream unobstructed	Lower viscosities	Steam, water, gases, air

COMPARISON OF AVAILABLE FLOW MEASUREMENT OPTIONS

Table 1. An overview of available flow meters and the applications best suited for each.

is to control a batching process, such as adding ingredients to a food product, accuracy and repeatability would probably be the most important considerations. Adding the same measured amount of vinegar to a wing sauce or raspberry flavor to an iced tea is critical to producing the same taste to the consumer every time.

Other key questions to ask include:

- What is the expected result of the measurement?
- How much is this instrument going to cost?
- What modifications am I going to have to make to my process piping or at the receiving device such as the PLC or DCS?
- How accurate or repeatable does the measurement need to be?
- What is the expected lifespan and maintenance requirement I am looking for?

Before selecting a technology for making the measurement, be sure to thoroughly define the process and the desired measurement.

FLOW MEASUREMENT CHOICES

A wide range of choices are available for making flow measurements. Each meter technology has advantages and drawbacks. Main device categories include:

- Differential pressure with primary flow elements, for example orifice or Venturi.
- Mechanical devices, including variable area, turbine, or positive displacement meters.
- Electronic flowmeters, including magnetic flow, vortex, ultrasonic, and Coriolis mass.

First, we will review the available flow measurement options, including a brief summary of each device's method of measurement along with an overview of which applications it's best suited for.

Differential pressure devices with primary flow element. This device is placed into a flow stream with a primary flow element that produces a pressure drop proportional to a flow rate. The most popular flow elements are orifice plates or Venturi meters. Other flow elements may include nozzles and pitot tubes.

A differential pressure meter must be mounted in the pipe, so using them incurs installation costs. Regular maintenance is necessary for calibration and inspection, as well as cleaning the taps and the pressure devices. These devices are best suited for measuring single phase products, either all liquid or all gas with a single composition. They are also ideal for measurement of natural gas (for example, methane) or liquids such as light hydrocarbons or chemicals used in water treatment. These devices require a secondary device to measure the pressure.

Positive displacement (PD) flow meters directly measure volume of flow using cavities (also called chambers) that hold a known volume of fluid. They pass the fluid from the meter's input to its output.

Each progression of the fluid produces a pulse — usually from a magnetic pickup —and each pulse is equal to the cavity's volume. The process can be likened to ladling a sauce or gravy from a pot; the ladle holds the same volume each time it is filled and then emptied onto a plate.

There are numerous types of PD meters, including:

- Rotary vane
- Rotating disk
- Nuntating disk
- Oscillating piston
- Sliding vane

MAGNETIC FLOW METERS

Figure 1. These meters require the process fluid being measured have a minimum conductivity.

- Oval gear
- Bi-rotor
- Rotating paddle

Heavy viscous products such as crude oil are measured extremely well by the PD meters listed. When measuring less viscous fluid, the meters may experience an effect known as slippage — in which a small amount of the liquid being measured passes through the sealing of the chambers and is not measured, causing inaccuracies. This measurement technology also is generally not suitable for gaseous state products.

Electromagnetic flow meters use Faraday's Laws of induction to make the measurement. When a conductor (water or other process fluid) flows through a magnetic field, it generates a voltage, which is directly proportional to the conductor's velocity. With a known cross sectional area of the meter body, the velocity is directly proportional to the volume flow rate.

Magnetic flow meters must be installed in the pipe, so installation costs must be added to the cost of the meter. These flow meters are usually maintenance free and require no regular recalibration. Figure 1 shows an example of a magnetic flow meter, the OPTIFLUX 4300C from KROHNE. Magnetic flow meters require that the process fluid being measured have a minimum conductivity. In most cases this is around 5 micro Siemens per centimeter. In the case of liquids such as demineralized water the conductivity needs to be slightly higher, around 20 micro Siemens per centimeter.

Vortex flow meters infer a flow rate based on velocity and cross sectional area of the measuring chamber. Vortex meters measure the vortices produced when a product flows around an obstruction.

Picture a flag waving in the wind or water in a stream going around a rock. The vortices caused by the obstruction have a frequency, which is proportional to the velocity of the product moving through the measurement chamber.

Vortex meters are installed directly into the flow stream and require insertion into the process piping. Some also include a pressure and temperature measurement to output mass flow.

Variable area flow meters, unlike the other flow meters discussed so far, require no power to operate. They measure fluid flow by allowing the cross sectional area of the device to vary in response to the flow, causing some measurable effect that indicates the rate.

The measurement tube is of a tapered design, with a smaller diameter at the inlet and larger diameter at the outlet. Inside the measuring chamber is a float that is designed to match the density of the product being measured.

As the flow increases, the float moves higher in the chamber. If the tube is transparent, a scale is printed on the measuring tube. If the measuring tube is armored, a magnetic pick is used as an indicator. These meters can also be powered and report on a 4–20-mA loop. Limit switches can be added to signal an alarm during high and low flow rate conditions. The meters can be supplied to measure flow moving from bottom to top, from top to bottom, or horizontally.

Turbine flow meters are mechanical meters that also work by measuring velocity and are considered quite accurate and repeatable. The fluid passing over the turbine moves a set of blades, and each blade rotation indicates a specific product velocity. Normally these units require no power; the output is a frequency or pulse that is generated by a magnetic pick up. Turbine flowmeters also require insertion into the flow stream, so installation cost must be added to the meter price.

Because they are mechanical, turbine meters are subject to wear, which means over time they will lose accuracy. They can require frequent recalibration. However, the cleaner the application the less wear and tear there will be on the meters, so recalibration is not required as frequently.

Ultrasonic flow meters come in two configurations, referred to as clamp on and spool piece. The clamp on meter is attached to the outside of the process piping. The spool piece requires cutting the process pipe and installing the meter in the flow stream.

Ultrasonic measurement relies on either transit time or Doppler technology. With transit time a sound wave is sent across the pipe from one transducer to another with the flow. A sound wave is then sent in the opposite direction. The flow causes a change in the time it takes the sound wave to travel across the pipe. Traveling with the flow takes less time and traveling against the flow takes a longer time. The difference in time is proportional to the velocity of the process fluid.

With Doppler technology, a sound wave is sent into the product. The device looks for a return, which bounces off particles in the flow stream. It then measures a frequency shift to determine flow velocity.

Transit time works best for a cleaner product, with low suspended solids and entrained air. The Doppler technology is designed for processes where there are higher amounts of suspended solids or entrained gases. It requires something to "bounce" back the signal.

Coriolis mass flow meters work on the Coriolis effect, which describes forces generated in oscillating systems when a liquid or a gas moves away from or towards an axis of oscillation. A Coriolis device measures a frequency at no flow conditions. Then, when flow begins, there is a shift in the phase of the frequency that is proportional to the rate of mass flow. The frequency the meter sees changes with the density of the product in the measuring tubes. A less dense product causes a higher frequency and a more dense material causes a lower frequency. Coriolis meters are one of the fastest-growing flow measurement products.

COMPARING THE OPTIONS

The brief overview of available options provided basic information on how each technology works and a general idea of what applications suit each technology. Table 1 offers an overview matrix table to compare the pluses and minuses of each technology. ■

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Ponder Using Press Fittings

Case study shows how press fittings speed installation and can withstand harsh environments and materials

By Viega

We often don't think about all the components that come together to make driving a car an enjoyable experience. But in the dead of winter when we reach for de-icer or clean our windshields, we are grateful for them.

One company that helps our cars run at peak performance is Minnesota-based SPLASH, which manufactures and distributes windshield washer products, as well as de-icers, ice melt, antifreeze, pressure washer cleaner, wiper blades and all-purpose cleaners (Figure 1). In business since 1995, SPLASH operates out of Saint Paul, Minn., but, to manage increasing demand for its product, the company opened a second plant in Ayer, Mass. The company selected P.K. McGuane Plumbing and Heating as the plumbers for the new plant because of the relationship they already had built.

"Brian and his dad, Paul, have been our plumbers for many years," says Adam Lorance, manager at SPLASH. "They introduced Viega systems to me as a sturdy,

WINDSHIELD WASHER MANUFACTURER

Figure 1. SPLASH manufactures a variety of windshield washer products, including de-icers, bug removers and all-purpose cleaners.

time-saving union that would be able to withstand the chemicals we use and the harsh elements of the Northeast."

PLUMBING EFFICIENCY

Brian McGuane is a fourth-generation licensed master plumber working for the company owned by his father. McGuane took a class on business development after he started working for his father. In that class, he wrote a business plan with an emphasis on high-efficiency equipment. During his research, McGuane discovered Viega press fittings and decided to give it a try.

"The first job we did was a 4-in. copper line," McGuane says, "and the older guys who had never pressed before looked at me like I had two heads because there was no way that this was supposed to work."

But it did.

CORROSION-RESISTANT PIPING

Figure 2. Galvanized pipe because with a zinc material was used to make the steel pipe more resistant to corrosion.

"The first joint you press, you can't believe it worked," McGuane notes. "But you're done and can go on to the next one."

PRESS FITTING PROJECT

On the SPLASH project, McGuane was tasked with creating a plumbing system that would transport ethanol and methanol into and out of four 23,000-gal. rail cars; he suggested installing Viega MegaPress fittings.

Used as storage vessels, the rail cars are loaded by tanker trucks. When a tanker truck comes in, it connects to a pump, at which point SPLASH is able to select which rail car should be offloaded through the use of an electronic panel inside the facility that operates which valves open and close. Because the piping needed to withstand the harsh winters in Massachusetts, P.K. McGuane selected Viega MegaPress with an EPDM sealing element to connect the approximately 500 ft. of galvanized pipe used to transport the liquids. McGuane chose galvanized pipe because it is covered with a zinc material to make the steel pipe more resistant to corrosion (Figure 2).

A series of valves allow switching the direction of flow. Instead of only being able to extract methanol to use in the blending process, SPLASH can connect to the tanker truck to fill and extract at the same connection point (Figure 3).

"With that in mind, there was a higher

TRANSFER VALVE

Figure 3. Ethanol and methanol are transported to and from rail cars with a bidirectional flow valve.

amount of pressure because you're actually filling from the bottom of the rail car," Lorance explains. "Using Viega fittings did the trick, and we were able to sustain the pressure with absolutely no leaks."

P.K. McGuane got the job done quickly and efficiently to everyone's satisfaction, but the true test came during Massachusetts' punishing winters.

WITHSTANDING HARSH WINTERS

"It was a massively cold winter with lots of snow," McGuane remembers. "A big ice dam fell off the side of the building and hit my pipe. It was secured to the building with hangers, and the owner of the building told me that my hangers had failed."

McGuane went out to the project to check the damage. The falling ice had detached the pipe hangers from the wall, but he was stunned to realize that the pipe joined with press fittings was still intact. Not only was it intact, it was still holding pressure (100–120 psi).

FITTINGS THAT SPEED INSTALLATION

Press fittings not only provide a strong, secure connection, but they also help installers save time and labor.

"Threading is a pain," McGuane says. "It's really a two-man job, but sometimes you don't have enough room for two guys, or you don't have a second guy. It's just you fighting a machine. Using press fititings is a dream. You can do work that you couldn't have done before by yourself."

With the exception of the damage caused by the weather, the project was so successful that Lorance already is planning another project with the same setup.

"Methanol is a highly flammable chemical, so we needed to use couplings we knew we could trust, and it's been nothing but a success," Lorance says. "We are going to be doing another large project, and we definitely plan on incorporating Viega systems." ■

THE VIEGA GROUP manufactures and distributes plumbing, heating and pipe joining systems. Viega LLC currently offers more than 3,000 products in North America, including press technology systems like Viega ProPress for copper and stainless and Viega MegaPress for black iron pipe. www.viega.us

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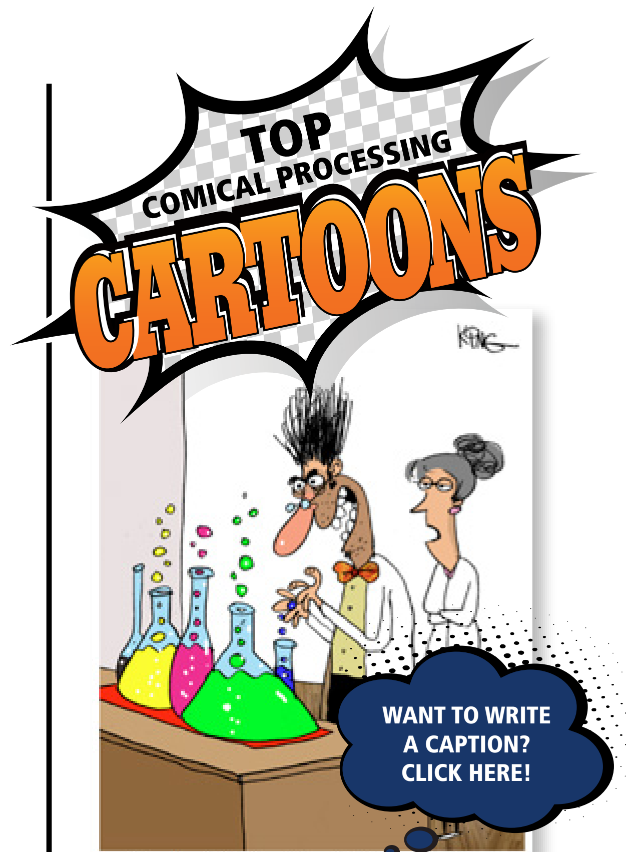

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