CONNECTION BULLETIN

Vogt Valves

Bellows Seal Valves

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Experience In Motion

Bellows Seal Valves

The Ultimate Solution to Preventing Fugitive Emissions through Valve Packing

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Abstract

Emerging Environmental Protection Agency (EPA) regulations will reduce the acceptance standard of volatile organic compounds (VOCs) fugitive emissions (leakage from equipment from 10,000 PPMV to 500 PPMV). User leak detection (screening) of operating equipment, including valves, will be a major part of this regulation. Reliably meeting the 500 PPM standard with standard high pressure/temperature packed valves will be suspect. EPA incentives to reduce fugitive emissions are expected to increase the usage of bellows valves with their "leakless characteristic." This paper presents information that correlates current PPM leakage data to the traditional standard cubic centimeters per minute leakage rates so familiar to the valve manufacturer and user. All the potential fugitive emission leakpaths in valves are discussed. Special testing procedures that can be used to detect leakpaths prior to valve shipment are presented. Current and available valve design features that remove the potential leakpaths are discussed.

A detailed review of how the bellows eliminates the most vulnerable fugitive emission leakpath in valves is discussed. The full scope of bellows valve issues, including bellows cycle life, corrosion resistance, pressure/temperature rating, higher costs and limitations, are presented.

VOC fugitive emission issues from all types of equipment (pumps, valves, compressors, flanges, etc.) will dominate the design discussions of the 1990s. This paper is especially timely in that it presents current information on the issue as it will impact on valves in VOC service.

About the Author

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He is active in the valve standardization activities of the American Society of Mechanical Engineers (ASME), the American Petroleum Institute (API), the Valve Manufacturers Association (VMA), the International Standardization Organization (ISO), and the Manufacturers Standardization Society of the Valve and Fitting Industry (MSS). He is currently serving as president of MSS.

Bellows (seal) valves will play a major role in the future as valve manufacturers prepare themselves to supply valves that are practically leak-free and can meet the emerging Federal Environmental Protection Agency's (EPA) fugitive emission (leakage) requirements for volatile organic compounds (VOCS) in the 500 PPMV (parts per million in volumetric terms; hereafter PPM) range. The correlation of PPM leakage, determined by screening the atmosphere about an operating valve with a portable organic analyzer, versus actual mass or volumetric leakage is currently the source of a lot of investigative work. Table 1 gives an EPA method for estimating emissions from various equipment sources by use of an average emission factor. Work is underway to develop new data and improve the correlation for fugitive emissions in the 500 PPM range.

It can be translated that the 500 PPM fugitive emissions requirement will parallel leakage from valves commonly witnessed by air-under-water testing, where countable air bubbles of leakage develop. The recognized test standards used to test valves supplied today are not expected to detect valves with such small leaks. In fact, the current test standards do not even require the more sensitive gas testing required to find such small leaks in a valve's vulnerable areas such as the packing, bonnet and gasketed joints. New valve designs and special testing procedures will be required to reliably meet the VOCs fugitive emissions requirements.

Bellows valve designs will emerge as a popular way to meet the VOCs fugitive emissions requirements because they eliminate the most vulnerable leakage path in a valve-the valve stem/packing path.

However, the addition of a bellows to a valve is not a cure-all for fugitive emissions from valves, because it eliminates only one of several leak paths. The other vulnerable areas in valve designs that can allow leakage to the environment, which can exceed the EPA VOC leakage requirements, are summarized as follows (see Figure 1):

1. Valve bonnet joint
2. Valve closure elements (seat, disc, gate, etc.)
3. Valve flanged or threaded connections
4. Valve socket welded or butt welded connections
5. Valve pressure boundary parts (castings, forgings, bar stock, etc.)

All the above areas must be considered as VOC leakage paths. Valve design, testing, installation and maintenance improvements must be made if valve manufacturers and users are to reliably eliminate the VOC leakage possibilities. The valve manufacturers may be expected to design, manufacture and test their products to assure that all the above vulnerabilities are overcome. Yet the above list includes VOC leak path possibilities in valves, such as valve piping connections, that the valve manufacturers have little control over. The valve installer and operators will have major responsibilities in eliminating VOC leakage from valves by properly installing, operating and maintaining them.

The valve manufacturers are expected to eliminate as many of the potential leak paths in their valve designs as possible. This can be done with current available designs described in the following discussion.

Bonnet Joints

Valve bonnet joints with gaskets are no better than the gaskets that seal them. There are well-designed gasketed bonnet joints that can meet the fugitive emission requirements. The gaskets for these designs must sustain the joint under all design pressure/temperature conditions, but reliability data developed by some users may prove the gasket joint unacceptable for their use. Next to the valve packing, gasketed joints present the greatest possibility of a leak path to the atmosphere.

The highly reliable welded or threaded and seal welded bonnet joint valve designs have been successfully used for years to eliminate this potential leak path to the atmosphere and are expected to become more popular for valves in VOC service. (Compare Figure 1 and Figure 2, gasketed and seal welded bonnet designs, respectively.)

Figure 1

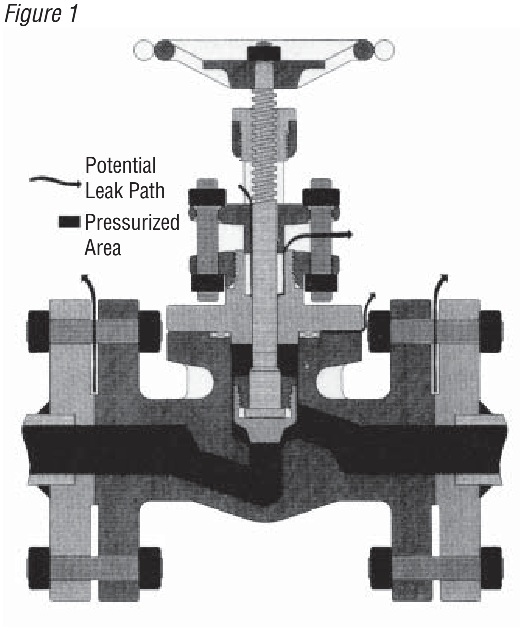
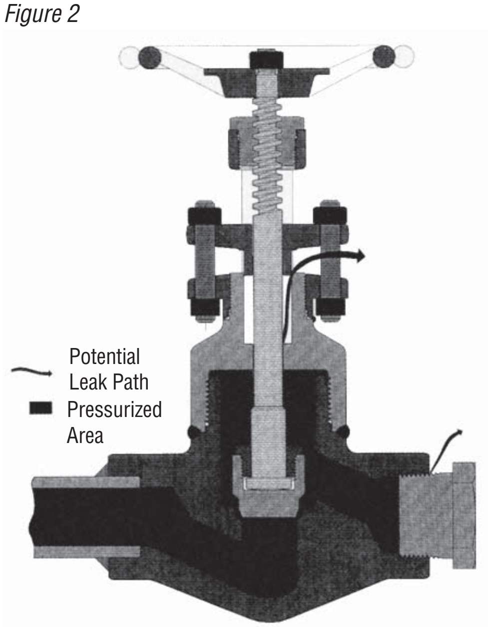


Figure 2



Valve Closure Elements (Gate/Seat Rings or Globe Discs/Seats)

Shutoff valves that are installed where the outlet side is open to the atmosphere)such as drip, drain or vent applications) should have reliable closure elements to seal the valve when closed. Such valves are subject to full pressure drops and high velocity flows with entrained debris that is capable of damaging the seats during operation. EPA rules are expected to require that such valves have a threaded plug or a blind flanged cover installed in the downstream port to back up the valve closure element. See Figure 2.

With this redundancy in place, a buildup of pressure on the packing will occur if the valve closure should leak. For this reason, a bellows valve should be considered for drip, drain or vent service valves in VOC service to totally isolate the valve packing from leaking to the atmosphere. As an alternate to plugging the downstream port of valves, the EPA rules may also allow dual valving on drip, drain and vent lines. In either case—plugging or dual valving—globe valves perform better than gate valves in drip, drain or vent applications because their seats are not as sensitive to damage by high velocity debris-laden flow. Valve closure element reliability can be greatly improved in gate and globe valves by lapping closure parts to a fine finish and by performing a supplemental high pressure gas test prior to shipment. Attention during valve operation by the valve operator to closure torque and sequence of opening and closing dual valving will also improve the service of the valves.

Flanged and Threaded Connections

Valve manufacturers are in a unique position relating to these vulnerabilities. The actual sealing mechanics of the pipe thread and flanged gasket connections are not tested by the valve manufacturers as part of the 100% final leak testing required of all valves. Pipe flanges, including the gasket faces, are manufactured to nationally recognized standards, and the valve user (installer) must control the selection of gaskets and make-up of these connections to ensure leak-free performance. User experience must be drawn on in this area, because the design standard for flange gasket joints or the total flanged valve do not require the valve manufacturer to test the gasketed joint. The preponderance of user experience indicates that gasketed flange joints utilizing non-asbestos gasketing materials will require a more restrictive gasket face finish range than required by the current flange standard.

The pipe threads used today in valves are manufactured to a national standard, which has as its intent that a thread sealant must be used to make a pressure-tight joint. The sealant's compatibility with the flowing fluid and service temperature must be considered to ensure a leak-free joint. The loss of thread sealant may allow the joint to leak beyond VOC emission requirements. A dry seal pipe thread standard exists for pipe threads that can be made up without a thread sealant, but it has not gained much popularity. Little data are available on its capability to provide a leak-tight joint. The requirements for testing of threaded and flange joints of installed valves are covered under the appropriate piping code and are the responsibility of the valve installer or user. It is expected that gas testing of these joints will become necessary for those users that continue to depend on threaded and gasketed flange joints for use in VOC service.

Highly reliable socket and butt welded valves are expected to become more popular to replace threaded and flanged valves going into high pressure/temperature VOC service. Welded joints are not expected to require monitoring as part of the EPA fugitive emission requirements.

Valve Pressure Boundary Parts

Valve castings (bodies, bonnets, gates and discs) must be high pressure gas tested to reliably detect small leaks that pass through porosity type defects. VOC leaks in the 500 PPM category are so small that it is unlikely that current test standards, which permit the use of high pressure water for testing of the valve pressure boundary, would detect such a small leak. Pressure boundary valve forgings offer high reliability in this area. It is expected that forged valves will be a popular choice for VOC service.

The emerging popularity of welded joint and pipe connections to eliminate leak path must be supported by quality welding processes. It makes no sense to replace a gasketed joint with a poor-quality welded connection. Valve manufacturers and valve installers will have to place great emphasis on the quality of welds to ensure the elimination of leakage of valves in VOC service. Special high pressure gas testing of VOC valves is also expected to emerge as a method for manufacturers to reliably supply valves that meet the EPA fugitive emission requirements.

In the author's paper, "A Treatise on Leakage" (available from Flowserve Vogt Valves), it was theoretically and practically presented that gas leakage greatly exceeds water leakage and valves tested on water to a no-visible-leakage standard can leak when placed in gas service. The paper also presents why hydrocarbon liquids leak less than do their vapors. VOC fluids include liquids and/or vapors with low viscosities when compared with the typical test media, water; and, as the paper presents, the lower the viscosity, the greater the leakage potential. Testing valves with water as the national test standards permit may not detect small leaks that can occur on valves used in VOC service. Gas testing of valves is a much more sensitive method than water testing when looking for leaks in the 500 PPM range. It is expected that supplemental high pressure gas testing will become popular for valves going into high pressure gaseous VOC service where leak rates less than 500 PPM must be maintained.

Packed Valves

The stem/packing leak path is the most vulnerable leak path to the environment in a valve design. It is also the most difficult and expensive leak path to eliminate. The valve's packing is a dynamic seal and must perform its function during idle periods, when pressure and temperatures can fluctuate within the full pressure/temperature capability of the valve, and during periods when the valve stem is stroked.

One former supplier of asbestos packing reported that in high pressure dry gas service, some leakage must be tolerated because the asbestos packing is not capable of effectively sealing the gas. It has also been reported that asbestos packing sets in certain high performance chemical and refinery valves had emissions routinely in the 350,000–500,000 PPM range after six months of usage. Flowserve Vogt's own in-house testing of asbestos packing has proven that leak rates of high pressure dry gases significantly exceed that required for valves in VOC service.

Flexible graphite packing set tests indicate that it is superior to asbestos in leak tightness and very capable of sustaining leak rates less than 1000 PPM. However, if a leak is left unattended in such packing, it has the potential to escalate and cannot be stopped by merely adjusting the packing.

It is expected that for most high pressure/temperature VOC gas applications, the user will look for more reliable ways to eliminate packed valves. For high pressure/low temperature VOC applications, the use of shaped PTFE packing (cup and cone, chevron, etc.) has proven very successful in providing leak-free service in nitrogen, helium and air service. VOC leak rates less than 25 PPM have been achieved with this type of packing. With this success, it is expected that shaped PTFE packing will become popular in valves for VOC service, providing the service temperature is less than 450°F and fire-safe considerations can be met.

An aggressive leak detection and maintenance program will be required to reliably meet and maintain the VOC emission requirements for those valve users that continue to depend on packed valves in VOC service. Leak performance testing by the manufacturer is also expected to become a condition of sale.

The continued acceptability of packed valves in VOC service may be legislated against by state regulations that prescribe design fugitive emissions expected for various types of valves. The piping designers using these prescribed design fugitive emissions may find it impossible with packed valves to meet the total plant design fugitive emission requirements when large quantities of valves may be required in the installation. In this case, the only option will be to use bellows valves that are considered “leakless” by many state regulations. To improve the reliability of the stem/packing leak path, valve manufacturers are expected to rely on metal bellows designs that totally isolate the packing.

The main purpose for a bellows in a gate or globe valve is to eliminate the stem packing leak path. The bellows is the primary sealing element between the valve stem/packing leak path and the environment. The packing normally supplied in a bellows valve serves only in a backup role in the unlikely event the bellows develops a leak. Even though the packing is under no pressure, the selection of packing to perform its long-term backup role should not be considered lightly. Packing maintenance is not expected to receive much attention in a bellows valve during operation; and if the packing must be relied on in the event of a bellows failure, a major VOC escape path could exist if it doesn’t perform. An abbreviated packing seal is not recommended for a bellows valve because of its backup role.

Bellows-Seal Valves

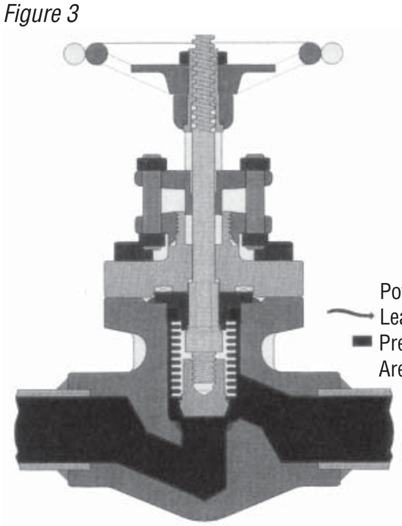
The heart of a bellows valve is the bellows. A bellows is a continuous convoluted tube that can sustain external or internal pressure and, much like a coiled spring, can be flexed in compression or extension. The bellows totally surrounds the rising valve stem and also covers the stem penetration (packing chamber) with a flexible pressure barrier. Numerous manufacturing methods are used to make bellows for gate and globe valves today.

The hydraulically formed bellows normally starts with a seamless tube or sheet stock hydraulically formed into a cylinder. The tube or cylinder is expanded outward by hydraulic pressure into longitudinally collapsing dies to form the convolutions. Good bellows uniformity is achieved and the hydraulic pressure used to form the bellows inherently tests the bellows material for defects during manufacturing. There is a limit on the length of the bellows that can be manufactured by hydraulic forming; and it is expected that in gate valves (with their large lift requirements), two or three bellows circumferentially welded in series will be required to minimize the unit convolution deflection needed to support the total valve stroke.

The roll formed bellows are widely used. In this process thin material is rolled into a tube, seam welded; and the convolutions are formed in the tube by rolling into shaped dies. This is the least expensive method to manufacture bellows, and they can be made to greater lengths than the hydraulically formed bellows. They are popular in bellows gate valves. The longitudinal seam weld over the full length of the bellows is characteristic of this method of manufacture, and its reliability is paramount to the success of this bellows design.

The welded bellows is made from a multiply stack of diaphragms circumferentially welded together at the inside and outside edge of each convolution. A minimum of nine welds would be required to make a single-ply bellows with five convolutions. Such a bellows can normally sustain greater compression and extension (stroke) than can other bellows designs leading to a more compact bellows valve. It is more expensive, and its performance is heavily dependent on the reliability of the welding process used in manufacturing of the individual convolutions of the bellows.

Figure 3



The bellows design length must be such that the unit convolution deflection and total number of convolutions will support the full stroke of the valve. Each convolution of a bellows, much like a spring, shares equally in the total deflection of a bellows. Life expectancy or cycle life of a bellows is greatly influenced by the length of its stroke. The stroke should be an in-line mode. Lateral or angular offset in a bellows design reduces cycle life. A bellows can be made to fail merely by stroking. Overstroking of a bellows beyond its elastic limit reduces life expectancy tremendously. Conversely, the cycle life of a bellows can be greatly improved by reducing its stroke.

The bellows response to compression or extension is characterized by its spring rate (lb/in deflection). Equal increments of load lead to equal deflection within the elastic limit of the bellows material. In bellows gate and globe valve designs, it is important to keep the bellows spring rate as low as possible. The lower the spring rate, the lower the handwheel torque required just to flex the bellows.

Overextending or overcompressing a bellows can lead to convolution damage and low cycle life. A rule of thumb suggests that bellows extension should be limited to approximately 20% of the total stroke of the bellows. Most bellows support load better in compression than in extension.

In addition to stroke, cyclic pressure on the bellows is another factor that affects cycle life of a bellows. The cycle life of a bellows is controlled more by stress change in a bellows during its service than by stress level. The stress change in a bellows generated by cyclic stroke and cyclic pressure can be formulated as follows:

$$\text{Stress Change} = \begin{array}{c}\text{Bending Stress (cyclic stroke)} \\ + \\ \text{Pressure Stress (cyclic presure)}\end{array}$$

In a bellows gate or globe valve, the stress change in the bellows is a function of the valve stroke and the differential pressure experienced by the bellows during its stroke. If the valve is not stroked, then the only stress change in the bellows is due to the differential pressure experienced by the bellows during its service life. The bellows cycle life could be infinite if the bellows endurance strength was not exceeded during pressure fluctuation. If the bellows is stroked while the pressure on the bellows remains constant, the cycle life is expected to be better than if the pressure fluctuates widely. This is a major consideration when comparing advertised cycle lives of bellows valves from various manufacturers. The comparison of test data on cycle life for bellows valves should be made on the basis that all bellows are pressurized to a common pressure, such as the valve's 100°F rated pressure and stroked to the full stroke requirements of the valve in which they are to be used. The cycle life of a bellows valve is determined by flexing it to its full design stroke while exposing it to its full design pressure. A constant pressure during cycle testing is less severe than a highly fluctuating pressure.

The pressure retention capability of a bellows is determined by a modified version of the thin wall formula for tubing, and this capability must be carefully balanced with its flexibility and spring rate. Doubling the wall thickness of a bellows will increase its pressure retention capability but will reduce its stroke significantly and increase its spring rate eightfold. The higher spring rate would lead to higher handwheel torques just to mechanically stroke the valve bellows. The reduction in stroke and increase in spring rate due to thicker bellows may be unacceptable for gate and globe valve designs. Valve and bellows designers balance pressure retention capability, flexibility and spring rate of a bellows by using a multiply design. The pressure that a bellows can withstand can be doubled or tripled by using two or three plies of metal wall. If one wall thickness will withstand a certain pressure and compression/extension, a two- or three-ply bellows of the same wall thickness will withstand two or three times the pressure while maintaining the same extension/compression. Conversely, if a one-ply bellows has the wall thickness equivalent to a two-ply or three-ply, it will withstand the same pressure as the multiply bellows; but its stroke (compression/extension) will be significantly reduced, while the spring rate is increased at a rate approximately equal to the cube of the wall thickness. Two- and three-ply bellows are common in bellows gate and globe valve designs.

Elevated service temperature of bellows leads to a decline in tensile strength and may reduce cycle life. The bellows valve operating pressures must be reduced by a pressure/temperature rating scheme if the cycle life of the bellows is to be maintained at elevated service temperatures.

Incorporating the bellows into a globe or gate valve must be well thought out. The first consideration must be in the selection of the bellows material and its corrosion resistance. In the normal ASME/ANSI B16.34, *Valves—Flanged, Threaded, and Welding End*, or API-602, *Compact Steel Gate Valves*, globe or gate type valves, the minimum wall thickness requirements for the pressure boundary include a corrosion allowance of approximately .125". Yet the bellows that isolates the packing in these valves is of membrane proportions and must also withstand the full 100°F pressure rating of the valve. Typical total wall thicknesses for bellows used in gate and globe valves are in the .005" to .012" range. Such membrane thicknesses are only a small fraction of the corrosion allowance thickness inherent in the pressure boundary parts of valves supplied today to credible national valve standards. This means that the bellows must be made of a material whose corrosion resistance greatly exceeds that of the valve pressure boundaries and interfacing the bellows into the valve design cannot violate this corrosion resistance. Interfacing the bellows into the valve usually by welding must be done in such a manner that the corrosion resistance inherent in the bellows material is not deteriorated. The effective thickness of the weld to interface the bellows into the valve and to create the pressure-tight barrier is expected to be no more than the thickness of the bellows. The corrosion resistant membrane-thick bellows should not be welded directly to a carbon steel or alloy steel body, bonnet, disc, stem or transition piece. The stem and disc may be made of the same material as the bellows in small valves, so in this case welding the bellows directly to the disc or stem is acceptable. The best way of transitioning the bellows into the valve's carbon or alloy steel bonnet, disc and/or stem is by using a specially designed corrosion resistant transition piece of substantial thickness made of the same material as the bellows. The thickness of the weld of the transition piece to the carbon steel or alloy steel body, bonnet, stem or disc should exceed .125", restoring the corrosion allowance inherent in the wall thickness of the body and bonnet. See Figure 3.

The pressure/temperature (P/T) rating of bellows valves is currently a source of confusion. The reason for this may be British Standard BS 5352, *Steel Wedae Gate, Globe and Check Valves, 50 MM and Smaller for the Petroleum, Petrochemical, and Industries*, which identifies a Class 800 bellows valve with a P/T rating scheme that closely approximates the ASME/ANSI B16.34 Class 600 P/T rating. The API-602-1988 Edition Class 800 P/T rating has exact agreement with the ASME/ANSI B16.34 standard. The BS 5352 Class 800 P/T rating scheme for bellows valves is totally different than the P/T scheme they use for their standard gate valve equivalent to the API-602 gate valve. Since the BS 5352 is the only standard that has published P/T ratings for Class 800 bellows valves—and many bellows valves are foreign made—Class 800 gate and globe valves are being offered today with P/T ratings that do not meet the Class 600 or 800 P/T ratings of a typical ASME/ANSI B16.34 or API-602 valve. Some Class 600 and Class 800 bellows valves are also being offered today that place a maximum pressure limitation on the valve less than 65% of the 100°F pressure rating of a Class 600 and/or Class 800 valve. Due to this pressure limitation, the user should be aware that the purchase of some Class 600 and Class 800 bellows valves may not be used in the full P/T rating expected of such a valve.

Bellows Seal Valve Limitations

There are a number of limitations that can be expected from a bellows valve. They can be summarized as follows:

Cycle Life Bellows have a finite life when used in valves that expose them to pressure fluctuations and full compression and extension loads. BS-5352 requires that bellows gate valves have a 2000 cycle life and that globe valves have a 10,000 cycle life. The cycle life limitation may not allow their use in some highly stroked valves whose cycle life exceeds the bellows life. The cycle life limitation will require a quality backup packing system to overcome a leak in the bellows.

Pressure Retention Capability Since bellows are designed with the intent that thin wall formulas be used, bellows with membrane thickness that provide flexibility and low spring rates are the outcome. It is highly unlikely that bellows can be designed to interface with larger high pressure valves that have traditionally used the thick wall formulas in designing of the pressure boundary. It may not be possible to design bellows for use in gate and globe valves that can retain high pressures while providing flexibility and a low spring rate.

Size Limitation The operating torque of a standard gate or globe valve is influenced by the area of the stem and the operating pressure acting on this area. The load on a bellows valve stem is a function of the bellows inside/outside diameters. The size of the bellows required to accommodate the stem, pressure and stroke of larger valves may lead to a bellows with a spring rate and unbalanced area on the valve stem so large that it will be impractical to operate when used in a gate or globe valve.

Corrosion Control The selection of the material for the bellows will be critical. Matching of service to the bellows material will require greater caution because unlike the pressure boundary of a valve, there is no inherent corrosion allowance in the bellows of a bellows valve.

Bellows are typically available in 304, 316, 321 stainless steels, Inconels 600 and 625, Incoloy 825, Monel 400 and Hastelloy “C” materials.

Envelope Dimensions Bellows gate valves will have a much greater height than the conventional gate valves. The bellows must be designed to accommodate the high stroke requirements of a gate valve. This leads to a long bellows that requires the bellows gate valve to be extended, impacting on piping configuration and layout.

Bellows Valve Costs It is expected that bellows valves will be anywhere from three to ten times more expensive than their standard packed valve equivalent. This higher cost is primarily due to the cost of the bellows and interfacing it to the valve pressure boundary. The higher price tag for reliable bellows valves still may be economically attractive when reviewed in regard to emerging EPA requirements and incentives.

A Quality Improvement Program (QIP) will be required for those plants who consistently have more than 2% of their valves exceeding the 500 PPM fugitive emission requirement. Greater valve repair and leakage monitoring costs are expected to result as part of this program. There are also incentives in the EPA requirement that will reduce the monitoring requirement for bellows valves reducing the leak detection costs.

Flowserve Vogt Bellows Seal Valve Program Finite Element Analysis has been used to design the bellows for Vogt valves. This is a great engineering tool for designing bellows and moves away from the traditional approach that utilized a great amount of empirical data and formulas.

Table 1 – Average Emission Factors for Fugitive Emisions

Equipment	Service	Emission Factor (kg/hr/source)
Valves	Gas	0.0056
	Light Liquid	0.0071
	Heavy Liquid	0.00023
Pump Seals	Light Liquid	0.0494
	Heavy Liquid	0.0214
Compressor Seals	Gas/Vapor	0.228
Pressure Relief Seals	Gas/Vapor	0.104
Flanges	All	0.00083
Open-Ended Lines	All	0.0017
Sampling Connections	All	0.0150

The most basic method for estimating emissions requires application of average emissions factors, developed by EPA. The product of the emissions factor and the number of equipment components yield the emissions rate per source type; and the emission rates for all source types are summed to generate the unit-specific emissions estimates. Screening is not required with the above method. Other EPA methods require screening of equipment leaks on a sample basis.

Reference: EPA-450/3-88-010, Oct. 1988, Protocols for Generating Unit-Specific Emissions Estimates for Equipment Leaks of VOC and VHAP, Section 2 and Table 2.1.

Flowserve Vogt bellows valves utilize hydraulically formed multi-ply bellows. The bellows are welded into a bellows subassembly to ensure that the corrosion resistance of the membrane-thick bellows is maintained. They are designed to ensure that no torque is placed on the bellows during operation and that the bellows does not experience any angular or lateral offset. The design permits in-line compression and/or extension of the bellows only. All Vogt bellows subassemblies are tested before assembly into the valve with a helium mass spectrometer to detect helium leaks in the 10^{-7} standard cubic centimeter per second range. Such a small leak would not generate a bubble in an air-underwater test. It would take years for 1 cc of leakage to occur.

All Vogt bellows valves use long-life flexible graphite as the backup packing. A full size packing chamber is used. The valves are also designed with backseats to provide additional insurance that the stem/packing leak path can be eliminated even in the event the bellows and packing should fail.

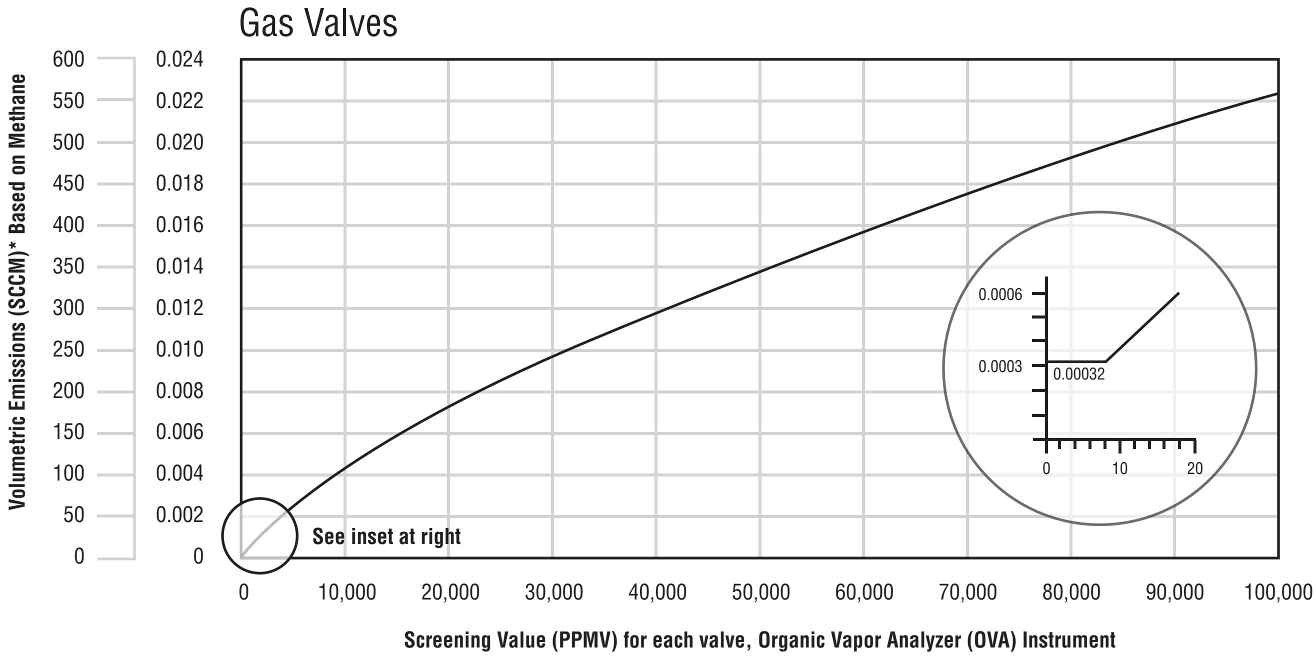
Vogt bellows valves use seal welded construction in their globe and gate valves. Even though the globe valve has a bonnet gasket (Figure 3), this gasket (like the packing) is only used in a backup role in the event of bellows failure. As Figure 3 illustrates, the bellows subassembly is seal welded to the body and the gasket is under no pressure as long as the bellows remains leak-tight

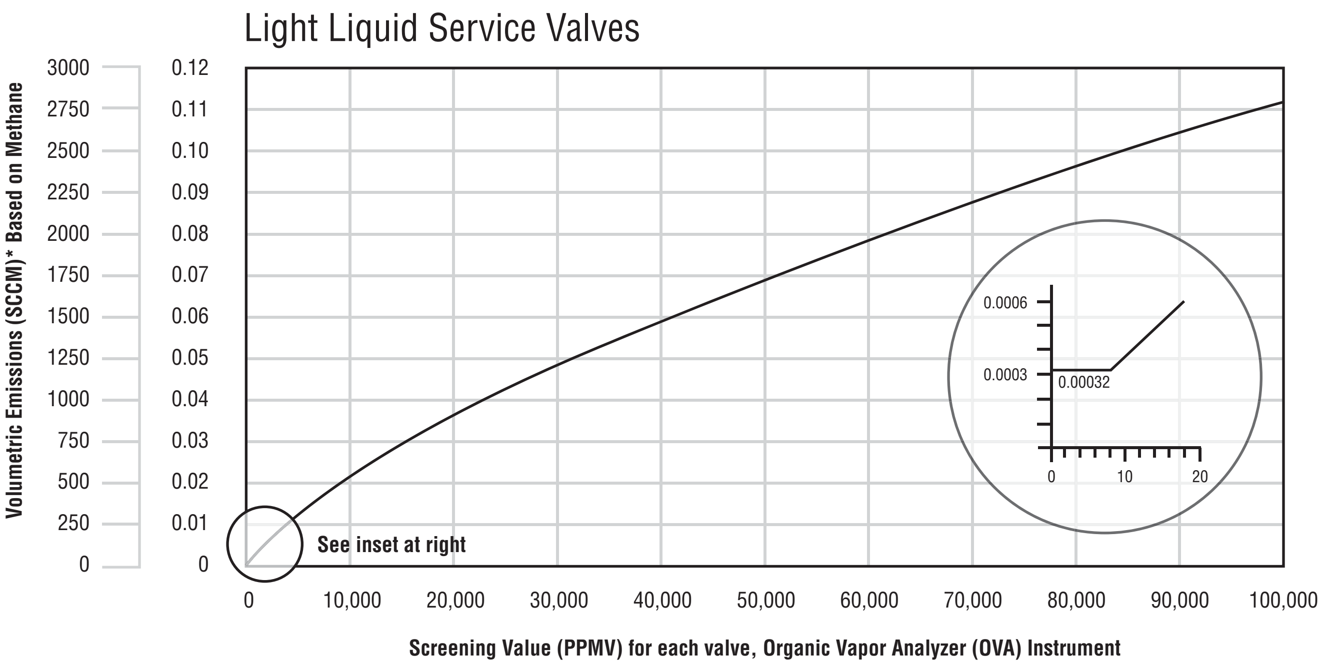
Vogt bellows valve pressure/temperature rating scheme is in accordance with ASME/ANSI B16.34, and they can be used within the full P/T scheme of the applicable class of ASME/ANSI B16.34. The 100°F pressure rating is not restricted and is equal to the ASME/ANSI B16.34 rating for the applicable class.

The life cycle of Vogt bellows valves is based on the bellows being pressurized to the 100°F rating while it is fully stroked. This includes extension and compression, since Vogt bellows are designed to be extended during full closure of the valve. During cycle testing, the pressure is allowed to fluctuate, which is worst-case-type testing.

In addition to the normal national standard required testing, all Vogt bellows valves are gas pressure tested following assembly. This testing is specifically designed to detect any leakage at the seal welds and valve closure elements. A full series of Class 150, 300 and 600 valves are offered. Work is underway to extend our line to include a Class 1500 series of gate and globe valves. The gasket surfaces for flanged bellows valves have a restricted finish of Ra 125–250 microinches.

Mass Emission Factor vs. Screening Value





** Standard Cubic Centimeters per Minute*

These graphs (mass emissions versus screening value) are based on the prediction equations for nonmethane leak rate for valves in Synthetic Organic Chemical Manufacturing Industry (SOCMI) processes in which the default zero values (≤8 PPMV) have been shown.

The volumetric flow rate based on methane has been added as a practical reference to compare a typical methane volumetric leak to the wt. flow leakage predicted by the equations.

Reference: EPA-450/3-88-01 0, Oct. 1988, Protocols for Generating Unit-Specific Emissions Estimates for Equipment Leaks of VOC and VHAP (Volatile Hazardous Air Pollutants), Section 2.5 and Appendix D.

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