Operating and Safety benefits of Bellows Sealed Globe Valves (BSGV) compared with conventional valve designs

Ms. Aneta Stephens, Director, Global Marketing Communications, Mr. Thorsten S. Beyer, Area Sales Manager Central & South Germany (ASM), Crane ChemPharma & Energy

Introduction:

Industries whose production methods incorporate-conveying and processing of materials continually search for safer and more economic means of production while enabling increased output. The Chemical, Refining, and Pharmaceutical industries are included in this category. Each essential componentwithin a processing system can impose productivity constraints on the entire system. Each element in a processing system needs to permit increased throughput while accommodating plant safety and environmental concerns and must comply with relevant industry standards and legislation. Every critical component in a processing system affects the effectiveness of the entire system, determining the plant's capacity to deliver results according to production targets. Valves play such a critical role in most processing environments.

Development of valve technologies matches demands of industry and typically aims at meeting or exceeding requirements in terms of safety and production efficiency. Conventional technologies are increasingly being replaced by designs that are more effective and which comply with new industry standards. Lifetime cost of ownership is a measure often used to determine the real value of a valve and such a calculation ought to take account of the cost of outages, downtime for maintenance, and potential expenses associated with environmental clean-up or containment. There is a growing industry acceptance of the fact that the most optimal valve type for hazardous media processing (also called "demanding" applications) is known as the "bellows sealed globe valve" (BSGV). It is designed to meet current and evolving requirements of "processing industries."

The ability to exercise strict control over inadvertent release of environmental pollutants is paramount in processing operations. To control and minimize leakage risk, it is necessary to deploy high quality valves that can maintain a tight shutoff, facilitated by the leak resistant design and construction of bellows sealed globe valves (BSGV). A high quality bellows sealed globe valve incorporates several essential design principles, such as a leak-tight seal around the valve stem.

In order to demonstrate the advantages of BSGVs, we will discuss comparisons of several valve types, and will contrast the pros and cons of conventional valve technologies against those of BSGVs. These comparisons will be based on construction features, technical advantages, and total cost of ownership over the life of the valve.

General Overview

Valves are a critical component of fluid processing systems as their role is to stop or regulate the flow of fluid into a designated area of the system. Valves can be operated manually or be automated with a variety of actuators depending on the style and operation of the valve. Many valves can operate as isolation valves that shut down a specific segment of a processing system. Valves are often exposed to challenging or even extreme conditions. The valve body material and all internals which are in a direct and constant contact with the medium have to be resistant against its destructive characteristics. Very frequently, the medium being processed is very aggressive, toxic, inflammable, abrasive, corrosive, and sometimes explosive. The next challenge is to enable tight shutoff, which in BSGVs occurs between the piston and the seat. Another concern, and one that is often overlooked or underestimated by users and the market generally, is the performance of the top flange and stem sealing, where even high quality products can fail and start to leak. Additionally, pipeline and process design and operating parameters may introduce unique challenges that the valve must withstand while continuing to operate as specified. A few examples are:

- Temperature: Extremely low or high temperatures or rapidly changing temperatures with a huge delta.
- Pressure: The number of possible failure points increase with rise in pressure. Typical leak areas include packing, top flange sealing, and piston/seat (some or all of which in some cases have to be redesigned to handle ultra-high pressures).
- Flow rate: Long pipes or multiple valves typically reduce the flow and pressure dramatically, and flow co-efficients and pressure drop ratings of a valve can become critical to ensure constant flow through the system.

Public concern about the effect on environment arising from the actions of business, government and individuals is expected to become more persistent. The "going green" movement is impacting the expectations and practices of chemical, petrochemical, and other processing plants, and will influence the design and operating methods in the future. Many such developments are driven by environmentally activist organizations, while others are a consequence of changing governmental regulations or industrial standards. Standards like the German TA-Luft, relevant US EPA laws and the European Norm ISO 15848, are aimed at reducing hazardous emissions through stricter environmental standards. These trends also become evident in countries where until recently hazardous emission control was not a significant public concern.

The industries representing the largest market for valves are chemical, petrochemical, oil & gas, pharmaceutical, and mining. As might be expected, with increases in the level of hazard presented by a particular type of application or process the extent of relevant regulationsincreases as well. The global processing industry emulates many practices and standards already well-established in America and Europe. Increasingly, however, the Asian-Pacific region develops its own standards or adapts other established standards to the particular needs of that region's developing economies.

The valve market is relatively conservative in its adoption of new technologies and standards, unlike electronic consumer goods, information technology, or Internet based market segments. Such conservative approach is made necessary by the far reaching consequences and costs relating to the potential for leaking hazardous materials into the atmosphere and the environment. Accordingly, new developments have to endure long periods of testing, and often a period of field deployment before becoming "accepted technology." As is the case in most industries, innovation does become faster over time and it will continue to do so in valve design and manufacture. It will be driven by a combination of what may be competing objectives, one being to improve efficiency and the other striving to improve safety and compliance with environmental and other regulations or standards.

Valve designs and applications

The European standard EN 736-1:1995 distinguishes between isolating, regulating, and control valves, as follows:

- Isolating valves - Valves intended for use only in the closed or fully open position.
- Regulating valves - Valves intended for use in any position between closed and fully open.
- Control valves - Power-operated devices which change the fluid flow rate in a process control system.

Isolation valves are used in a wide variety of different applications where On/Off type control is required, including:

- Diverting process media.
- Flow isolation to:
  - Facilitate maintenance
  - Allow the removal of equipment
  - Allow the shutdown of a plant

A variety of types and designs of isolation valves have been developed in order to support this range of applications and the diverse operating conditions in which they are deployed. Valves are further categorized into two groups (see Table below), based on the direction of motion of the closure device (obturator).

- Linear movement valves - The plug (the part that presses against the aperture or opening which either stops or governs flow through the valve) moves in a straight line. Included in this category are gate valves, globe valves, diaphragm valves, and pinch valves.
- Rotary movement valves - The plug rotates about an axis at right angles to the direction of flow. Ball valves and butterfly valves are the two most important rotary valve types associated with steam applications.

An overview of the benefits and drawbacks of valve types:

Valve Type	PROs	CONs
Gate	• High flow rate • Small installation interface	• Long stroke travel • Complex design
Globe	• Tight shutoff between plug & seat • Virtually no leakage (especially if bellows sealed) • Lower life time cost and low downtime/ maintenance	• Lower flow rate • Higher purchase price
Ball	• High flow rate	• Potential for media traps • High wear-out of the inner sealing materials/plug • Environmental leakage susceptible
Butterfly	• Lower purchase price	• Disc surfaces located in the media stream • Environmental leakage susceptible

Industry requirements and standards pertaining to valves

Users (mostly processing plants) require valves that minimize impedance of flow otherwise achievable in their processing system, while minimizing pressure drops between the ingress and egress points in the valve. Such objectives have to be obtained while satisfying all regulations as they pertain to safety and the environment.

Demanding applications (processing hazardous media) call for valve designs that are especially reliable in terms of safety and environmental protection, without undue effects on productivity. This is made all the more challenging when these objectives have to be achieved at the minimal lifetime product cost of operation.

This requires a valve design that accommodates mutual constraints of these objectives.

Design challenges

Typical design challenges can be categorized by four topics:

1. Material

Demanding applications are those where the medium ("fluid" or slurry) possesses various hazardous or aggressive characteristics, such as being inflammable, explosive, volatile, or toxic and whose unwanted emission into the atmosphere and the environment must be prevented.

Demanding applications require the use of highly impervious and damage resistant materials, which is made more challenging where the wetted part is in continued contact with aggressive chemical media. Even the construction of the valve bonnet and other external parts, such as nuts and bolts, may be exposed to harsh conditions which often lead to corrosion or other structural damage.

2. Temperature & Pressure:

Severe (high or low) temperatures or fluctuation between high and low tempertures can create operating conditions that might not be easily accommodated by any single common material and specialized materials must be selected to suit the mix of conditions for which a valve is intended. Extreme swings and frequent changes in temperature may further restrict the options, as fewer materials can withstand these conditions without its properties deteriorating beyond tolerance. High pressure designs require significant strengthening of the materials and increasingly robust multiple-wall high pressure bellows. Temperature and pressure vary in direct relation – as one increases, so does the other (where volume remains constant), and both have to be considered.

3. Flow characteristic
Different valve styles and designs (apart from size considerations) permit different flow rates and impart different flow characteristics to the medium. Maximization of flow rates and minimization of pressure drops are usually the desired and required characteristics when choosing among valve options. Energy cost, design requirements and overall system efficiency are the main drivers for the high flow rate requirement.

4. Shutdown
In applications where aggressive media are processed, a tight shutoff or shutdown class of valves is required. Also known as "Bubble tight", such a shutoff is necessary to assure safety and security for plant operations and maintenance staff, as well as to protect the environment.

Industrial Standards

Industrial standards vary geographically, as well as by industry and segment. Among the more universal ones are standards issued under the authority of ASME, DIN, and EN, which serve to define requirements for valve designs and their performance parameters and specify safety prerequisites. Although other standards and standard-setting bodies are gaining recognition globally, due consideration continues to be given to the aforementioned established standards organizations.

Safety Considerations and Standards

Two criteria are generally accepted as a measure of the safety of valves: how tightly they perform in shutoff position, and how much unwanted emission (if any) can be measured during operation over a specified period. No one can absolutely guarantee that a given valve will allow zero emissions under any circumstances over any length of time. What can be guaranteed, is that a given valve will allow less than "x" amount of unwanted emission (where x can be arbitrarily small) under defined conditions and over specified time. To address the requirement to be able to rate the safety of valves, two major standards for emission control have been issued. They are TA-Luft and the more recently developed EN15848.

TA-Luft

The scope of TA-Luft is defined by its own statement of applicability: "These Technical Instructions serve to protect the general public and the neighborhood (of a plant) against harmful effects of air pollution on the environment and to provide precautions against harmful effects of air pollution in order to attain a high level of protection for the environment generally."

Established in 1964 and amended multiple times, most recently in 2002, the standard is widely recognized. However, its official jurisdiction is limited to Germany, and while it serves as a reference and is used elsewhere as a proxy for local standards, it is not expressly given official status by other governments.

TA Luft only provides guidelines relating to compliance with permissible leakage limits, and refers to regulations which define basic conditions for inspections. For shutoff and regulating valves, this affects VDI (Association of German Engineers) Guideline 2440.

EN 15848
EN 15848 is the European (and more stringent) extended version of the TA-Luft, which is intended for a wider international audience.

Testing and other standards

Normal testing standards whose purview is leakage and emission, as well as shell and function tests, are DIN 12266, API 598 and PAS 1085. PAS 1085 is a specification which was developed in a cooperative effort by large German chemical companies. Please see (further) a detailed table for a comparison of these standards.

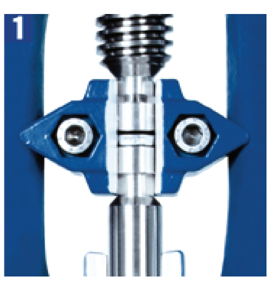
In addition to "performance" (and safety) testing standards, there are standards pertaining to casting quality, positive material identification (PMI), magnetic testing, dye penetrant testing, X-Ray and other tests or certifications.

Test	DIN 12266	PAS 1085	API 598
P10 (Body Strength Test)	Test Medium: Water Test Pressure: 1,5 PN / Class	Test Medium: Water Test Pressure: 1,5 PN / Class	Test Medium: Water Test Pressure: 1,5 PN / Class
	Test Time: ≤ DN 50 (2"), 15 sec. DN 65 (2-1/2") up DN 200 (8"), 60 sec. ≥ 250 (10"), 180 sec.	Test Time: ≤ DN 200 (8"), 60 sec. ≥ DN 250 (10"), 180 sec.	Test Time: ≤ DN 50 (2"), 15 sec. DN 65 (2-1/2") bis DN 150 (6"), 60 sec. DN 200 (8"), up DN 300 (12"),120sec. ≥ DN 350 (14"), 300 sec.
P11 (Body Leakage Test)	Test Medium: Gas Test Pressure: 6 bar / 87 psi	Test Medium: Gas Test Pressure: 6 bar / 87 psi	
	Test Time: ≤ DN 50 (2"), 15 sec. DN 65 (2-1/2") up DN 200 (8"), 60 sec. ≥ 250 (10"), 180 sec.	Test Time: ≤ DN 200 (8"), 60 sec. ≥ DN 250 (10"), 180 sec.	
P12 (Seat Test)	Test Medium: Gas Test Pressure: 6 bar / 87 psi or 1,1 times maximal allowable Pressure Difference (if lower than 6 bar / 87 psi)	PN / Class <= 100 / 600 Test Medium: Gas Test Pressure: 6 bar / 87psi	Test Medium: Gas Test Pressure: 6 bar / 87 psi
	Test Time: ≤ DN 200 (8"), 15 sec. ≥ 250 (10"), 30 sec.	PN / Class > 100 / 600 Test Medium: Gas Test Pressure: Nominal Pressure PN or maximal allowable Pressure Difference	Test Time: ≤ DN 50 (2"), 15 sec. DN 65 (2-1/2") bis DN 150 (6"), 60 sec. ≥ 200 (8"), 120 sec.
	-	Test Time: ≤ DN 200 (8"), 60 sec. ≥ DN 250 (10"), 180 sec.	-
P20 Closure Strength Test	Test Medium: Water oder Gas Test Pressure: 1,5 times maximal allowable Pressure Difference	-	Test Medium: Water Test Pressure: 1,1 times maximal allowable Pressure Difference
	Test Time: ≤ DN 50 (2"), 15 sec. DN 65 (2-1/2") bis DN 200 (8"), 60 sec. ≥ 250 (10"), 180 sec.	-	Test Time: ≤ DN 50 (2"), 15 sec. DN 65 (2-1/2") bis DN 150 (6"), 60 sec. 200, 120 sec.
P21 Back Seat Test	Test Time: ≤ DN 200 (8"), 15 sec. DN 250 (10") bis DN 500 (20"), 30 sec. ≥ 550 (22"), 60 sec.		Test Time: ≤ DN 50, 15 sec. 65, 60 sec.

Key features and benefits of BSGVs

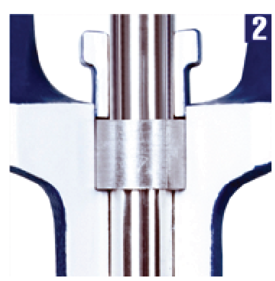
BSGV valves combine helpful user features with latest technologies designed for maximum safety in Demanding applications. Key features (some of which refer to special-use models whose purpose specifically requires that feature), are given below:

1. Two-part rising stem with outside roll-formed thread; stem coupling with bellows anti-torque device and position indicator



- Unambiguous, clearly visible position indicator promotes safety by making it easy to determine position status
- Roll formed thread resists damage from dirt/dust or rust/abrasion
- Two-part rising stem isolates rotational movement of the stem, shielding inner parts from torque effects

2. Full size safety gland packing made of pure graphite; optionally can be supplied in PTFE



- Safety backup in case

of emergency or failure

- Plant shutdown not necessary thanks to continued functioning of the valve when sealed by safety gland packing backup

3. Metal back seat with stroke limiter in open position and bellows anti-vibration device

- Second safety backup as a metal to metal seat for constant operation even in case of bellows failure
- Secures the bellow against over compression and vibration

4. Multiple wall, fully flushed stainless steel bellows, secured against torsion, designed for 10,000 cycles; fully welded

- Superior welding construction/connection between the bellows and the valve body/bonnet (welded in neutral position into the valve)
- Flushed systems keep the bellows clean and free from any particles settling into the fins of the bellows

5. Stainless steel cam-profiled bonnet gasket coated with pure graphite, mounted in tongue and groove bonnet flanges

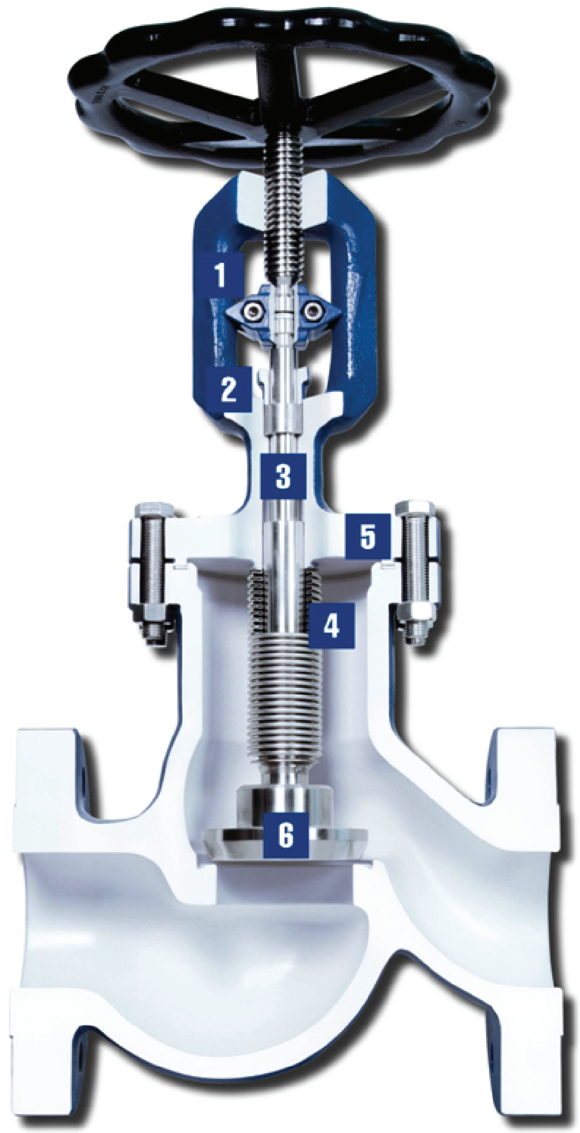
- Tongue and groove design focuses the force of the nuts and bolts on a smaller area
- The gasket cannot wear out nor become dislodged due to temperature swings
- Cam-profile works as a multiple seal to achieve leak tightness in every situation

6. Conically shaped plug with hard-faced/Stellited surface; body seat hard-faced or Stellited

- Conical shape reduces possibility of trapping sediments [cont'd]

- Closure is effected against a small "target" surface between plug and seat, ensuring low closure torque while preventing leakage
- Harder surfaces assure high performance without leakage over a long product life.

PHOTO: CRANE ChemPharma Flow Solutions®, WTA® - Bellows Sealed Globe Valve



Applied results for BSGVs

According to industry standards, each BSGV must meet or exceed the following test parameters: (for a mounted BSGV, manually operated, in DIN design – other designs have virtually the same standards, as applicable to that design)

Comparison between Bellow Sealed & Traditional Valves in Demanding Applications

	BELLOW SEAL VALVES	PISTON VALVES	CONVENTIONAL VALVES
Primary stem seal	Metallic Bellow	Piston ring	Gland Packing
Secondary stem seal	Gland Packing	None	None
Stem Leakage	Stem seals withstand several thousand cycles while preventing stem leakage	Occurs as soon as the rings wear out (made of gasket material)	Very common. Due to friction between stem and its surrounding walls, leakage occurs within a few cycles (this applies to all makes and all gland packing versions)
Packing Replacement	Not applicable	Rings need to be changed frequently	Packing needs to be replaced very frequently
Replacement Cost	Not applicable	Very high	High
Media Loss	Isolation effected by metallic bellows prevents leakage	Once seals deteriorate, leaks can be substantial	Considerable amount of media continues to escape through gland leakages.
Equipment Downtime	Nil	Very high for replacing rings	Very high for replacing gland packing
Maintenance Cost often	Nil	High as rings need to be changed at least once in six months	Very high gland packing needs to be replaced / repacked. This cost along with equipment down time, man hours spent etc. is very high
Valve Life	Longer than other options (number of years up to double digits)	Several years (measured in low single digits)	Very low (months). Due to leakage through gland, certain parts erode, making the valve irreparable after some months.
Safety	Offers maximum safety for almost any media	Suitable for certain media, especially steam and hot water	Critically unsafe for use with hazardous
Cost	Higher initial purchase cost, lowest total cost of ownership (optimal lifetime cost)	High in relation to overall benefits (lifetime cost substantially higher than bellow sealed valves)	Low purchase cost, followed by highest total cost of ownership (packing, process system downtime, maintenance hours, early replacement of valve)

- Requirements of EN 12266 - part 1, table 1

- Shell test with liquid (WTA: water), valve in half-open position
  - Test pressure: 1.5 x nominal pressure class
  - Testing time acc. table A.2 – EN 12266
  - No leakage allowed

- Tightness test with gas (WTA: air), valve in half open position
  - Test pressure: 6 bar
  - Testing time acc. table A.2 – EN 12266
  - No leakage allowed

- Seat tightness test with gas (WTA: air), valve in closed position
  - Test pressure: 6 bar
  - Testing time acc. table A.4 – EN 12266
  - Leak rate A: absolute bubble tight

For other designs (such as ASME valves), testing according to standard API 598 can be added to the above DIN tests, depending on the application.

Additional or more extensive tests are often performed as per customer request (and this may be performed pro-actively without request if the application parameters are known by the testing team in advance,and if it is deemed appropriate). Other types of tests that the BSGV can be subjected to may deploy X-Ray, Helium, PMI, etc., and will be performed as requested by the customer.

The design of a BSGV intentionally limits the stroke length while permitting a sufficient flow rate through a large diameter of the aperture. The bellows length is adjustable to satisfy force and movement requirements. Also, the bellows diameter needs to be considered when it comes to bellows performance. No part of media is trapped in the valve itself, as the medium flow is unobstructed by the inner structure of the valve (this is the case with the valve in an open or closed position). The packing area is completely sealed by the bellows.

Very low potential for inner parts wear: No "soft" materials (e.g. PTFE, sealing rings) are used. All internals are made of metal. (Note: Soft seat is available as an option). Very small interface between plug and seat (called a knife-edge seating system) limits wear. Compared to valves with significant rotational movements,the BSGV is minimally affected by abrasion between plug and seat.

Leakage prevention and environmentally safe design: The construction of a bellows system valve prevents leakage around the packing. This is especially true for the BSGV built with high quality materials and construction methods, aided by the fact that the bellows is fully welded into the valve.

Optimal maintenance and cost of ownership: The superior design of the BSGV obviates the need for intensive or frequent maintenance (this fact becomes even more evident when the valves are operated as directed). Due to the prevention of product (medium) emissions into the environment and the long-lasting design of BSGV, the lifetime Cost of Ownership (COO) is significantly lower compared to other valve types.

Conclusion

BSGVs satisfy a processing plant's requirements and conditions pertaining to operating economy. This is true in consideration of actual flow and control characteristics that BSGVs enables within the processing system. Additionally, a BSGV provides the best lifetime cost option among available valve types for Demanding applications, and its purchase cost becomes insignificant in relation to the cost of maintenance and processing stoppages necessitated when other valve types are used instead.

However, even the above considerations are overshadowed by the non-negotiable conditions of personal and environmental safety that are imposed upon processing plants by governing bodies. In this realm, there currently isn't a sufficiently technically suitable and reliable option available other than the BSGV.

For these reasons, the BSGV earns its nearly unanimous endorsement and recommendation for use in Demanding process applications – globally, and universally for all industries handling hazardous media.