The Function of Globe Valves Used in the Oil & Gas Industry

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2020

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GLOBE VALVES

Globe valves are closing-down valves in which the closure member is moved squarely on and off the seat. It is customary to refer to the closure member as a disc, irrespective of its shape.

By this mode of disc travel, the seat opening varies in direct proportion to the travel of the disc. This proportional relationship between valve opening and disc travel is ideally suited for duties involving regulation of flow rate. In addition, the seating load of globe valves can be positively controlled by a screwed stem, and the disc moves with little or no friction onto the seat, depending on the design of seat and disc. The sealing capacity of these valves is therefore potentially high. On the debit side, the seatings may trap solids, which travel in the flowing fluid.

Globe valves may, of course, be used also for on-off duty, provided the flow resistance from the tortuous flow passage of these valves can be accepted. Some globe valves are also designed for low flow resistance for use in on-off duty. Also, if the valve has to be opened and closed frequently, globe valves are ideally suited because of the short travel of the disc between the open and closed positions, and the inherent robustness of the seatings to the opening and closing movements.

Globe valves may therefore be used for most duties encountered in fluid-handling systems. This wide range of duties has led to the development of numerous variations of globe valves designed to meet a particular duty at the lowest cost. The valves shown in Figure 3-2 through Figure 3-11 are representative of the many variations that are commonly used in pipelines for the control of flow. Those shown in Figure 3-12 through Figure 3-14 are specialty valves, which are designed to meet a special duty, as described in the captions of these illustrations.

An inspection of these illustrations shows numerous variations in design detail. These are discussed in the following section.

Valve Body Patterns

The basic patterns of globe-valve bodies are the standard pattern, as in the valves shown in Figure 3-2, Figure 3-3, Figure 3-5, Figure 3-6, Figure 3-9 and Figure 3-11; the angle pattern, as in the valves shown in Figure 3-4 and
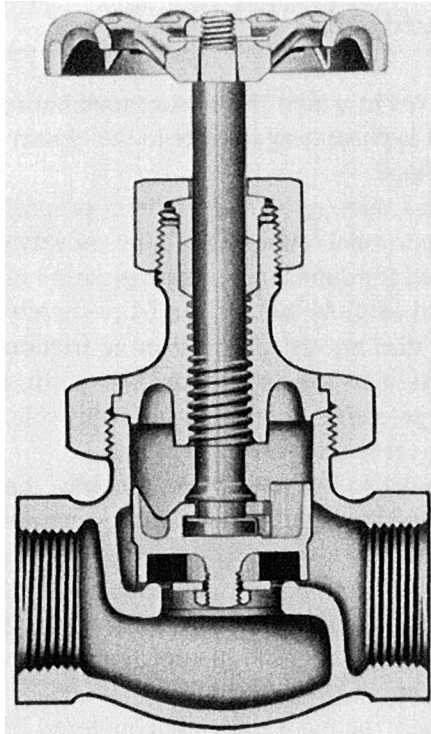
Figure 3-2. Globe Valve, Standard Pattern, Union Bonnet, Internal Screw and Renewable Soft Disc. (*Courtesy of Crane Co.*)

Figure 3-8; and the oblique pattern, as in the valves shown in Figure 3-7 and Figure 3-10, Figure 3-12 and Figure 3-13.

The standard-pattern valve body is the most common one, but offers by its tortuous flow passage the highest resistance to flow of the patterns available.

If the valve is to be mounted near a pipe bend, the angle-pattern valve body offers two advantages. First, the angle-pattern body has a greatly reduced flow resistance compared to the standard-pattern body. Second, the angle-pattern body reduces the number of pipe joints and saves a pipe elbow.

The oblique pattern globe-valve body is designed to reduce the flow resistance of the valve to a minimum. This is particularly well achieved in the valve shown in Figure 3-10. This valve combines low flow resistance for on-off duty with the robustness of globe-valve seatings.
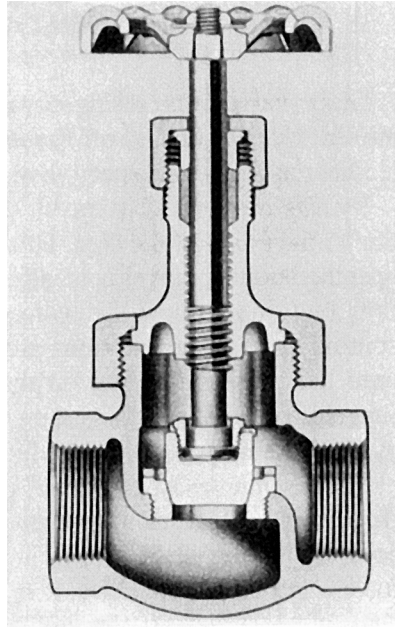
Figure 3-3. Globe Valve, Standard Pattern, Union Bonnet, Internal Screw, Plug Disc. (*Courtesy of Crane Co.*)
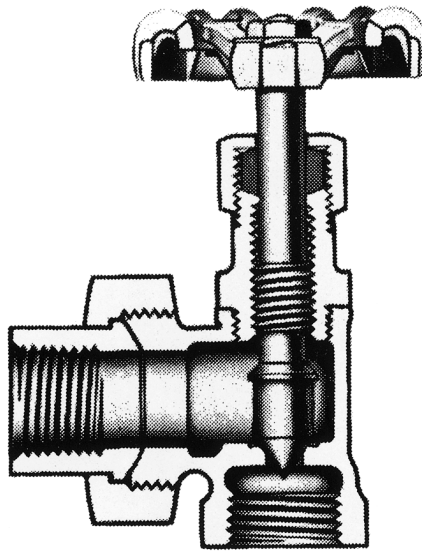

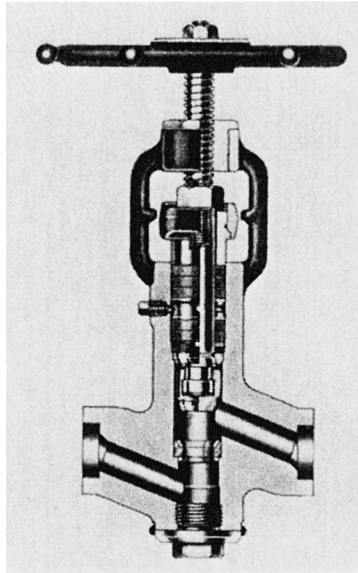**Figure 3-4.** Globe Valve, Angle Pattern, Screwed-in Bonnet, Internal Screw Needle Disc. (*Courtesy of Crane Co.*)

Figure 3-5. Globe Valve, Standard Pattern, Integral Bonnet, External Screw, Plug Disc. (*Courtesy of Velan Engineering Limited*)
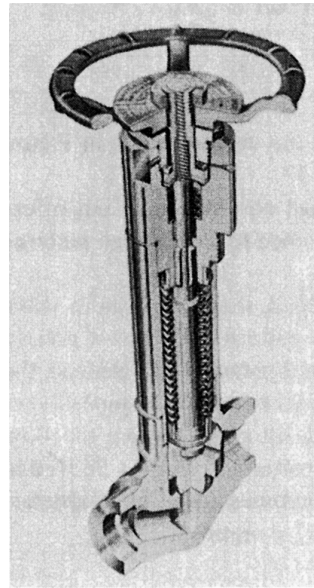

Figure 3-6. Globe Valve, Standard Pattern, Welded Bonnet, External Screw, Plug Disc, Bellows Stem Seal with Auxiliary Compression packing. (*Courtesy of Pegler Hattersley Limited*)
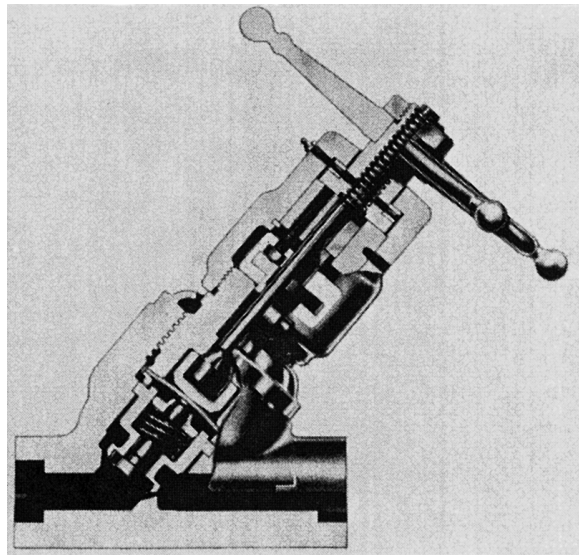

Figure 3-7. Globe Valve, Oblique Pattern, Screwed-in and Seal-Welded Bonnet, External Screw, Plug Disc, with Domed Diaphragm Stem Seal and Auxiliary Compression Packing for Nuclear Application. (*Courtesy of Edward Valves Inc.*)
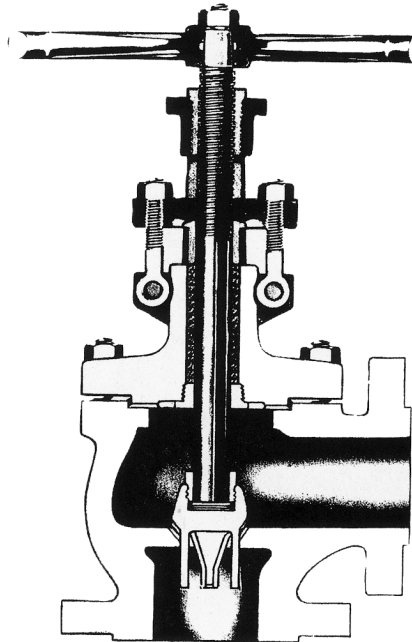
Figure 3-8. Globe Valve, Angle Pattern, Bolted Bonnet, External Screw, Plug Disc with V-Port Skirt for Sensitive Throttling Control. (*Courtesy of Crane Co.*)

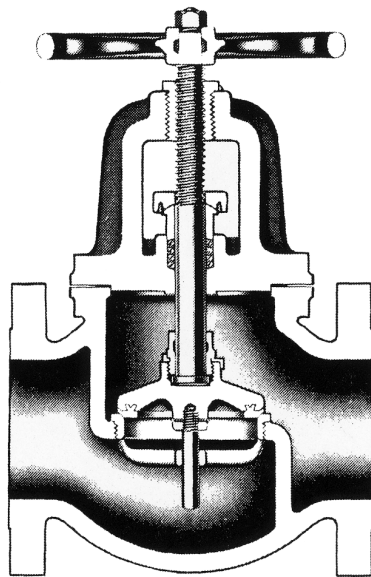**Figure 3-9.** Globe Valve, Standard Pattern, Bolted Bonnet, External Screw, Plug Disc. (*Courtesy of Crane Co.*)
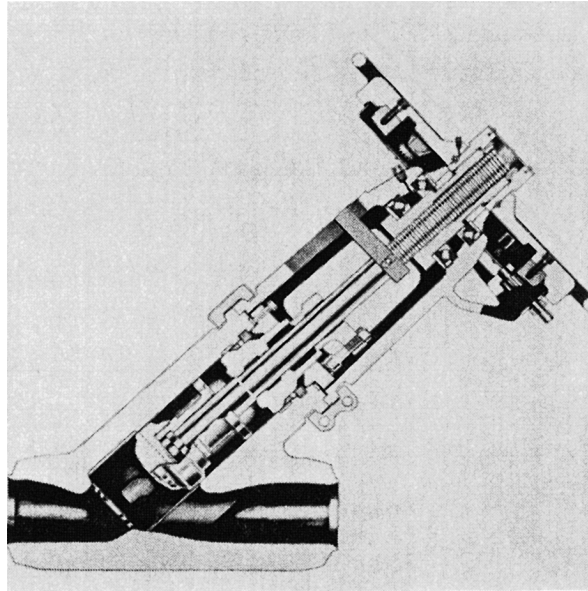
Figure 3-10. Globe Valve, Oblique Pattern, Pressure-Seal Bonnet, External Screw, with Impact Handwheel, Plug Disc. (*Courtesy of Edward Valves Inc.*)
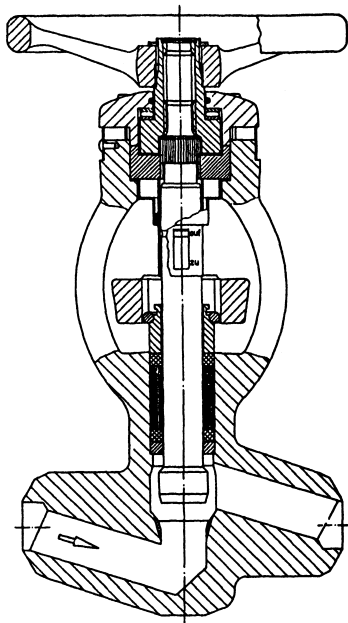
Figure 3-11. Globe Valve, Standard Pattern, Integral Bonnet, Plug-Type Disc Integral with Non-Rotating Stem. (*Courtesy of Sempell A.G.*)
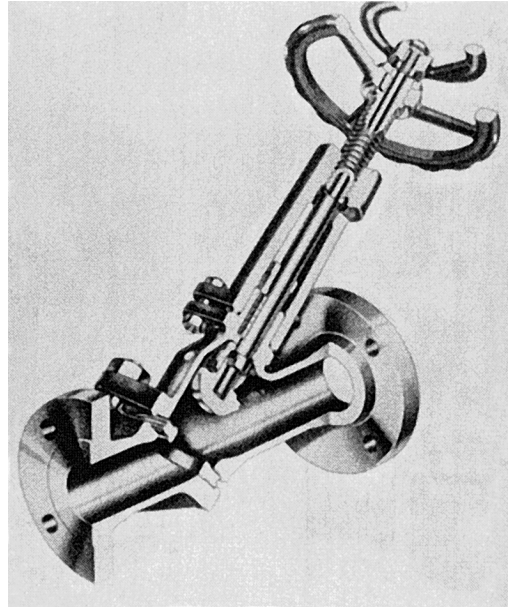
Figure 3-12. Globe Valve, Oblique Pattern, Split Body, External Screw, with Seat-Wiping Mechanism for Application in Slurry Service. (*Courtesy of Langley Alloys Limited.*)
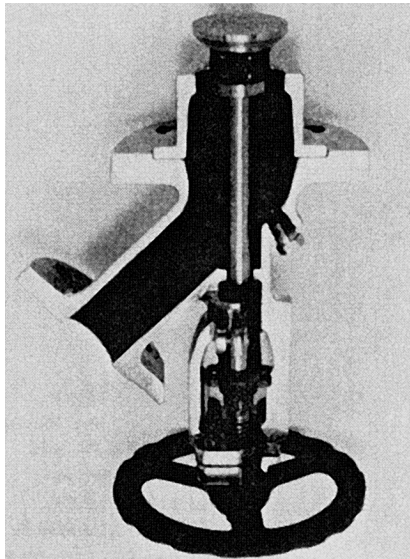
Figure 3-13. Globe Valve Adapted for the Draining of Vessels, Seat Flush with Bottom of Vessel. (*Courtesy of Langley Alloys Limited.*)
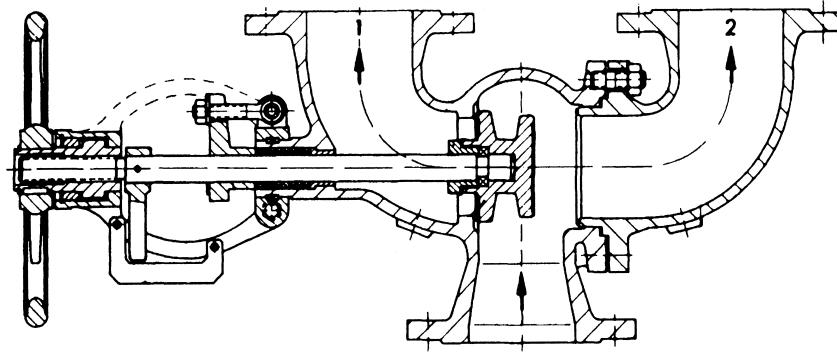
Figure 3-14. Globe Valve, Three-Way, Used as Change-Over Valve in Pressure Relief Valve Installations: One Pressure Relief Valve is Isolated While the Second One Is in Service. (*Courtesy of Bopp & Reuther GmbH.*)

Valve Seatings

Globe valves may be provided with either metal seatings or soft seatings. In the case of metal seatings, the seating stress must not only be high but also circumferentially uniform to achieve the desired degree of fluid tightness. These requirements have led to a number of seating designs. The ones shown in Figure 3-15 are common variations.

Figure 3-15. Seating Configurations Frequently Employed in Globe Valves.

Flat seatings (see Figure 3-15a) have the advantage over other types of seatings in that they align readily to each other without having to rely on close guiding of the disc. Also, if the disc is moved onto the seat without being rotated, the seatings mate without friction. The resistance of the seating material to galling is therefore unimportant in this case. Deformation of the roundness of the seat due to pipeline stresses does not 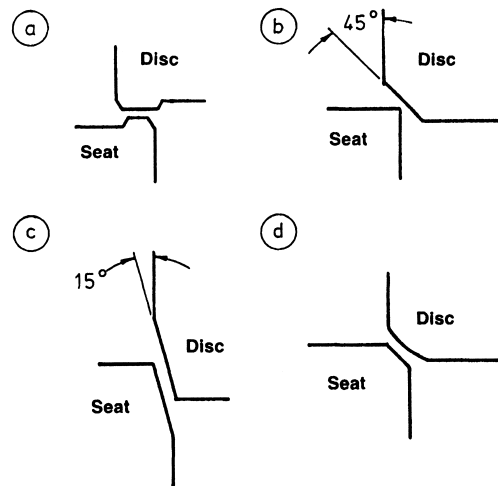interfere with the sealability of the seatings as long as the seat face remains flat. If flow is directed from above the seat, the seating faces are protected from the direct impact of solids or liquid droplets travelling in the fluid.

By tapering the seatings, as shown in Figure 3-15b, c, and d, the seating stress for a given seating load can be greatly increased. However, the seating load can be translated into higher uniform seating stress only if the seatings are perfectly mated; that is, they must not be mated with the disc in a cocked position. Thus, tapered discs must be properly guided into the seat. Also, the faces of seat and disc must be perfectly round. Such roundness is sometimes difficult to maintain in larger valves where pipeline stresses may be able to distort the seat roundness. Furthermore, as the seatings are tightened, the disc moves further into the seat. Tapered seatings therefore tighten under friction even if the disc is lowered into the seat without being rotated. Thus the construction material for seat and disc must be resistant to galling in this case.

The tapered seatings shown in Figure 3-15b have a narrow contact face, so the seating stress is particularly high for a given seating load. However, the narrow seat face is not capable of guiding the disc squarely into the seat to achieve maximum sealing performance. But if the disc is properly guided, such seatings can achieve an extremely high degree of fluid tightness. On the debit side, narrow-faced seatings are more readily damaged by solids or liquid droplets than wide-faced seatings, so they are used mainly for gases free of solids and liquid droplets.

To improve the robustness of tapered seatings without sacrificing seating stress, the seatings shown in Figure 3-15c are tapered and provided with wide faces, which more readily guide the disc into the seat. To achieve a high seating stress, the seat face in initial contact with the disc is relatively narrow, about 3 mm ($\frac{1}{8}$ in.) wide. The remainder of the seat-bore is tapered slightly steeper. As the seating load increases, the disc slips deeper into the seat, thereby increasing the seating width. Seatings designed in this way are not as readily damaged by erosion as the seatings in Figure 3-15b. In addition, the long taper of the disc improves the throttling characteristic of the valve.
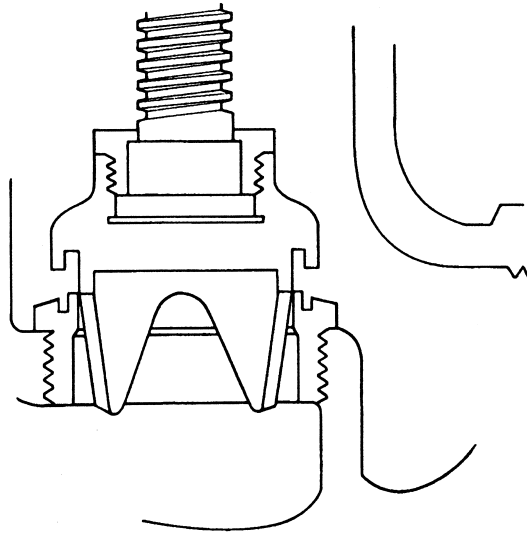
Figure 3-16. Seatings of Globe Valves Adapted for Throttling Duty. (*Courtesy of Pegler Hattersley Limited.*)

The performance of such seatings may be improved by hollowing out the disc to impart some elasticity to the disc shell, as is done in the valve shown in Figure 3-11. This elasticity permits the disc to adapt more readily to deviations of the seatings from roundness.

The seatings shown in Figure 3-15d are ball shaped at the disc and tapered at the seat. The disc can therefore roll, to some extent, on the seat until seat and disc are aligned. Because the contact between the seatings approaches that of a line, the seating stress is very high. On the debit side, the line contact is prone to damage from erosion. The ball-shaped seatings are therefore used only for dry gases, which are also free of solids. This construction is used mainly by U.S. manufacturers.

If the valve is required for fine throttling duty, the disc is frequently provided with a needle-shaped extension, as in the valve shown in Figure 3-4; or with a V-port skirt, as in the valve shown in Figure 3-8 and in the seatings shown in Figure 3-16. In the latter design, the seating faces separate before the V-ports open. The seating faces are, in this way, largely protected against erosion.

An example of soft seating design is the valve shown in Figure 3-2. The soft seating insert is carried in this case by the disc, and may be renewed readily.

Connection of Disc to Stem

The stem of a globe valve may be designed to rotate while raising or lowering the disc, or be prevented from rotating while carrying out this task. These modes of stem operation have a bearing on the design of the disc-to-stem connection.

Most globe valves incorporate a rotating stem because of simplicity of design. If the disc is an integral component of the stem in this case, as it frequently is in small needle valves such as those shown in Figure 3-4, the seatings will mate while the disc rotates, possibly resulting in severe wear of the seatings. Therefore, the main field of application of such valves is for regulating duty with infrequent shut-off duty. For all other duties involving rotating stems, the disc is designed to swivel freely on the stem. However, swivel discs should have minimum free axial play on the stem to prevent the possibility of rapid reciprocating movements of the disc on the stem in the near closed valve position. Also, if the disc is guided by the stem, there should be little lateral play between stem and disc to prevent the disc from landing on the seat in a cocked position.

In the case of nonrotating stems, as in the valves shown in Figures 3-6, Figure 3-7, Figure 3-10, and Figure 3-11, the disc may be either an integral part of the stem (see Figure 3-11) or a separate component from the stem (see Figure 3-6, Figure 3-7, and Figure 3-10). Nonrotating stems are required in valves with diaphragm or bellows valve stem seal, as in Figure 3-6 and Figure 3-7. They are also used in high pressure valves such as those shown in Figure 3-10 and Figure 3-11 to facilitate the incorporation of power operators.

Inside and Outside Stem Screw

The screw for raising or lowering the stem may be located inside the valve body, as in the valves shown in Figure 3-2 through Figure 3-4, or outside the valve body, as in the valves shown in Figure 3-5 through Figure 3-14.

The inside screw permits an economical bonnet construction, but it has the disadvantage that it cannot be serviced from the outside. This construction is therefore best suited for fluids that have good lubricity. For the majority of minor duties, however, the inside screw gives good service.

The outside screw can be serviced from the outside and is therefore preferred for severe duties.

Bonnet Joints

Bonnets may be joined to the valve body by screwing, flanging, welding, or by means of a pressure-seal mechanism; or the bonnet may be an integral part of the valve body.

The screwed-in bonnet found in the valve shown in Figure 3-4 is one of the simplest and least expensive constructions. However, the bonnet gasket must accommodate itself to rotating faces, and frequent unscrewing of the bonnet may damage the joint faces. Also, the torque required to tighten the bonnet joint becomes very large for the larger valves. For this reason, the use of screwed-in bonnets is normally restricted to valve sizes not greater than ND 80 (NPS 3).

If the bonnet is made of a weldable material, the screwed-in bonnet may be seal welded, as in the valves shown in Figure 3-6 and Figure 3-7, or the bonnet connection may be made entirely by welding. These constructions are not only economical but also most reliable irrespective of size, operating pressure, and temperature. On the debit side, access to the valve internals can be gained only by removing the weld. For this reason, welded bonnets are normally used only where the valve can be expected to remain maintenance-free for long periods, where the valve is a throw-away valve, or where the sealing reliability of the bonnet joint outweighs the difficulty of gaining access to the valve internals.

The bonnet may also be held to the valve body by a separate screwed union ring, as in the valves shown in Figure 3-2 and Figure 3-3. This construction has the advantage of preventing any motion between the joint faces as the joint is being tightened. Repeatedly unscrewing the bonnet, therefore, cannot readily harm the joint faces. As with the screwed-in bonnet, the use of bonnets with a screwed union ring is restricted to valve sizes normally not greater than DN 80 (NPS 3).

Flanged bonnet joints such as those found in the valves shown in Figure 3-8 and Figure 3-9 have the advantage over screwed joints in that the tightenening effort can be spread over a number of bolts. Flanged joints may therefore be designed for any valve size and operating pressure. However, as the valve size and operating pressure increase, the flanged joint becomes increasingly heavy and bulky. Also, at temperatures above 350°C (660°F), creep relaxation can, in time, noticeably lower the bolt load. If the application is critical, the flanged joint may be seal welded.

The pressure-seal bonnet found in the valve shown in Figure 3-10 overcomes this weight disadvantage by letting the fluid pressure tighten

the joint. The bonnet seal therefore becomes tighter as the fluid pressure increases. This construction principle is frequently preferred for large valves operating at high pressures and temperatures.

Small globe valves may avoid the bonnet joint altogether, as in the valve shown in Figure 3-5 and Figure 3-11. Access to the valve internals is through the gland opening, which is large enough to pass the valve components.

Stuffing Boxes and Back Seating

Figure 3-17 and Figure 3-19 show three types of stuffing boxes, which are typical for valves with a rising stem.

The stuffing box shown in Figure 3-17 is the basic type in which an annular chamber contains the packing between the gland at the top and a shoulder at the bottom. The underside of the stuffing box carries a back seat which, in conjunction with a corresponding seat around the stem, is used to isolate the packing from the system fluid when the valve is fully open.

The stuffing box shown in Figure 3-18 is supplemented with a condensing chamber at the bottom. The condensing chamber served originally as a cooling chamber for condensable gases such as steam. In this particular case, the condensing chamber has a test plug, which may be removed to test the back seat for leak tightness.

A third variation of the stuffing box has a lantern ring mounted between two packing sections, as shown in Figure 3-19. The lantern ring is used
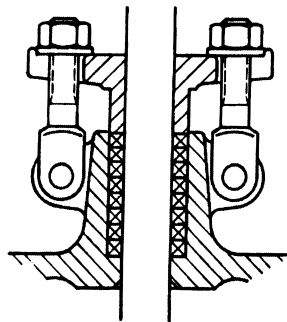

Figure 3-17. Basic Stuffing Box. (*Courtesy of Babcock-Persta Armaturen-Vertriebsgesellschaft mbH.*)
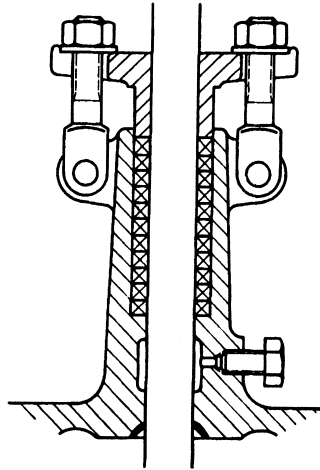
Figure 3-18. Stuffing Box with Condensing Chamber. (*Courtesy of Babcock-Persta Armaturen-Vertriebsgesellschaft mbH.*)
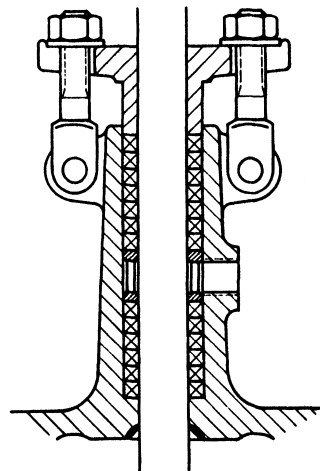

Figure 3-19. Stuffing Box with Lantern Ring. (*Courtesy of Babcock-Persta Armaturen-Vertriebsgesellschaft mbH.*)

mainly in conjunction with compression packings and may serve four different purposes:

1. As an injection chamber for a sealant or an extruded or leached-out lubricant.
2. As a pressure chamber in which an external fluid is pressurized to a pressure equal to or slightly higher than the system pressure to

prevent any leakage of the system fluid to the outside. The external fluid must thereby be compatible with the system fluid and harmless to the surroundings of the valve.

3. As a sealant chamber in vacuum service into which an external fluid is fed to serve as a sealant.
4. As a leakage collection chamber from which the leakage is piped to a safe location.

The inclusion of the lantern ring, however, increases the depth of the packing column. Sidewall friction reduces the gland packing input load as the packing depth increases, leading to an impairment of the seal integrity.[37] Replacing the lantern ring with a spring is used in rotating pump shaft seals to improve the seal integrity.[38]

Direction of Flow Through Globe Valves

The question of direction of flow through globe valves has two answers.

If the possibility exists that flow from above the disc can remove either the disc from the stem or a component from the disc, flow directed from below the disc is mandatory. In this case, hand-operated globe valves with rotating stem and metal seatings can be closed fluid-tight without undue effort, only if the fluid load on the underside of the disc does not exceed about 40–60 kN (9,000–13,000 lb).[39] With a non-rotating stem and roller-bearing supported stem nut, as in the valves shown in Figure 3-10 and Figure 3-11, hand operated globe valves with metal seatings may be closed fluid-tight against a fluid load of about 70–100 kN (16,000–22,000 lb), depending on the leakage criterion and the construction of the valve.[39] One particular advantage of flow directed from below the disc is that the stuffing box of the closed valve is relieved from the upstream pressure. On the debit side, if the valve has been closed against a hot fluid such as steam, thermal contraction of the stem after the valve has been closed can be just enough to induce seat leakage.

If flow is directed from above the disc, the closing force from the fluid acting on top of the disc supplements the closing force from the stem. Thus, this direction of flow increases greatly the sealing reliability of the valve. In this case, hand-operated globe valves with a rotating stem may be opened without excessive effort, only if the fluid load acting on top of the disc dose not exceed about 40–60 kN (9,000–13,000 lb).[39]

If the stem is of the nonrotating type with a roller-bearing supported stem nut, the globe valve may be opened by hand against a fluid load of about 70–100 kN (16,000–22,000 lb).[39] If the fluid load on top of the disc is higher, a bypass valve may have to be provided that permits the downstream system to be pressurized before the globe valve is opened.

Standards Pertaining to Globe Valves

Appendix C provides a list of U.S. and British standards pertaining to globe valves.

Applications

Duty:
  Controlling flow
  Stopping and starting flow
  Frequent valve operation
Service:
  Gases essentially free of solids
  Liquids essentially free of solids
  Vacuum
  Cryogenic

PISTON VALVES

Piston valves are closing-down valves in which a piston-shaped closure member intrudes into or withdraws from the seat bore, as in the valves shown in Figure 3-20 through Figure 3-24.

In these valves, the seat seal is achieved between the lateral faces of the piston and the seat bore. When the valve is being opened, flow cannot start until the piston has been completely withdrawn from the seat bore. Any erosive damage occurs, therefore, away from the seating surfaces. When the valve is being closed, the piston tends to wipe away any solids, which might have deposited themselves on the seat. Piston valves may thus handle fluids that carry solids in suspension. When some damage occurs to the seatings, the piston and the seat can be replaced *in situ*, and the valve is like new without any machining.
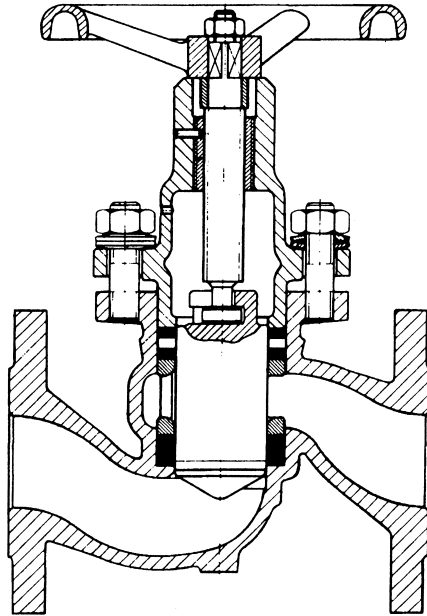
Figure 3-20. Piston Valve, Standard Pattern, Seat Packing Mounted in Valve Body, Piston Pressure Unbalanced. (*Courtesy of Rich. Klinger AG.*)
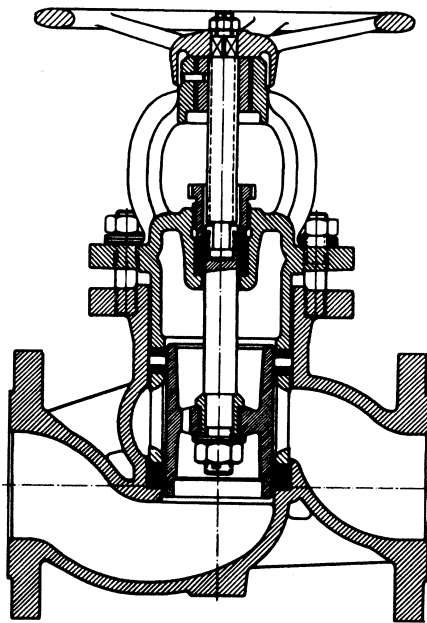
Figure 3-21. Piston Valve, Standard Pattern, Seat Packing Mounted in Valve Body, Piston Pressure Balanced. (*Courtesy of Rich. Klinger AG.*)
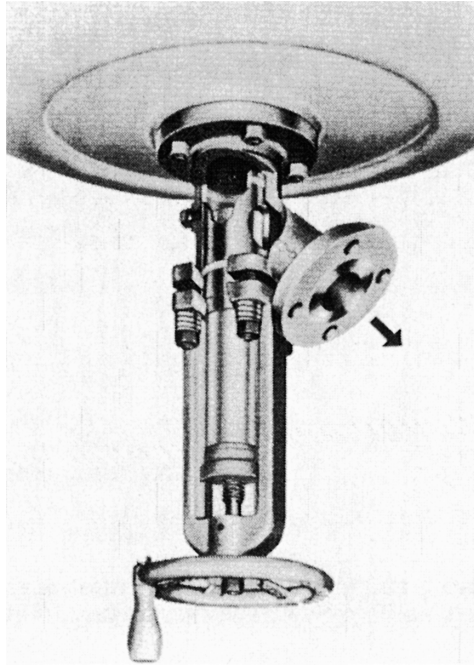
Figure 3-22. Piston Valve, Adapted for Draining Vessels, Seat Packing Mounted in Valve Body. (*Courtesy of Yarway Corporation.*)
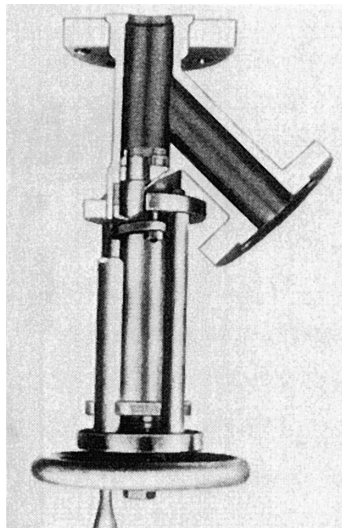

Figure 3-23. Piston Valve Adapted for Draining Vessels, Seat Packing Mounted on Piston; the "Ram-Seal" Principle. (*Courtesy of Fetterolf Corporation.*)
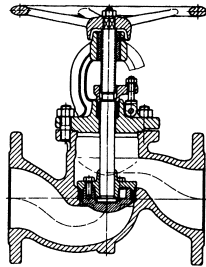
Figure 3-24. Piston Valve, Standard Pattern, Seat Packing Mounted on Piston. (*Courtesy of Rich. Klinger AG.*)

Like globe valves, piston valves permit good flow control. If sensitive flow adjustment is required, the piston may be fitted with a needle shaped extension. Piston valves are also used for stopping and starting flow when flow resistance due to the tortuous flow passage is accepted.

Construction

The seatings of piston valves are formed by the lateral faces of the valve bore and the piston. A fluid-tight contact between these faces is achieved by a packing that either forms part of the valve bore, as in the valves shown in Figure 3-20 through Figure 3-22, or part of the piston, as in the valves shown in Figure 3-23 and Figure 3-24. Packings commonly used for this purpose are compression packings based on compressed asbestos or PTFE and O-ring packings.

In the case of the piston valve shown in Figure 3-20, the piston moves in two packings that are separated by a lantern ring. The lower packing represents the seat packing, while the upper packing seals the piston to the atmosphere. The bonnet serves thereby as the gland that permits both packings to be tightened through tightening of the cover bolts. Disc springs under the nuts of the cover bolts minimize variations in packing stress due to thermal contraction and expansion of the valve parts. When one of the packings leaks, the fluid seal can be restored by retightening the bolts. Retightening must be carried out while the valve is closed to prevent an unrestrained expansion of the seat packing into the valve bore.

The valve shown in Figure 3-21 differs from the one in Figure 3-20 only in that the piston is pressure balanced. The two packings around the piston are both seat packings, and a separate packing is provided for the stem. The purpose of balancing the piston is to minimize the operating effort in large valves operating against high fluid pressures.

The packing train of the valve shown in Figure 3-22 is likewise stressed through the bonnet in conjunction with springs under the nuts of the cover bolts, or with a spring between the bonnet and the packing. However, as the piston moves into the final closing position, a shoulder on the piston contacts a compression ring on top of the packing so that any further progression of the piston tightens the packing still further.

The piston valve shown in Figure 3-23 carries the seat packing on the end of the piston instead of in the valve bore. The packing is supported thereby on its underside by a loose compression ring. When the piston moves into the final closing position, the compression ring comes to rest on a shoulder in the seat bore so that any further progression of the piston causes the compression ring to tighten the packing. Because the packing establishes interference with the seat in the last closing stages only, the operating effort of the valve is lower over a portion of the piston travel than that of the foregoing valves.

The piston valve shown in Figure 3-24 also carries the seat packing on the piston. However, the loose compression ring is replaced by a friction ring that acts as a spring element and, as such, pre-stresses the packing. When the piston moves into the seat, the friction ring comes to rest in the seat bore, and any progression of the piston increases the packing stress.

National standards that apply specifically to piston valves do not exist.

Applications

Duty:
    Controlling flow
    Stopping and starting flow
Service:
    Gases
    Liquids
    Fluids with solids in suspension
    Vacuum

PARALLEL GATE VALVES

Parallel gate valves are slide valves with a parallel-faced gate-like closure member. This closure member may consist of a single disc or twin discs