

Guidance on Valves Type Selection

VALVE TYPE SELECTION

Valve type selection should take account of :

- 1. Required function.**
- 2. Service conditions.**
- 3. Fluid type and condition.**
- 4. Fluid characteristics.**
- 5. Frequency of operation.**
- 6. Isolation requirements.**
- 7. Maintenance requirements.**
- 8. Environmental considerations.**
- 9. Past experience in comparable conditions.**
- 10. Weight and size.**
- 11. Cost.**

1. Required Valve function and description

Isolation (block) valves

Valves intended for starting and stopping flow or for isolation of equipment generally be selected to provide:

Low resistance to flow (low pressure drop) e.g. by means of a straight through flow configuration which may also facilitate line clearing.

Bi-directional sealing i.e. providing good shut off when the flow or pressure differential is from either direction.

The most common types of block valves include:

Gate valves – wedge/parallel slab/parallel expanding/parallel slide.

Ball valves – floating ball/trunnion mounted; metal/soft seats.

Butterfly valves – double or triple offset/rubber lined.

Plug valves – lubricated balanced/sleeved, Lined/expanding/lift.

Diaphragm valves – weir/full flow/pinch.

Isolation efficiency

1. Soft seated valves should normally be selected only for clean service. Soft seated block valves, such as ball valves, lined plug valves, soft seated gate valves, and butterfly valves can provide a good tight shut off on gas or liquid when new. Hard metal seated valves should normally be selected if the service is other than clean.
2. For high temperature service (> 200°C (390°F)) only metal seated valves should be used.
3. For steam service, parallel slide valves are the preferred option in which high temperature swings occur after valve closure. Wedge gate valves may be used as an alternative for general isolation duty or if good, low pressure leak tightness is required.

Method to achieve valve shut off

Valve type	Shut off by:	
	Torque/force	Position
Gate (wedge, expanding)	√	
Gate (slab, parallel slide)		√
Ball (floating and trunnion mounted)		√
Butterfly	√	
Plug (sleeved, lubricated balanced)		√
Plug (expanding and wedge (lift) type)	√	
Globe	√	
Diaphragm/Pinch	√	

Reduced bore valves

1. Reduced bore or venturi pattern valves should be selected when minimum weight, cost, and operating time are required.
2. The seat (throat) diameter of reduced bore valves should be selected.
3. If reduced bore valves are used, the following additional criteria should be satisfied:
 - a. The increased pressure drop is considered in the design of the piping.
 - b. The reduced section modulus is considered in the piping flexibility design.
 - c. Not to be used in horizontal lines which are sloped for continuous draining.
 - d. Drains are installed at all additional low points caused by the installation of reduced bore valves.
 - e. Not to be used in erosive applications such as sandy service, slurries, or fluidized solids without an analysis of the effects of erosion.
 - f. Not to be used in severe fouling, solidifying, or coking services.
 - g. Not to be used in lines specified to be mechanically cleaned or "pigged".
 - h. Not to be used as block valves associated with pressure relief devices and flare pipe headers.

Gate valves

Gate valves are used for on/off operation on hydrocarbon, general process, and utilities service for all temperature ranges. They have a straight through configuration.

Gate valve types are:

- Wedge.**
- Expanding Parallel (internal wedge)*.**
- Parallel Slab*.**
- Parallel Slide*.**
- Knife-edge.**

*Usually provided as “through conduit” which offers an uninterrupted pipe bore in the fully open position.

Extended bonnets are available for cryogenic service. Gate valves should not be used:

- i. In horizontal lines transporting heavy or abrasive slurries in which sediment may become trapped in the pocket below the valve seat, preventing closure. Reverse acting through conduit and knife-edged types are unaffected by this.
- ii. For throttling duties as the valve is very inefficient at controlling flow. Full flow persists until the valve is 80% closed and very high velocities can be generated. Erosion of seats and gate, etc. may cause leakage.

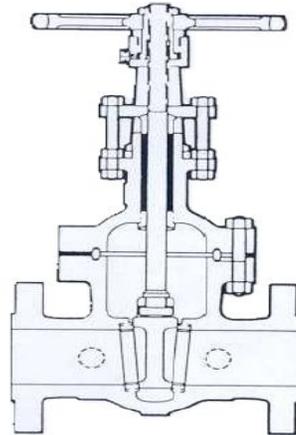
Operating arrangements

Hand operated gate valves usually have the following stem arrangements:

- Inside screw, non-rising stem.
 - Outside screw, rising stem.
- a. An outside screw, rising stem valve should be the normal first choice as it is easier to maintain, allowing access for lubrication of the thread. In marine environments the rising stem and threads should be protected against corrosion.
 - b. If headroom is limited, an inside screw, non-rising stem type valve may be specified. As the stem thread is within the body and is exposed to the line fluid, this type is unsuitable for corrosive or slurry service (excessive wear of threads may occur) or for high temperature applications (expansion and contraction may cause thread binding).
 - c. Gear operated gate valves can take many handwheel turns to open/close and the vendor should be asked to advise the number of turns required. If this would lead to unacceptably long operating time, consideration should be given to the provision of a pneumatic turning device or an electric motor actuator.

Wedge Gate Valve

Wedge gate valve (outside screw)

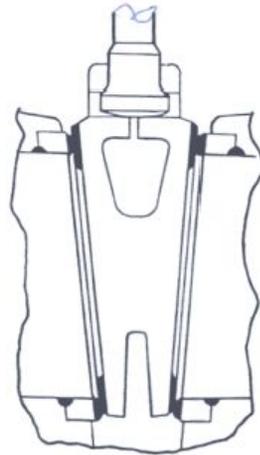


This is the most common type of gate valve. Closure is obtained by driving a taper wedge gate between two similar taper wedge seats.

Steel wedge gate valves are classified by wedge type: plain solid wedge, flexible solid wedge (having a groove cut around the circumference, and split wedge (two separate halves).

- a. A flexible solid wedge may more easily accommodate misaligned seats and minimise galling of sealing surfaces, but the degree of flexibility is extremely limited in small sizes.
- b. A plain solid wedge may be more difficult to grind to an accurate fit. Seats are always fixed. Solid and flexible wedge gate valves are good general service block valves offering a good sealing capability with low pressure drop.
- c. A 100% shut-off capability cannot always be relied upon however, and slight leakage may occur with variations in temperature and pressure after being in service for some time.

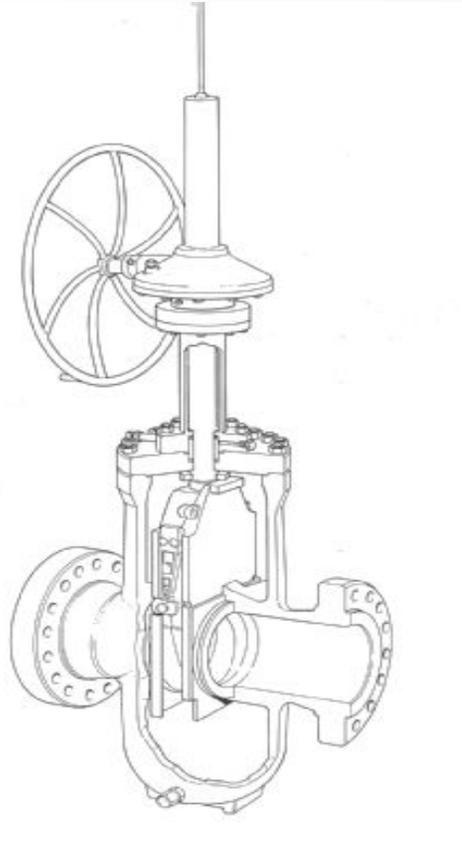
Flexible wedge



- d. Standard steel wedge gate valves should normally be specified with outside screw and yoke, rising stem, non-rising handwheel, and bolted bonnet.
- e. Valves less than DN 50 (NPS 2) should normally have solid wedges and larger. Valves for general service should normally have flexible wedges. Split wedges should be reserved for steam applications in which good low differential pressure sealing is required and comparable applications in which a parallel slide valve cannot be used.
- f. Services with abrasive particles or applications in which wire drawing is possible require hard faced wedges and seats. Wedge gate valves may have seating problems on dirty service due to material collecting on seats or in the body cavity of the valve.
- g. Slab or expanding gate valves are preferred for high pressure gas service. A wedge gate valve does not shut off against high pressure gas as efficiently as a slab or expanding gate valve.
- h. If large wedge gate valves are mounted with stems horizontal in a horizontal pipe, gate guides should have a minimum length of 50% of the valve DN (NPS). If flexible or solid wedge gate valves are installed below the horizontal, the valve bonnet should be provided with a drain. Split-wedge and double-disc gate valves should only ever be installed with the valve stem vertical.

- i. Cast iron valves should not be used except for underground water services where freezing is not a possibility.
- j. Class 150 stainless steel wedge gate valves are sometimes specified in accordance with API Std 603 which allows reduced wall thickness on the grounds that the material does not corrode.
- k. Gate valves < DN 50 (NPS 2) are normally provided with reduced (sometimes called conventional or standard) port in accordance with the minimum diameters specified in the reference standard e.g. ISO 15761.

Parallel Expanding Gate valve



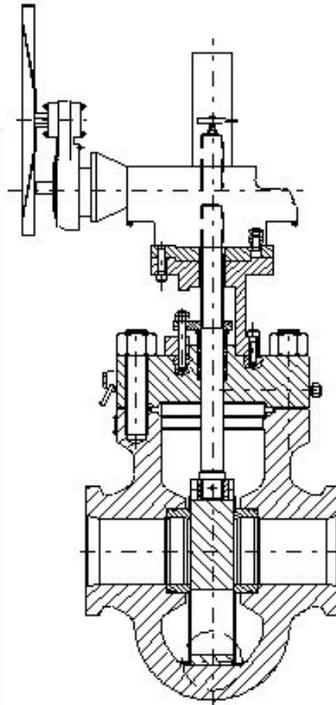
This valve has a split gate with parallel sealing faces, inclined internal surfaces, and parallel seats. The two gate halves are forced out against the seats at point of closure, providing a tight seal without the assistance of fluid pressure. Seats may be fixed or floating. Valves are normally of through conduit design, but may also be available without a conduit. They are heavier than comparable wedge or slab gate valves.

- a. When ordering, it is essential to be clear about the functionality required – gates which seal against the seats in the closed position only or gates which seal against the seats in the open and closed positions; unidirectional or bi-directional sealing.
- b. Expanding gate valves are not recommended for frequent operation in sandy/abrasive service. Designs with electroless nickel plated (ENP) gates are suitable for clean service only. If gate and seat faces are tungsten carbide coated, the design has reasonable tolerance to dirty service. However, the expanding gate valve is not as good as the slab gate valve in this respect and the expanding action can tend to trap hard particles between gate and seat.
- c. Internal screw designs should not be specified where frequent operation is likely.
- d. Expanding gate valves should not be used on steam service.

The increased differential pressure resulting from condensate forming in the body cavity after closure may result in leakage and operating forces may increase as a result of thermal changes after closure. In liquid or condensing service, an external thermal relief valve (isolated by a locked open block valve) and set between 1,1 x and 1,33 x valve rated pressure should be provided to prevent body cavity overpressure.

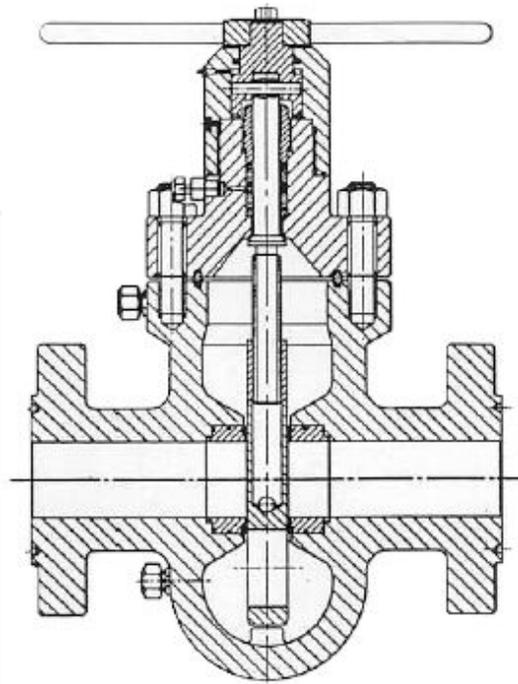
Slab Gate Valve

Slab gate valve (outside screw)



This valve has a single parallel faced slab gate, which slides over floating seats. Sealing is by differential pressure. The gate design is always of the through conduit type incorporating an aperture the same diameter as the valve bore. When the gate is in the fully open position it allows free and uninterrupted flow. Valves may have rising stem or be of non-rising stem, internal screw type). They can be obtained with a reduced bore, and are available in reverse acting version in which the gate rises to close the valve (commonly for actuated designs). This allows some of the closing force to be provided by the pressure inside the valve body acting over the sealed area of the stem.

Slab gate valve (internal screw)

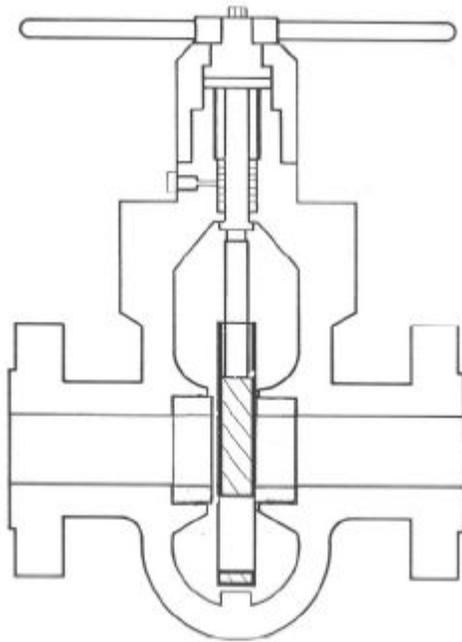


The floating seats are pressure energised onto the gate. Operating forces can be predicted much more accurately than is the case for wedge or expanding gate valves (or trunnion mounted ball valves) and are generally lower. This is an advantage when sizing actuators.

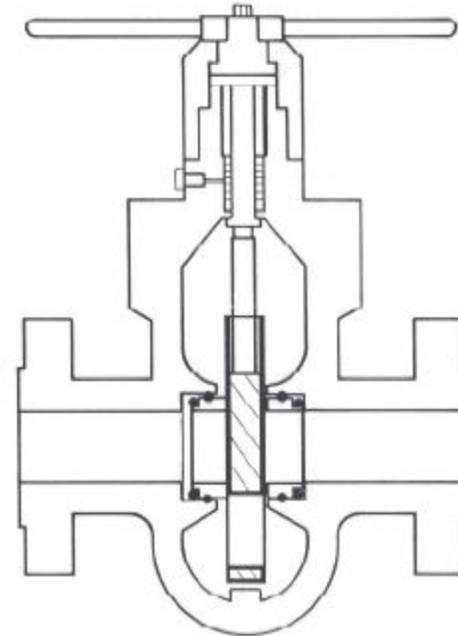
The basic design is suitable for use on a wide range of applications e.g. well head isolation, process piping, storage tanks, and pipeline service.

When ordering, it is important to be clear about the sealing functionality required or being offered - “downstream sealing” or “upstream + downstream sealing”. (See the below Figures).

Downstream sealing slab gate valve



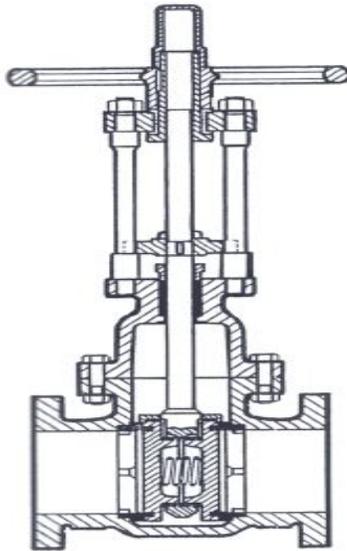
Upstream and downstream sealing slab gate valve



The latter design may be used to provide double isolation in which the gate is free to float on the end of the stem, but operating forces are higher than for comparable downstream only sealing types. Christmas tree gate valves are most often downstream sealing only, but pipeline and piping valves are frequently “upstream + downstream sealing” (e.g. O-ring seals are used between seat and body).

- a. Valves having tungsten carbide coated gates and seats should be specified for dirty or abrasive service. Designs with electroless nickel plated (ENP) gates or incorporating polymer seat ring inserts are suitable for clean service only.
- b. Flat sided, fabricated designs are economical in terms of space and cost, but it is recommended that their use should normally be restricted to the lower pressure ratings (\leq Class 600) unless the design is justified by finite element analysis.

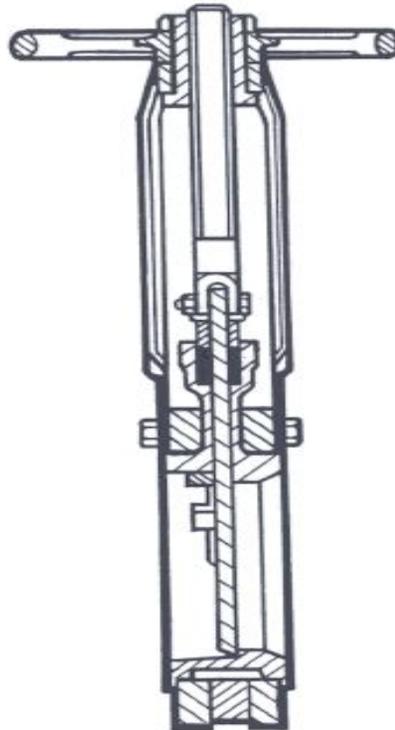
Parallel slide gate valve



Parallel slide gate valves (like split wedge and expanding gate valves) in liquid or condensing service and which are used in situations in which heat (process, fire, etc.) may be applied to a closed valve should be provided with a means of relieving pressure built up in the body cavity. If this involves making the valve uni-directional, the flow direction shall be clearly marked.

If small ($< \text{DN } 50$ (NPS 2)) parallel slide valves are used on liquid systems, similar measures should be taken to relieve cavity overpressure regardless of heat considerations.

Knife Gate Valve



Knife gate valves should not be used on hazardous service or at other than low pressure.

This valve has a bevel or knife-edged single piece parallel sided gate, and is designed to handle slurries, solids, etc. liable to obstruct a wedge gate. The knife-edge pushes aside or cuts through solids in the flow. Valves generally have rectangular bodies and are sometimes sealed around the gate. The valve is generally designed to manufacturer's standards. A stainless steel bonnetless version is addressed in MSS SP-81.

Ball valves

Ball valves are a low torque quarter turn valve, with low resistance to flow, suitable for many on-off utility and process services. They have a straight through configuration. They have a good control characteristic (equal percentage), but is not generally used for throttling applications in their standard form because of the potential for seat damage and cavitation (high pressure recovery). Designs include floating ball and trunnion mounted ball types. Most designs are double seated, but there are some special single seated designs e.g. eccentric ball (Orbit) types.

- a. The majority of valves have soft seat inserts and elastomer or polymer seals. Such valves are recommended for clean service only and are unsuitable for dirty/abrasive service or high temperatures. Hard metal seated designs are suitable for abrasive and scaling service and versions having graphite stem, etc. seals can be used at elevated temperature.
- b. Reduced opening valves should normally be specified for lines which do not have to pass pigs and if the increased velocity and pressure drop can be accommodated. They are not recommended for fluids containing solids in which the resulting high velocity could cause erosion.
- c. Levers should be mounted such that in the open position, the lever is parallel to the pipe axis. Because smaller valves are lever operated (fast open/close), the possibility of accidental operation should be considered.
- d. If “water hammer” would be unacceptable on liquid systems, valves should be gear operated.

Body design

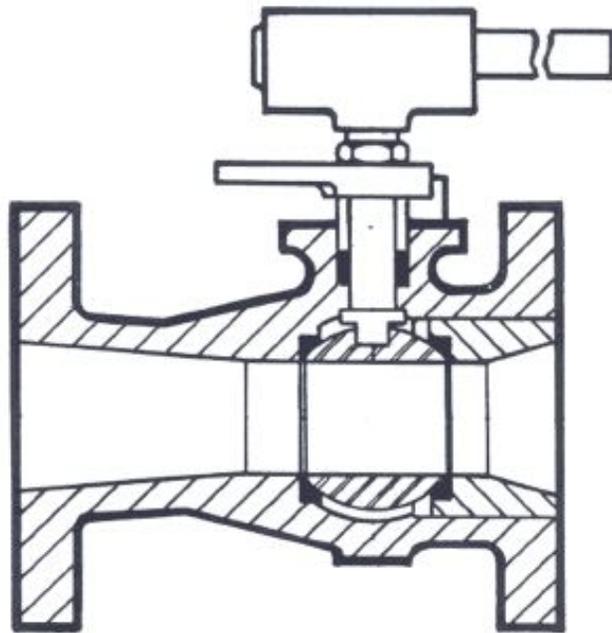
There are three basic body designs:

- End or side entry (ball fitted through body ends).
- Top entry.
- All welded design.

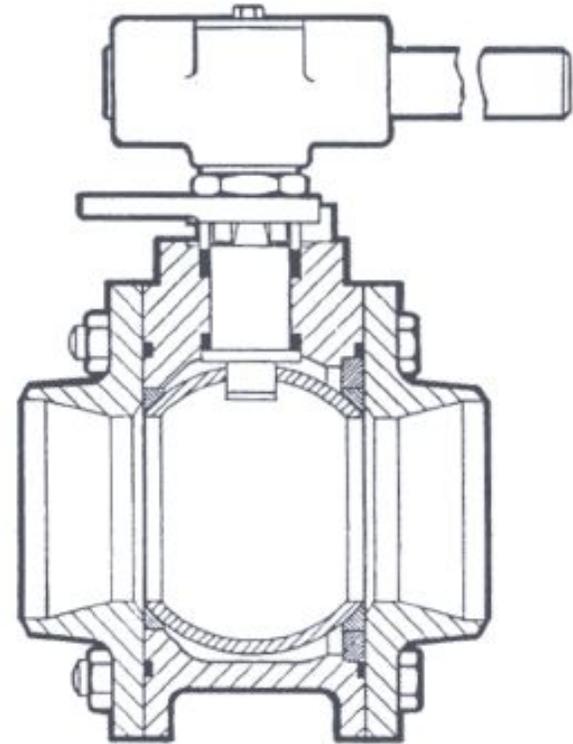
All may be obtained in full opening (full bore) or reduced opening (reduced bore) versions.

End entry valves may comprise a single piece body (usually small, low pressure designs with a threaded seat retainer).

Floating ball valve (single piece body)



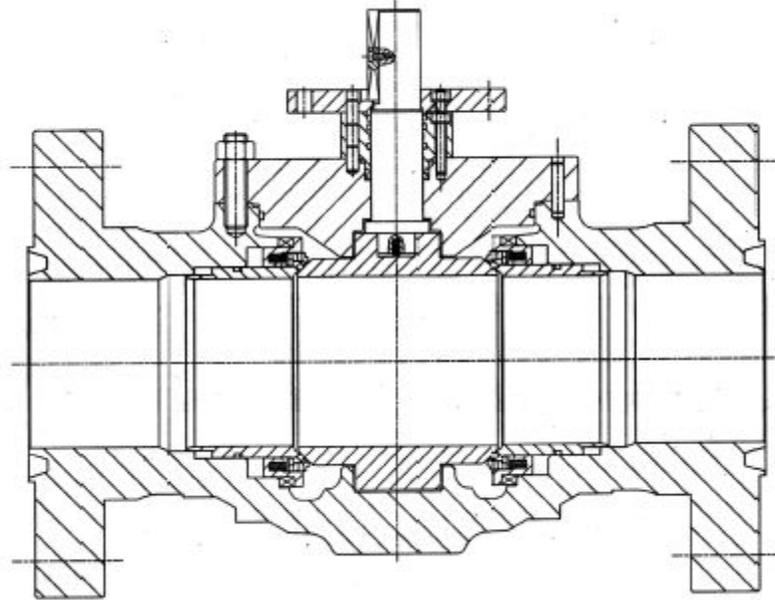
Floating ball valve (three piece body)



- a. The removal of the central section of three piece valves is only recommended in small sizes/low pressures.
- b. If larger size (e.g. > DN 150 (NPS 6)) end entry valves are manufactured to order, at least one valve of each unique size and rating should be hydro-tested with blank flanges or welded end caps so as to load the body joints. Bolting torque for other valves should then be confirmed to be identical.

Top entry designs (See Figure) have the advantage of only a single leak path to the environment which is not subject to piping loads and offer the possibility of in-situ maintenance. In practice, in-situ maintenance may be limited by the valve location, weight of ball, availability of lifting, etc. equipment and removal of the complete valve is often necessary.

Top entry trunnion mounted ball valve



c. Hard metal seated designs having all welded bodies should normally be avoided because of the risk of experiencing seat sealing problems during FAT which may necessitate cutting open the welds.

All welded body valves have the fewest potential leak paths to the environment, but usually have to be returned to the manufacturer for maintenance.

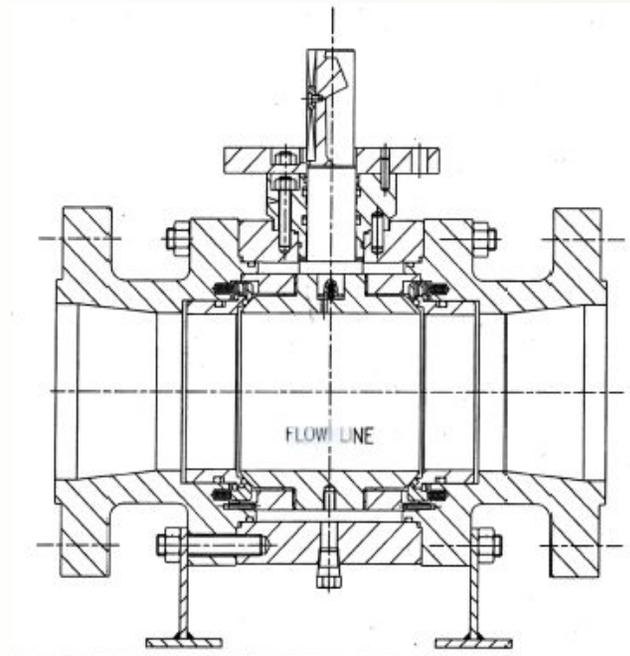
Ball support

a. Seat supported (floating ball)

The ball is supported between the two seats in the valve body. The differential pressure urges the ball onto the downstream seat, compressing the seal and shutting off fluid flow.

b. Trunnion Supported (Mounted)

End entry trunnion mounted ball valve



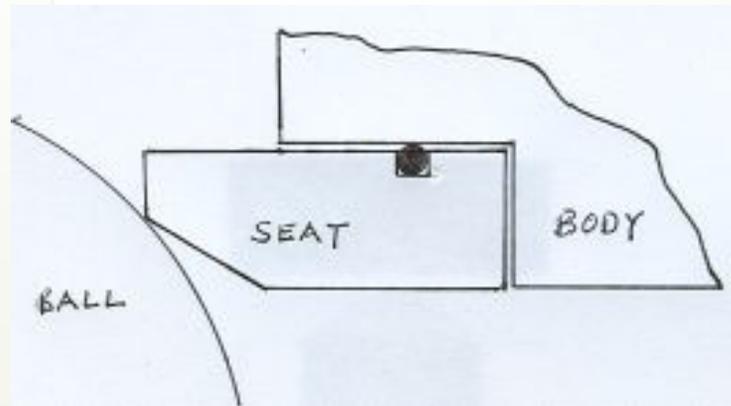
The ball is mounted on trunnions supported in body bearings above and below the ball. Sealing is achieved by a floating (spring loaded) seat, sealed against the body, which is urged against the ball by differential pressure. This design is upstream sealing and provides automatic cavity relief. It can be fitted with “double piston” seats (see below) which provide an additional seal on the downstream seat when a pressure differential exists between the body cavity and the downstream pipe.

Body cavity overpressure resulting from heating of trapped liquids is automatically relieved via the seats.

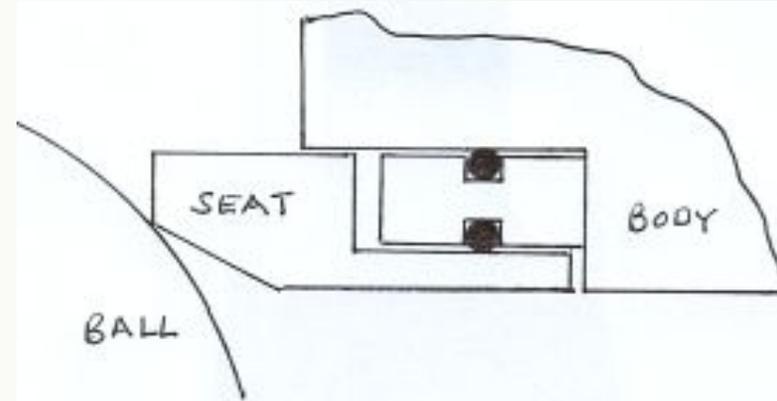
Trunnion supported designs are readily available in DN 50 (NPS 2) and larger sizes and are becoming more common in sizes less than DN 50 (NPS 2). They have lower operating torque requirements than seat supported types. Smaller sizes may only be available to special order.

1. Double piston seat trunnion ball valves

Single piston seat



Double piston seat



The design relies on the difference in annular area between outer and inner seat to body seals and the seat to ball seal which is located diametrically between them. This limits the freedom available to the designer so the normal seating function (particularly of metal seated ball valves) may be compromised.

- a. A double piston seat is recommended to be fitted to one side only (“downstream” seat) in liquid or condensing service and high pressure gas service. In this case the valve should be marked as required by ISO 14313 to indicate the directionality.

When this feature is provided on both seats the automatic cavity pressure relief feature is negated and external pressure relief must be provided on liquid and condensing service in fire hazard areas.

- b. Designs which rely on a single, large section, O-ring to provide the differential annular areas should be avoided in gas service where the large size O-ring is vulnerable to explosive decompression damage. Arrangements involving two back-to-back lip seals with the open ends facing each other should also be avoided as they can trap high pressure fluid between the seals.
- c. Double piston seats present a difficult design/manufacturing problem at high pressure and are not recommended above Class 1500 rating.

2. Ball Valve trim materials

- a. Unplated valve balls should be stainless steel (normally 316 grade). Chrome plated carbon steel balls and stems should not be used because of the danger of pitting corrosion caused by test water, etc. Electroless nickel (ENP) plated carbon steel balls (and stems, if integral with the ball) may be used for non-corrosive service or if water may be present for only a limited period (e.g. line test water). If valves are being refurbished, a proprietary ENP containing chrome carbide particles may be used to increase wear resistance (Hychrome).
- b. The manufacturer should normally be allowed to choose the soft seat insert material.

Three materials are commonly used :

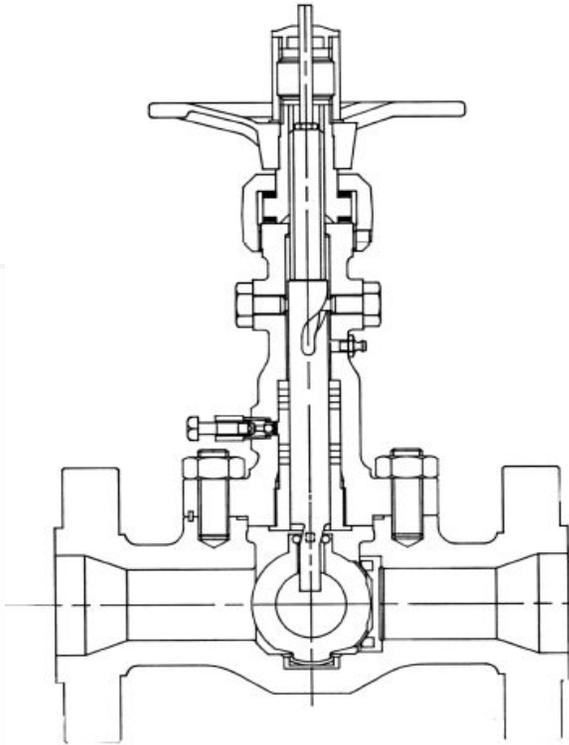
- **At low pressure – virgin PTFE.**
- **At medium pressure – filled PTFE or nylon.**
- **At high pressure – PEEK.**

- c. Virgin PTFE should never be used at high pressure and PEEK should never be used at low pressure. Nylon should not be used if there is water present in the working fluid or if prolonged exposure to test water is likely followed by service at a temperature above 70°C (158°F).
- d. Valves incorporating soft seals should be fully rated up to their maximum temperature limit. Pressure/temperature ratings of soft seated valves are limited. The same is true of all ball valves incorporating soft seals. Some standards (e.g. ISO 17292) allow the manufacturer to reduce maximum operating pressures below those in the ASME B16.34 rating tables.
- e. Metal seated ball valves require the use of hard coatings. If operating temperatures are below 150°C (302°F) the coating should normally be tungsten carbide although other carbides (e.g. chrome carbide) are sometimes used for specific applications.
- f. At elevated temperatures (e.g. in refinery applications) alloys from the Stellite or Colmonoy range should be chosen (with a suitable differential hardness between ball and seat to prevent galling or seizing).
- g. Metal seated ball valves should always be chosen for dirty or abrasive service.
- h. For high temperature service (> 200°C (392°F)), metal to metal seats and graphite stem/body seals should be specified. Trunnion mounted designs are normally not suitable.
- i. Brass or bronze materials for bushings or other wetted parts are not acceptable.

3. Other ball valve designs

There are a number of special ball valve designs, some made by only a single manufacturer, which have design features making them suitable for particular applications.

Eccentric (Orbit) ball valve



- This is a single (downstream) seated valve which has a rising stem and incorporates a cam mechanism which, when opening, jacks the ball off the seat before turning through 90 degrees and jacks it back on again at the end of closure. Tight shut-off is achieved by application of mechanical force and is not dependent on differential pressure. This design can cope well with dirty service given appropriate material selection and versions suitable for high temperature are available. It is particularly suited for very frequent operation and either a resilient seat or a metal seat may be specified.
- The single seat should theoretically make the valve suitable for high pressure gas blow-down applications, but there has been experience of vibration damage on this service.

Butterfly valves

A low torque, quarter turn, rotary action valve with a straight through flow configuration in which the disk is turned in axial trunnion bearings. The disk is exposed to the flow in the open position. Butterfly valves can be obtained with flanges, weld ends, or in wafer pattern, the latter being very economical of expensive material. Seating arrangements may be soft (use of body lining, elastomer or polymer inserts, etc.) or metal to metal.

Valve and actuator position stops should be set with care. Since butterfly valves are torque seated they are very sensitive to errors/variations in the setting of actuator end stops, air supplies, etc. If actuator stops are fully backed off, the maximum actuator output torque is applied at every closure.

Butterfly valves should not be specified in small sizes or for high pressures (> Cl 600).

The increasing intrusion of the disc in the flow path as size reduces or pressure increases results in high pressure drop.

Application requirements should be made clear when ordering since, although butterfly valves are generally suitable for bi-directional sealing, they always have a preferred sealing direction.

Butterfly valves have the following disadvantages:

The line cannot be pigged.

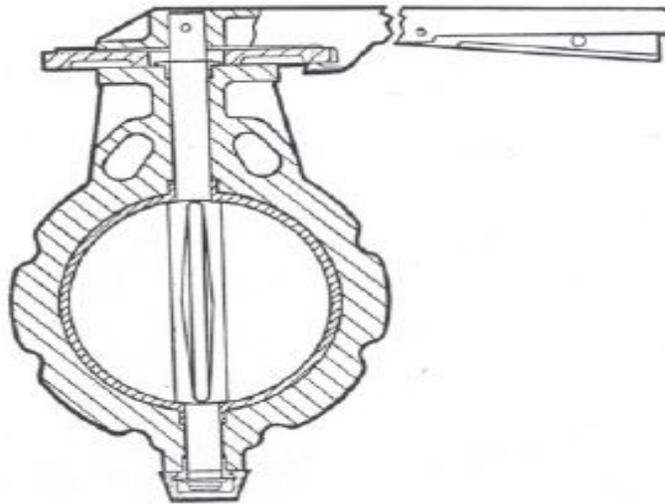
They create higher pressure drop than full bore gate or Ball valves.

They have to be withdrawn from the line for maintenance.

There are three basic designs:

Concentric disk, lined type

The disk seals against a ridge in the elastomer or polymer lining and offers tight shut-off (API 609 Type A). The valve stem is generally mounted through the vertical axis of the disk. For tight closure the disk/seat interface has to be suitably designed, particularly if the stem penetrates the lining



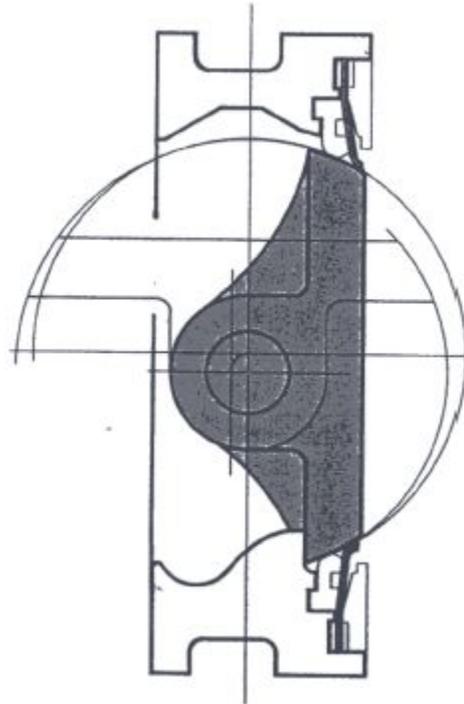
Suitable for isolation or control service. When used for control, butterfly valves exhibit high pressure recovery downstream and are thus susceptible to generating cavitation in liquid service.

Not recommended above Class 150 Rating and approx. 120°C (248°C) (dependent on resilient lining material). Should not be used on hydrocarbon service or in hazardous areas. Because the valve cannot be supplied with fire type test certification. Should normally be restricted to undemanding water service.

Lined valves should not be used in corrosion resistant alloy piping systems. Lined valves are economical for corrosive services, but prone to damage of the lining (especially around the shaft penetrations) leading to consequent rapid corrosion of the body.

Double offset (API 609 Type B)

Double offset butterfly valve



These have a shaft which is offset from the plane of the seat in two directions and are normally provided with a resilient seat ring (elastomer or polymer) or, sometimes, a metal seat ring (e.g. modified metal O-ring). Recommended for use in Class 150, to Class 600 Rating.

At higher ratings they become impractical because of the space taken up by the disk in the open position.

Recommended for isolation or control in clean service.

Differential pressure is usually equivalent to the full flange rating except if restricted by resilient seat material. Capable of tight shut-off with resilient seats – metal seated designs usually have some seat leakage in gas service. Normally available with fire type test certification. Many designs are suitable for cryogenic service.

c. Triple offset

The shaft is offset as for double offset designs and the disk seat contact axis is then further offset (API 609 Type B). The design claims to virtually eliminate sliding contact between disk and seat. A common feature of all designs is a laminated seal ring (usually consisting of alternate thin graphite and metal sheets) mechanically retained on the disk or in the body. Available with fire type test certification. Offers leak tight sealing on clean service.

- i. Recommended for isolation or control in clean service.
Seat rings generally do not employ abrasion resistant material and tests have shown that erosion of the seating faces can occur at high velocities in abrasive service (e.g. when valve is almost closed) leading to seat leakage which exacerbates the erosion. The relatively soft seal rings are vulnerable to mechanical impact damage from debris in the flow. For these reasons triple offset designs are not recommended for dirty service.
- ii. Recommended for elevated or low temperature application. Valves are all metal with graphite seals.
- iii. Recommended for use in Class 150 to Class 600 Rating.
At higher ratings they become impractical because of the space taken up by the disk in the open position).

Specification

- a. Successful butterfly valve application requires close attention to the operating conditions and the following should always be specified:
 - i. Process fluid specific gravity, viscosity, any solids content, composition (gas service).
 - ii. Flow rate.
 - iii. Max/min temperature.
 - iv. Pressure - upstream, downstream, and maximum differential in each direction (Consider the possibility of either partial reduction or total loss of differential pressure due to any abnormal conditions.).
 - v. Maximum permissible pressure drop or required Cv.
 - vi. Piping moments (flanged valves).
- b. Butterfly valve shafts should be "blow out proof" without relying on the means of attachment to the disk. Shaft retention should also not rely on the presence of the valve operator (hand lever, gear operator, or actuator).
- c. If wafer butterfly valves are specified for double isolation service, the installation should consist of two valves with a spool piece and bleed valve between.

- d. Valves in which the gasket contact area is reduced by counterbored or countersunk holes for retaining rings or screws, used to secure seat ring assemblies in the valve body, are not recommended. If specified, they should be used only with the gasket manufacturer's recommended gasket, contact area, and surface finish. Spiral wound gaskets should not be used.
- e. If valves are intended to be used with flat sheet gaskets, retaining rings which encroach on the gasket sealing area should not be allowed to protrude beyond the surrounding body gasket contact surface.
- f. On liquid service, manually operated valves located such that rapid closure could produce "water hammer" should be gear operated.

"Dead end" service

- a. In dead end service (where it is required to dismantle pipe and leave the valve at the end of a pressurised line), bi-directional butterfly valves should be mounted so that the preferred sealing direction is isolating the "dead end".
- b. Valves having seat retainers, etc. which impinge on the flange sealing gasket face should not be installed with the seat retainer on the low pressure side.
- c. Wafer-type valves should not be used in dead-end service since they do not permit installation of a blind adjacent to the valve.
- d. Lug type valves with tapped holes could be used.

Wafer type butterfly valves

Butterfly valves are available in wafer style for mounting between flanges using the flange bolting and make extremely economical use of expensive material.

- a. Wafer style valves are not recommended for line sizes DN 50 (NPS 2) and below.
- b. If future replacement by other valve types may be a requirement, flanged butterfly valves should be selected having an overall length equivalent to that of a gate or ball valve (long pattern). Once selected, wafer butterfly valves cannot be replaced by valves of other types without pipework modifications.
- c. The user/purchaser should ensure the disk, when fully or partly open, will not foul adjacent valves, fittings, or connected pipework.

- d. Short pattern valves should not be specified for lined pipe applications. Fouling is unavoidable with some short pattern valve ratings/sizes.
- e. If used in process or fire water systems where there is a fire risk, valves should be through drilled lug style in order to protect flange bolting during a fire.
- f. If butterfly valves with exposed bolts are used on such services a light gauge sheet stainless steel shroud shall be wrapped around the valve and exposed bolts.
- g. Bolting should be thermally compatible with the valve body material and connected flanges.
- h. Lugged wafer valves with tapped holes in the lugs and with bolts inserted through from each adjacent pipe flange are not recommended. If the bolt threads corrode, the valve cannot be removed from the piping system.

Wafer butterfly valves should not be used in the following services

Service containing 25 percent or greater Volume of free hydrogen.

Liquids above their auto-ignition temperature.

Steam service.

Temperatures above 260°C (500°F).

As the first block valve against storage tanks or vessels containing hazardous material.

Reciprocating compressor or pump service.

Plug valves

1. General

Plug valves have quarter turn operation. They are extremely compact and can be attractive if weight, space, and cost must be minimised. Plugs are tapered or parallel and are suitable for most on-off process and utility services. The plug valve also has a good control characteristic that can be utilised in applications requiring limited throttling such as bypass, pressure balancing, etc. They have straight through configurations usually with reduced flow area. Only full bore, round port valves can be pigged. Plug types are taper (solid) and parallel (usually split). Most types have temperature limitations.

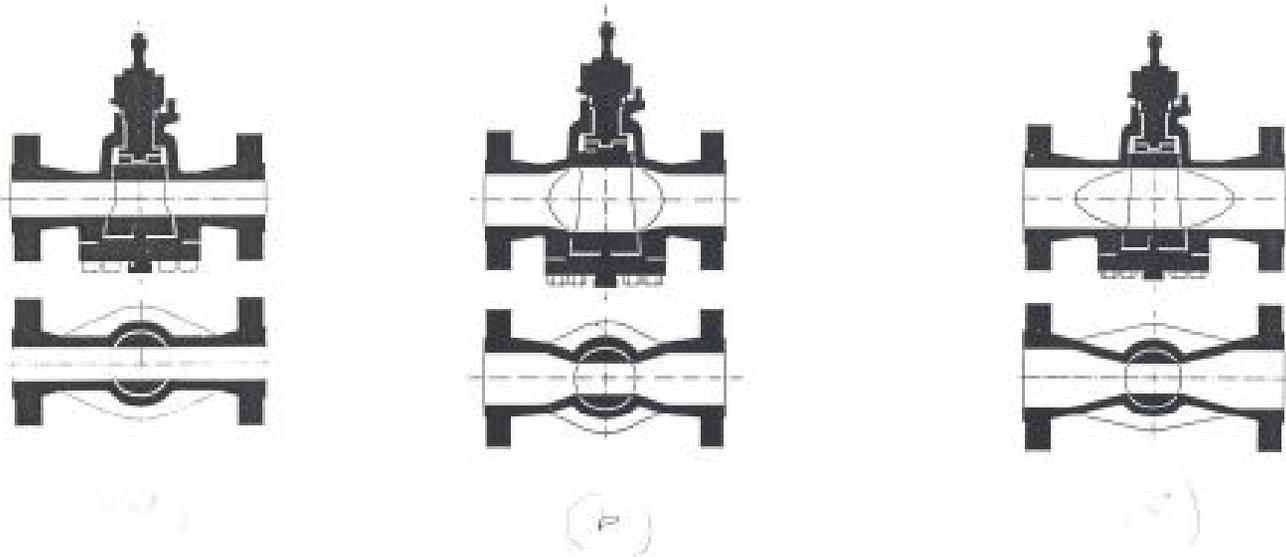
- a. Valves with parallel solid plugs are available, but should not normally be specified. Methods of stem operation are either direct (wrench or lever) or indirect (a gear mechanism and handwheel). If a wrench-actuated valve is selected, the wrench is usually supplied only if specified in the purchase order.
- b. If used on liquid service, manually operated valves should be gear operated if rapid closure could produce water hammer.
- c. Plug valves should be shipped in the open position.

There are six types of interest:

- 1. Pressure balanced, lubricated type which usually rely on injection of sealant to provide a bubble tight seal.***
- 2. Sleeved and lined which utilise a PTFE sleeve or lining.***
- 3. Semi- balanced type incorporating a thrust bearing and active seats.***
- 4. Expanding plug valve.***
- 5. Lifting wedge plug type.***
- 6. Eccentric plug valve.***

Body patterns

Plug valve patterns (round opening; regular; venturi)



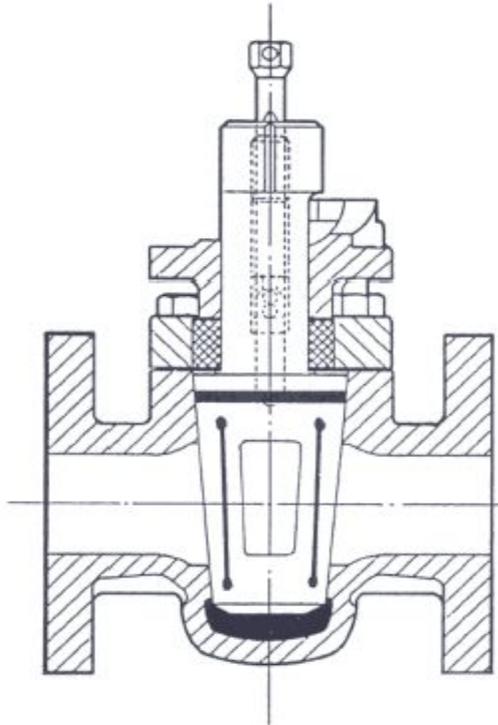
Plug valves are made in five body patterns, with port shapes and areas as follows:

- a. Round opening pattern.
Full bore round ports in both body and plug.
- b. Regular pattern
Approximately 60% of pipe area. Seat ports of rectangular or trapezoidal shape (actual area varies between manufacturers).
- c. Venturi pattern
Much reduced area seat ports of round or rectangular or trapezoidal shape approximating to a venturi to aid pressure recovery. Less expensive, with lower operating torque requirements than a regular pattern valve.
- d. Flow resistance of venturi pattern valves should be checked, particularly on liquid and multi-phase systems, and velocity should be checked if erosion is a possibility.

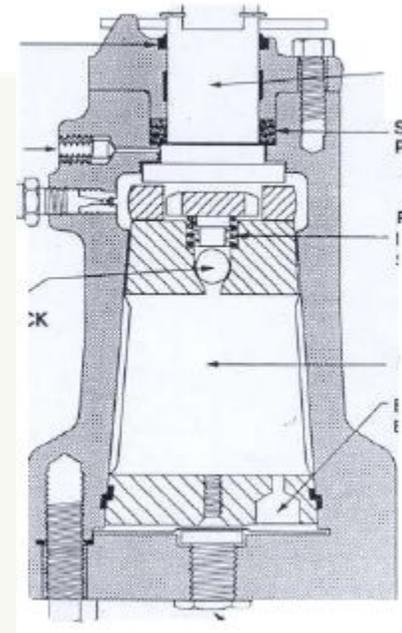
- e. Short pattern
 - Much reduced area seat ports of rectangular or trapezoidal shape, with face-to-face dimension corresponding to wedge gate valves. Only available in Class 150 and 300 ratings.
 - Not recommended in larger sizes on flow applications because the short length results in abrupt change of throat shape between the flanges and plug.
- f. Double plug pattern
 - Versions with two pressure balanced plugs in a single body are available providing a double isolation function and some of these (higher pressure ratings) occupy the same face to face length as a standard ball, plug or gate valve. However, this is at the expense of a much reduced flow passage (though not as much as a venture port valve).
 - i. Flow resistance should be checked, particularly on liquid systems.
 - ii. Because of the variety of types and overall lengths it is important to check theselected supplier's catalogue for face-to-face/end-to-end dimensions and port areas (which vary between manufacturers for a given type).

Pressure balanced, lubricated plug valves

Lubricated taper plug valve



Pressure balanced plug valve



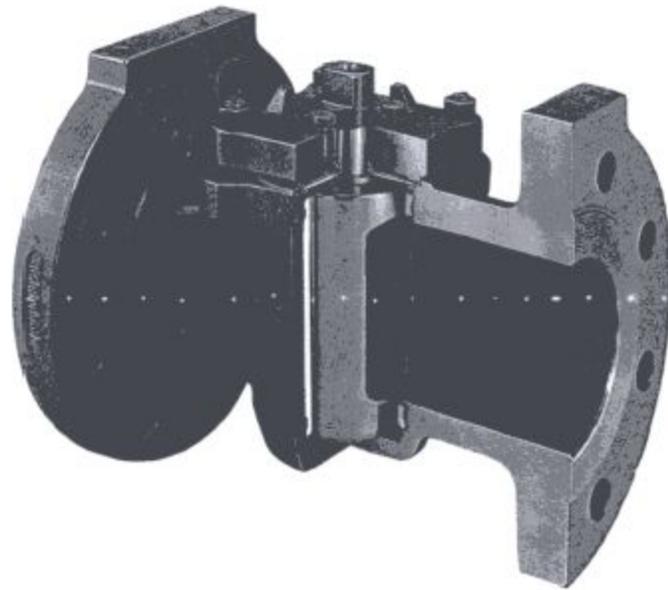
Pressure balanced, lubricated taper plug valves are pressure balanced across the majority of the plug cross sectional area to reduce operating torque. Sealant is injected under pressure between the plug face and body seat to reduce friction, provide port sealing, and to permit sealant jacking action to unseat the plug. They can provide an efficient and economical means of isolation, particularly on gas service combined with throttling capability and, in standard form, make a good choice for valve bypass and pig trap pressurisation/blowdown applications in which corrosion is unlikely. Hard faced versions (tungsten carbide, satellite, etc.) are less reliant on lubricant and can be a good choice for dirty service such as production manifold diverter service and produced water. Hard-faced plug valves are also a good choice for sand separation systems.

The following points should be noted:

- a. Most manufacturers use a low friction treatment on the plug surface to reduce friction.
- b. They require occasional injection of sealant. Ideally, inject before operation or, as a minimum, during plant turnaround. If it is intended not to lubricate valves, the supplier should be advised so he can take account of the increased operating torque.
- c. The sealant should be compatible with but resistant to the process fluid. Otherwise sealant may be washed from the plug face and may contaminate the process stream. Sealants generally cover a wide range of process applications and only one or two will be required at each site.
- d. The operating temperature range should be determined by the sealant.
- e. Each lubricated plug valve order should fully specify the service fluid(s) and operating pressure/temperature.

Sleeved and lined plug valves

Sleeved plug valve



Sleeved plug valves are of the tapered design and incorporate a polymeric sleeve (usually PTFE) in the body. Normally only available up to Class 600.
Lined plug valves are of the tapered design and are fully lined (plug and body) for chemical resistance.

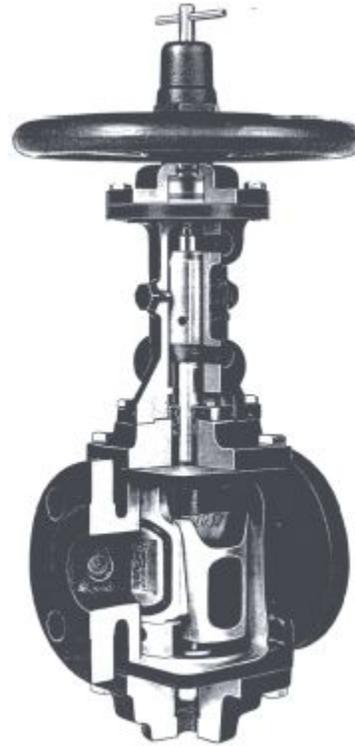
- a. Regular operation (or exercising) is recommended.
The operating torque tends to increase in service because of bedding-in of the plug.
- b. Recommended for use in caustic, chlorine, and similar services.
They generally have excellent leakage performance, both down the line and to atmosphere.
- c. Valves for chlorine service should incorporate a drilling to vent the plug and any body cavity to the upstream port.
On dirty service the seats are normally wiped clean and there are no cavities for trapping solids. These valves have been shown to be capable of acceptable performance where abrasives are present and the sleeves can sustain some damage before, eventually, leakage occurs. However, dirty service may increase the already high operating torque.
- d. Sleeved plug valves should always have a positive method of locking the sleeve into the body such as raised locking ribs.
The method of fitting or keying in the PTFE sleeve is important to prevent creep of the sleeve and to maintain a low operating torque. Some designs use a steel stiffening core to reduce creep and stabilise torque.
Fire tested glands can be obtained for sleeved valves although a fire tested valve cannot seal down the line once the sleeve is damaged. Nevertheless, plug valve sleeves take longer to suffer damage than ball valve soft seals.
- e. Sleeved or lined plug valves should be fitted with an anti-static device.

Semi-balanced, lubricated type

In this design a thrust bearing is used to reduce operating torque and piston type seats are incorporated whose sealing surfaces are shaped to match the plug which has a circular port. They are available in a limited range of sizes and pressure ratings. Plugs are normally plated and seats are nickel alloy. The design has been shown to cope well with abrasive service in which operation is relatively frequent and re lubrication limited (e.g. manifold diverter valves).

Expanding plug valve

Expanding plug valve

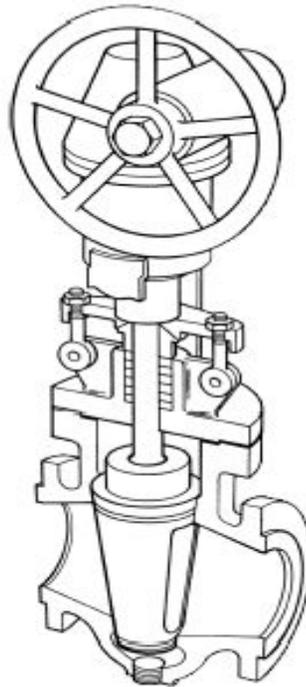


Expanding plug valves incorporate a split parallel plug with an internal wedge mechanism which is used to force the plug halves against the seats at the end of closure and to release them on commencement of opening. Soft seal rings are usually employed and the design is capable of excellent sealing performance.

- a. These valves should be avoided in gas service at pressures above 70 bar (1000 psi) because seal section sizes are large and elastomer seals are at high risk of suffering explosive decompression, regardless of formulation.
- b. Expanding plug valves provide double block isolation in a single body.

Wedge (or lift) plug valves

Wedge plug valve



Wedge (or lift) plug valves have a taper plug and utilise an operating mechanism whereby the plug is lifted from the seat before turning open or closed, the object being to reduce operating torque whilst maintaining good sealing capability. These valves are frequently used on solidifying service in combination with a steam purge of the valve body cavity and cope well with abrasive fluids. Soft seated lift type plug valves may be considered for tight shut-off applications.

Eccentric plug valves

Eccentric plug valves incorporate a parallel sided half plug and utilise a cam action to drive it onto the downstream seat. The plug is usually coated with elastomer or polymer material. Designs are limited to low pressure ratings and lined versions are available. Modifications of the design are used in control applications.

Diaphragm valves

1. General

Valves that can be used for both block and control functions. The closure member is a resilient diaphragm seating in the valve body. The diaphragm also provides the joint between the body and bonnet and often the stem seal as well. Diaphragm valves are either manually operated by a handwheel closing device or by fluid pressure, normally air.

Applications include chemical plant on/off service or flow control of most low pressure gases and liquids including slurries, viscous fluids, and fluids which are chemically aggressive. They are supplied with various types of diaphragms and can be lined. In the latter case, the lining usually serves as the flange end gasket. Diaphragms are subject to wear and fatigue so frequent maintenance may be required for regularly used valves. Operating pressure/temperature is limited by the diaphragm material.

- a. A “travel stop” should be specified as an accessory, particularly if temperatures exceed 80°C (175°F).
- b. For flammable, corrosive, or toxic service a special bonnet should be specified having a secondary stem seal to prevent leakage in the event of diaphragm failure. A bonnet vent port should be specified to provide a safe method of checking diaphragm integrity, including when the valve is under pressure.

2. Specification

- a. If ordering diaphragm valves the purchaser should list:
 - i. The process fluid.
 - ii. Its concentration (if applicable) and special characteristics to which attention must be directed.
 - iii. Operating pressure and temperature.
 - iv. Whether a secondary stem seal is required.
- b. If used in an atmospherically corrosive environment or subjected to corrosive spillage, a protective external coating should be specified.

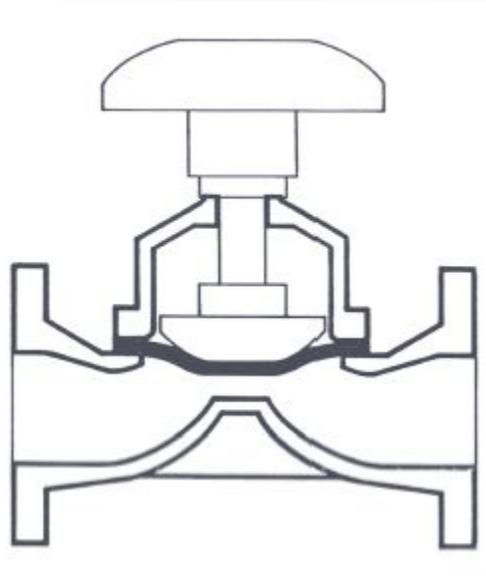
- c. Diaphragm valves should not normally be used on hydrocarbon service. Standard valves are normally supplied with ductile iron bodies which are not normally acceptable for hazardous petrochemical duties. Steel bodies are available, however.

Body configurations

The standard body configurations are:

- a. **Weir type valve**

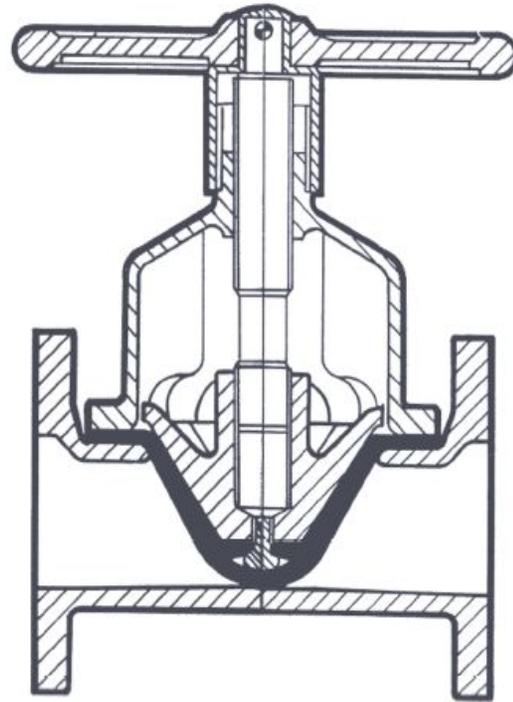
Weir type diaphragm valve



Tight shut-off is obtained with comparatively low operating force and short diaphragm movement giving longer diaphragm life and reduced maintenance. Suitable for flow control although control is poor at very low flow rates. Wide choice of polymer and elastomer diaphragm materials. Not suitable for slurries or viscous liquids.

b. Straight-through type valve

Straight pattern diaphragm valve



Suitable for viscous fluids, thick slurries, and fluids containing deposits. Has a longer diaphragm movement, which decreases diaphragm life and increases maintenance. Requires a more flexible diaphragm which limits material choice to elastomer.

Globe valves

General

Globe valves are used as a block valve if resistance to flow is not critical and a positive closing action is required e.g. they are useful for frequent on-off operation on gas or steam service. They may also be used for limited flow regulation or throttling duty in which case an integral stem and plug should normally be specified to avoid vibration and instability.

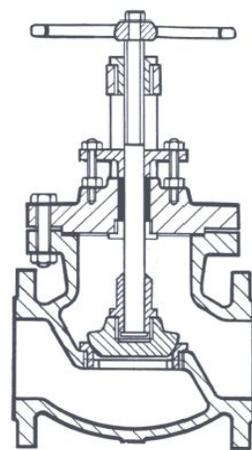
- a. For severe throttling service or if close control is required, conventional control valves with a hand operator should be used. Globe valves have a tortuous flow path which results in a higher resistance to flow and low pressure recovery compared with other valves.
- b. The configuration of the flow path is normally only suitable for uni-directional flow and globe valves should be mounted in the line such that flow is in a direction from beneath the disk.
- c. High un-balanced forces may prevent opening against reverse pressure differential so, if this is important, the requirement should be specified.

2. Body designs

Body types are:

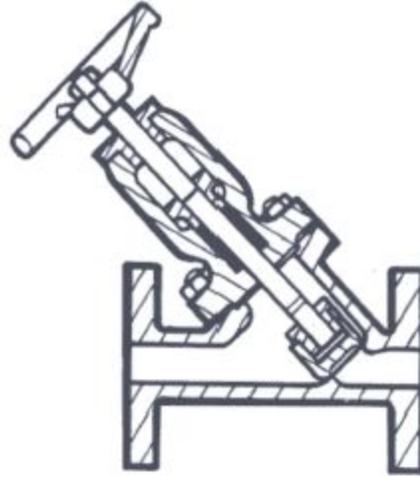
Standard

Standard (straight) pattern globe valve



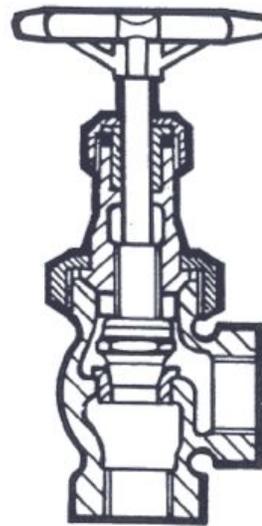
•Oblique (Y) pattern

Oblique pattern globe valve



•Angle pattern

Angle pattern globe valve



All of which can be provided in needle versions for simple flow regulation service. The oblique and angle type have much lower flow resistance than the straight-through globe (typically $1/3$ to $1/4$) and, usually, increased cost.

Oblique (Y pattern) type valves have a relatively straight flow path and, with hard-faced trim, are suitable for on-off or throttling duty on abrasive slurry or highly viscous services. Conventional globe valves are not recommended for these services. They are also useful in small sizes with screwed and seal welded bonnets for general purposes in steam, condensate and boiler feedwater service.

Angle type valves, when fitted at a change in direction of piping, save one bend or elbow and have the advantage of a smaller pressure drop than the straight through type Note that:

The 90 degrees bend in process piping may subject the valve to considerable bending stress at operating temperature.

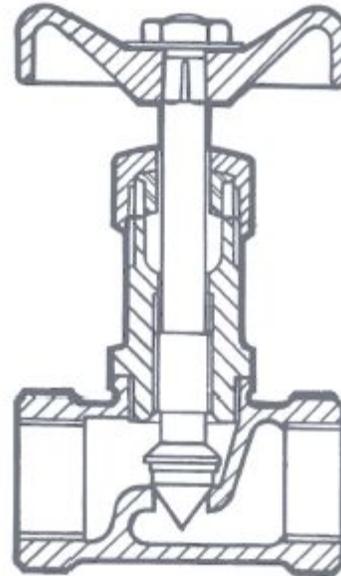
The handwheel may be placed in only one position with respect to the piping.

Disk variations

Disk types available are:

- a. Types having a flat seat/disk interface (metal-to-metal seat or with a soft seal ring incorporated).
A soft seal limits the maximum allowable temperature. This type is not suitable for flow control applications.
- b. Types in which the disk has a tapered or spherical seating surface and provides narrow line contact against a conical seat.
The narrow contact area tends to break down hard deposits that may form on the seat. This type is recommended if crude flow control may be required.
- c. Needle type having a long tapered plug type disk.

Needle pattern globe valve



This type is recommended for fine flow control.

Stem variations

- a. Only outside screw and yoke versions should be considered.
Valves are available with a rotating and rising stem (rising handwheel) or with rising, non-rotating stem (non-rising handwheel).
- b. The backseat of valves of the rotating and rising stem type should be mechanically locked or welded in place to prevent rotation.

Check Valves

The obturator (closure member) of swing check valves is variously described as a “clapper”, “plate” or “disk”.

General

Check valves permit flow in one direction and prevent flow in the reverse direction. This is achieved through linear or rotary (angular) motion of a closure member that is kept open by the kinetic energy of the flowing fluid. When the flow is reduced towards zero or reversed the valve is automatically closed against its seat by gravity, the effect of supplementary springs, back pressure or combinations of these effects. Check valves are intended to prevent gross back flow of fluid and should not be relied on to provide effective isolation. Check valves do not normally have shafts which breach the pressure containment except where this is necessary to provide mechanical override, position indication, or external damping or disk balancing. These features are usually only available on large swing check valves for critical applications.

- a. Shafts which penetrate the pressure containment should normally be avoided.
- b. Check valves other than diaphragm type should not be used in slurry service.

Check valve types

Characteristics vary considerably and should be considered when selecting valves for particular applications. Designs may be broadly categorised as follows:

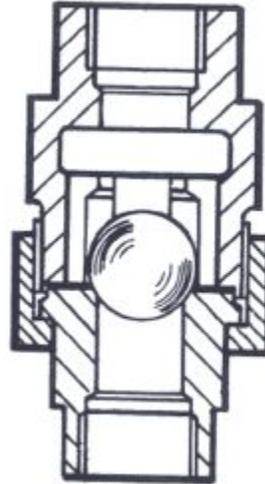
- **Lift check (linear motion of the obturator in direction transverse to pipe axis).**
- **Swing check (angular motion of the obturator).**
- **Axial flow nozzle check (linear motion of the obturator along the pipe axis).**
- **Plate check (linear motion of flexible metal or polymer plate along the pipe axis).**
- **Diaphragm check (flexing of a membrane).**

There are a number of variations in design of the most common types e.g.

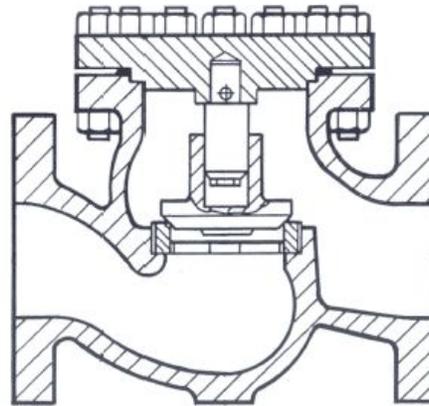
- **Lift check – disk, piston, and ball types.**
- **Swing check – standard, tilting disk, and duo-disk types.**
- **Other commonly occurring variations are:**
- **Wafer check (for installation between flanges – duo disk and single disk types).**
- **Screw-down stop and check (globe and swing types with provision for manual closure).**
- **Foot valve (pump suction duty).**

Lift check

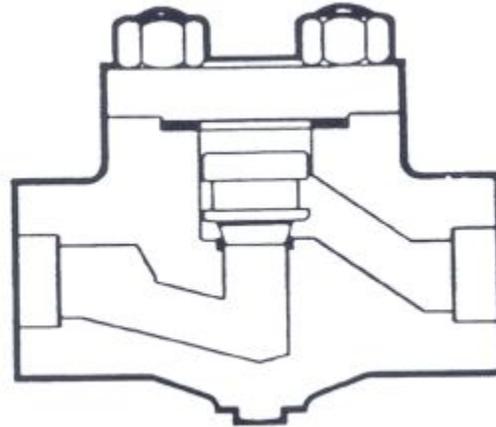
Lift check valve (ball type)



Lift check valve (disk type)



Lift check valve (piston type)



A lift check valve utilises linear motion of a disk, piston or ball moving transverse to the pipe axis. It either relies on gravity to effect closure or incorporates springs which bias the obturator towards the closed position. The piston type incorporates a piston and cylinder which provide a damping effect during operation and in some designs the degree of damping is adjustable. All designs cause a relatively high pressure drop although oblique (Y) pattern designs are available with much reduced flow resistance at increased cost. Note that ball type check valves are available in axial flow configuration in small sizes.

Lift check valves should be selected for applications which could result in surge problems for other types of valves. Closure response is potentially fast due to the short travel and the low inertia of the obturator.

This makes the valve suitable for reciprocating pump outlets and comparable applications.

The use of lift check valves with union bonnets should be limited to portions of piping systems in which pipe unions are allowed.

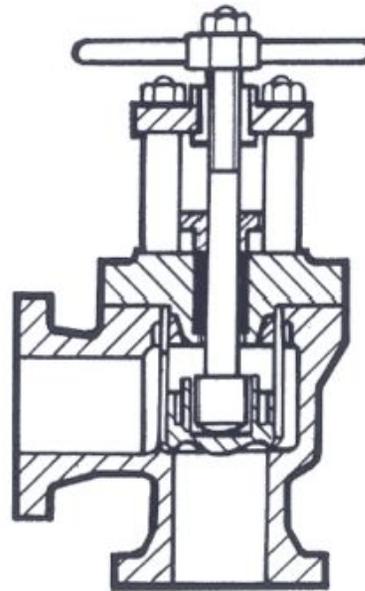
Piston and disk types should be avoided on dirty or viscous service and reserved for clean liquids and non-condensing gases.

Free movement of the obturator may be difficult to achieve in these services and slow response or jamming is likely as a result of blocking of clearances. Ball checks are less affected due to freer guiding of the ball.

- Ball checks with metal ball should not be used on gas or vapour service because of the potential for ball/seat damage as a result of irregular flow.
- Ball checks should not be used in sizes above DN 50 (NPS 2). Piston type can be used in larger sizes where pulsing flow is present (e.g. at the outlet of reciprocating pumps).
The most frequent application of lift check valves is in sizes less than or equal to DN 50 (NPS 2).
- f. Ball check valves should not be used with widely varying pressures, pulsing flow, and frequent flow reversals.

Screw-down stop and check

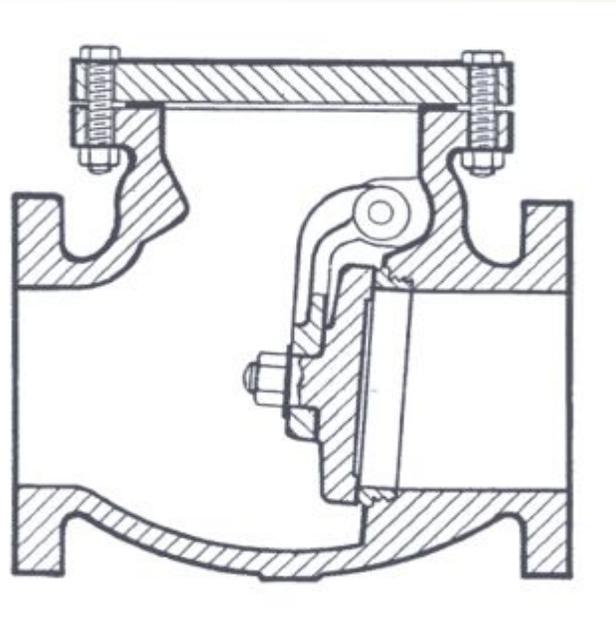
Screw-down stop and check valve



This is a variant of the lift check in which the disc is held closed by a valve stem which can be retracted to permit free movement of the disc. Generally used in steam generation using multiple boilers, in which a valve is installed between each boiler and the main steam header.

Swing check - Conventional type

Swing check valve

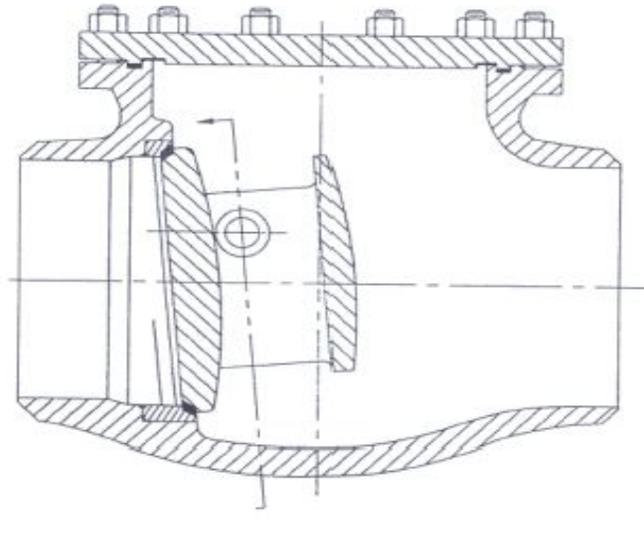


A check valve in which the mechanism incorporates a disk that swings on a hinge pin or shaft. The bearing assemblies for the hinge pin and disc are shrouded from the flow stream and thus dirty and viscous fluids are less able to obtain ingress and hinder rotation of the closure member.

- a. Swing check valves should be used in sizes above DN 50 (NPS 2).
- b. Weight and travel of the disc may become excessive in very large sizes at high pressures and special design may be required to ensure satisfactory operation.
- c. The two-piece stem design valve in which the shaft penetrates the body has the potential to blow the shaft out and should be designed so as to be blowout proof.
- d. Swing check valves are unsuitable for frequent flow reversal, applications with wide velocity variations, and applications with pulsating flow. If installed in a system liable to sudden flow reversal, a counterbalance weight or dashpot should be specified to prevent slamming.
- e. A counterbalance weight may also be required if the valve has to open with a minimum pressure differential. Full closure is sometimes supplemented by additional weighting of the disc or by an external weighted lever arm or spring. This may result in excessive closing force (slamming) unless a damper is also fitted.
- f. Some sophisticated designs (used for e.g. offshore riser protection) are available which have been shown to be able to withstand rapid flow reversal and slamming. Externally mounted weights or dashpots introduce the additional complication of a gland to seal the extension arm.
- g. Balance weights, spring loaded cylinders, and oil-filled dashpots should not normally be specified and should only be fitted after careful analysis and discussion with the manufacturer.
- h. Closure response of swing check valves is generally slower than that of lift check valves. This is due to the long travel of the disk, the inertia of the disk and hinge arm and the varying moment arm of the disk centre of mass.
- i. If pigging is a requirement, special variants of the conventional valve, incorporating shaped disks, should be used.
- j. Although widely used, swing check valves are generally best suited to gravity flow and pumped (liquid) systems where flow velocities are relatively low.

Swing check - Tilting disk type

Tilted disk swing check valve



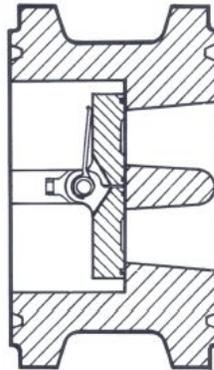
Tilting disk check valves incorporate a disk that rotates eccentrically on a shaft mounted above the horizontal axis of the pipe. They are a variant of the conventional type and have a faster response and reduced inertia. Closure at the instant of flow reversal is more nearly attained than with the conventional design. Tilting disk valves are suitable for use in viscous service and have less pressure drop at low velocities and more pressure drop at high velocities than a swing type valve.

Tilting disk check valves should not be used if pigging is a requirement.

If slamming is considered probable, both the tilting disc check valve and the duo disk wafer-type improve on the performance of a conventional swing check. Nevertheless there may be some conditions in which it is necessary to slow down the closure by fitting an external dashpot, etc. In such circumstances an axial flow check would be preferable.

Swing check - Duo-disk type

Duo disk wafer check valve



These valves provide a fast response due to a short path of travel of the half disc centre of gravity, the low inertia resulting from the light weight, short moment arm of the half disc, and the use of closing springs.

- a. Duo-disk check valves are recommended in preference to conventional swing checks in which high flow velocities occur e.g. in gas service.
- b. Duo-disk check valves depend on internal spring loading for closure and are therefore the most suitable type of check valve for location in vertical pipes with upward flow.

Duo-disk valves tend to have an increasing resistance to flow as the size decreases and the pressure rating increases owing to the obstruction of the body centre web and the thickness of the half plates which reduces the area of flow. However, designs are available up to API 6A 10 000 rating.

Originally, all these valves were provided with openings in the body through which the hinge pin, etc. was inserted and which were usually sealed by screwed plugs. If this type is supplied the recommendations contained in this GP for screwed connections should be observed. Nowadays designs are available (retainerless design) in which the half disks and hinge pin are inserted from one end, avoiding the need for holes in the body.

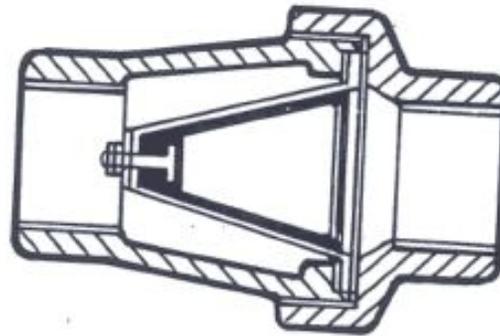
- a. If retainerless design is supplied, a check should be made to ensure there are no unacceptable interruptions of the gasket sealing face.

Swing check – Wafer style

- a. Both single plate and dual plate swing check valves are available in wafer style for mounting between flanges using the flange bolting and they make extremely economical use of expensive material.
The valve has to be removed from the line for maintenance or repair.
- b. These valves are not recommended for line sizes DN 50 (NPS 2) and below.
- c. Valve installation design should ensure that the plates do not foul adjacent valves or connected pipework.
- d. Single disk wafer check valves are not recommended because disk opening is usually severely restricted resulting in high pressure drop. Single disk wafer checks should never be used on low flow or low pressure gas services in which the disk position may oscillate.
- e. If used in process or fire water systems in which there is a fire risk, wafer checks should be through drilled lug style in order to protect flange bolting during a fire.
Body designs are either lug type (incorporating through drilled or tapped holes) or standard flangeless (designed to fit inside the bolt circle).
- f. Bolting should be thermally compatible with the valve body material and connected flanges. If wafer check valves with exposed bolts are used on such services a light gauge stainless steel shroud should be wrapped around the valve and exposed bolts to provide fire protection.
- g. Wafer valves with tapped holes in the lugs and with machine bolts inserted through from each adjacent pipe flange are not recommended.
If the bolt threads corrode, the valve cannot be removed from the piping system.
- h. Wafer checks should not be used in the following services:
 - * Service containing 25 percent or greater volume of free hydrogen.
 - * Liquids above their auto-ignition temperature.
 - * Steam service.
 - * Temperatures above 260°C (500°F).
 - * As the first block valve against storage tanks or vessels containing hazardous material.
 - * Reciprocating compressor or pump service.

Diaphragm check

Diaphragm check valve



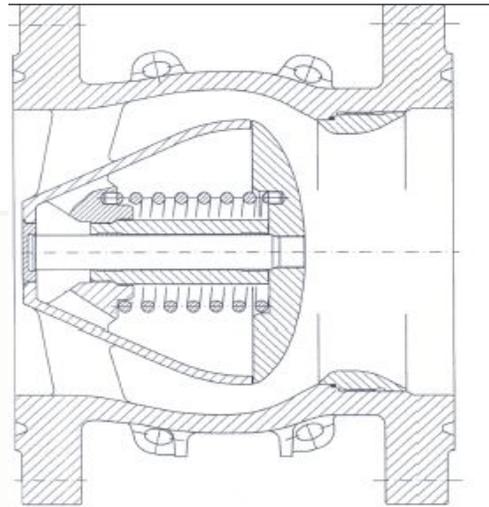
Diaphragm checks provide stable operation with pressure variations, pulsing flow, and frequent flow reversals and location may be in either horizontal or vertical lines.

Closure is provided by a flexible membrane supported by a metal frame or cage. The membrane imposes temperature, pressure, fatigue, and fluid compatibility limitations so care is required in material selection.

Small sizes are usually of the cone type and larger sizes are typically of the nozzle type. Although less commonly used than conventional lift or swing check valves, the diaphragm check valve has a number of useful characteristics such as: full closure, fast closure response, and the ability to handle viscous or abrasive fluids and slurries more reliably than other types.

Axial flow (nozzle) check

Axial flow (nozzle) check valve



- a. These valves can be characterised as a lift check disposed axially along the pipe axis. Recommended for preventing excessive pressure surge and providing stability if wide pressure variations, pulsing flow, and frequent flow reversals are likely. Axial flow checks have a short disk travel, low inertia, spring assisted closure, and are extremely responsive to changes in flow. This design is typically selected for onerous duties and uses the venturi principle in the design of flow passages through the body resulting in the least flow resistance of any check valve type. Sliding parts are largely shrouded from the flowing process fluid by the central housing. The valve can be mounted either horizontally or vertically and is available in a wide range of sizes and pressure ratings.
- b. Axial flow nozzle checks are recommended for use in compressor discharge lines subject to pulsating or low flow conditions in which a tilting disk type valve may 'chatter', but are not recommended for reciprocating pump applications. The valve body is usually made from a casting and is available with flanged or weld ends. There are no penetrations of the pressure containment.

Plate check valves

Plate check valve

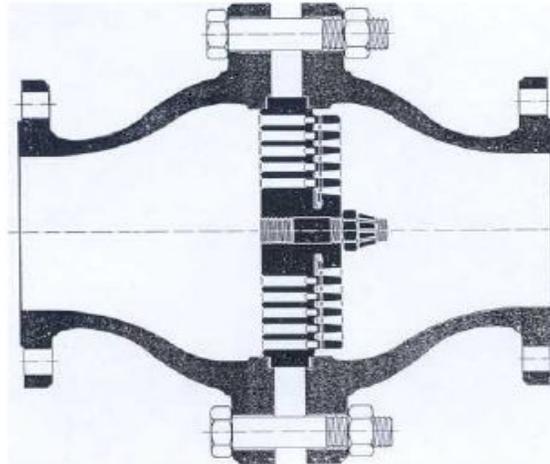
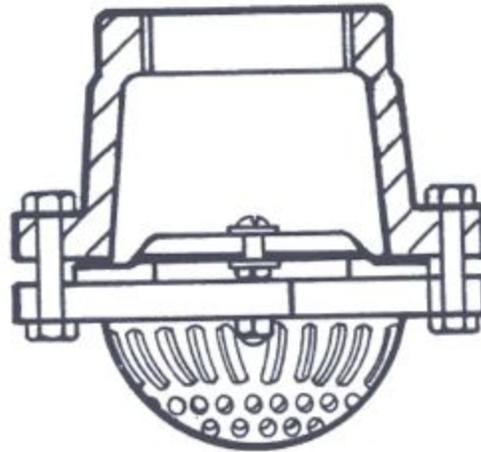


Plate check valves use flexible metallic or polymer plates or membranes and are normally fitted to compressors. This type of valve provides a very fast closing response and is particularly suited to pulsing flow with compressible fluids. The frequency of flow pulsations may require special consideration of design to avoid plate flutter. Generally limited to applications in which there is a low differential pressure across the valve. Suitable for mounting either horizontally or vertically.

Foot valves

Foot valve



These are generally installed at the suction inlet of a pump to maintain prime. The valve may be fitted with a strainer to keep dirt and other foreign matter from entering the pump suction.

Application Guidance

Pigging

- a. Only special designs of swing type check valves with contoured disks and (normally) seat faces at right angles to the flow should be selected for services which are required to pass pigs.
- b. If intelligent pigging is expected some means of mechanically lifting the disk should be necessary.

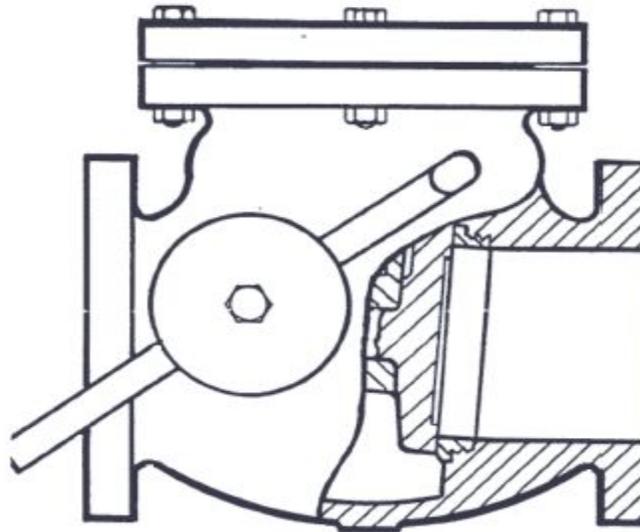
Dynamic response

The more closely the position of the valve closure member follows a declining forward flow rate and prevents back-flow the less likely it is to cause a high pressure surge (e.g. “water hammer”) as a result of closure after a reverse flow has been established. Surge can result in damage to the valve, piping system, and ancillaries, e.g. pump and compressors.

- a. Swing check valves which facilitate pigging are also most susceptible to inducing pressure surge. If pigging is not a requirement and high pressure drop cannot be tolerated, the following alternatives, listed in the order of their “anti-slam” performance, should be considered:
 - i. Axial flow, nozzle check.
 - ii. Dual plate check.
 - iii. Tilting disk check.
 - iv. Swing check with seat inclined to vertical and a maximum angle between disk and seat of 65/70 degrees.
- b. If low pressure drop is not required piston type check valves may be used. Valve types with a short travel and low inertia of the obturator, supplemented by spring loading, provide the most rapid response and lowest surge potential. A valve that closes at a mean velocity equal to or less than the normal flow velocity should avoid excessive pressure surge.

Supplementary loading can improve the response of some valves .

Swing check with supplementary loading



Pressure shocks may still occur if :

1. Loss of pressure at the valve inlet produces flashing of the decelerating fluid downstream from the valve.
2. A valve some distance downstream from the check valve is closed suddenly.

Unstable and pulsating flow

Rapid fluctuation in movement of the disk can result from large variations in pressure or from smaller variations caused by pulsing flow and can lead to valve chatter, excessive wear, and poor reliability.

- a. Standard swing checks should be avoided if wide velocity variations, pulsating flow, and frequent flow reversal are likely.

Under severe conditions fretting at the hinge pin and even mechanical failure may occur with all these valve types.

- b. Tilting disk and duo-disk valves are better at coping with unstable flows.
- c. Axial flow nozzle check designs are better still and should always be used at compressor outlets unless there are pressing reasons for doing otherwise. However, they are not normally suitable for fitting downstream of reciprocating pumps. For this and other applications involving pulsating flow piston type lift checks are particularly suitable and can be obtained with adjustable damping.
- d. In all cases the characteristics of check valves in compressor piping systems should be compatible with the compressor manufacturer's requirements.

Stability of conventional and tilting disc swing check valves may be improved by fitting an external damping device (dashpot) via a shaft extension sealed by a gland. This may also prevent surge (water hammer). Damping may also be a requirement in systems in which extremely rapid flow reversals could occur, e.g. catastrophic rupture of gas piping systems.

Duo disc check valves cannot normally be damped since external methods cannot be employed.

Frequent flow reversal

Numerous flow reversals may have an adverse affect on wear and reliability of valve components and manufacturers should be advised if this is likely to be the case.

Installation

- a. Check valves should be mounted at least three pipe diameters downstream of such pipe fittings. Check valves are extremely sensitive to upstream piping features and elbows, valves, etc. located immediately upstream can have a disastrous effect on performance.

- b. A vertical location adversely affects the response of most types of check valves and should be avoided if possible.
- c. Lift type and swing type check valves should ideally never be fitted in vertical pipes. If swing check or tilting disk designs are so installed the design should prevent the disk reaching a “stalled” position when fully open. It should be recognised that in the fully open vertical position the disk/hinge arm has a very small closing moment, further reducing response unless supplementary loading is used with the possible complication of damping. Any lift check valves mounted in vertical pipes should be provided with springs.
Duo-disk check valves are more suited to vertical applications.
- d. No check valve should be mounted in a pipe with flow vertically downward except axial flow nozzle type and duo disk type and then only with the full knowledge and agreement of the manufacturer.
- e. In cases where a vertical location is contemplated, the supplier should be fully appraised and asked to confirm that the obturator will not remain open to permit reverse flow.
- f. Lift check valves in horizontal pipes should always be mounted with their bonnet axis in the vertical plane.

Sizing

- a. Check valves should ideally be selected such that under normal flow conditions they are fully open against the stop and the user should advise the manufacturer of the minimum flow velocity at which the valve is required to be fully open. If swing check valves are used in pigged pipelines this is not usually possible. In such cases design should ensure that hinge pin and bearing design is adequate for the constant movement which may result. For critical applications the manufacturer should be asked to advise the flow velocity necessary to keep the valve fully open and to predict the position of the valve disk under normal and minimum flow conditions.

Swing check valve failures often result from sizing for a larger than normal flow such that, during most of the operating life, the valve disc is not fully opened against the stop. This results in instability and mechanical damage.

- b. Applications in gas or steam lines or in liquid lines with low or unsteady flow should be fully described in the purchase specification so that the manufacturer can evaluate the suitability of the valve design.

Flow resistance (pressure drop)

Resistance to flow varies widely in different designs and also generally increases disproportionately with smaller valve sizes and higher pressures (because disks have to be thicker and occupy more of the flow path). Typical flow resistance coefficients for DN 150 (NPS 6) valves are as follows:

Swing type	1,0.
Axial flow type	1,4.
Oblique pattern lift type	2,0.
Piston type	7,0.

Shut-off

If differential pressure in the shut-off direction is very low, it may be necessary to consider supplementary loading. This can be achieved in some designs by additional weighting (e.g. external in the case of swing checks) or stronger spring loading.

Special valve applications

Shut-down valves

Emergency shut-down (ESD) valves

ESD valves are required to contain and protect sections of a plant in the event of an emergency such as a fire. Standard types of valve intended for ESD service must achieve the highest degree of functional reliability and pressure boundary integrity and may be affected by legislation in some countries.

The chief requirement is that the valve can be relied upon to close when asked to do so under any likely conditions of operation. To demonstrate this, periodic tests involving full or partial closure of the valve are required. Tight shut-off is generally a secondary consideration.

Valve types are commonly trunnion mounted ball or slab type gate valves fitted with a fail closed actuator. Slab gate valves can utilize internal pressure and the piston effect of the valve stem to assist closure with consequent reduction in actuator size.

- a. Trunnion mounted ball or slab type gate valves should be the first choices for dirty service (if the height of the latter can be accommodated and if operating temperatures allow the use of elastomer and polymer seals).
- b. Floating (seat supported) ball valves should not be used for ESD service except if metal seated versions are necessary in high temperature ($> 200^{\circ}\text{C}$ (392°F), low pressure service. In such cases a metal seated, graphite sealed butterfly valve may provide an alternative choice.
Operating torque of floating ball valves (particularly metal seated type) is high and can increase markedly if valve condition deteriorates.
- c. Soft seated ball valves may be used in clean service, but if sand, pipescale, or corrosion product is likely or the valves have to pass pigs, hard coated metal seated valves should be selected.
A high degree of seat leak tightness in service is not generally required and, although the “as constructed” leak rate of metal seated valves is usually worse than that of soft seated valves, it is likely to be maintained without significant deterioration in adverse conditions.
- d. If soft seated valves can be justified, it is advisable to provide protection during line flushing, etc. operations.

- e. ESD ball valves should not normally be fitted with seat sealant injection facilities since this feature is ineffective (and usually unnecessary) in the case of metal seated valves and can never be used post ESD in the case of soft seated valves. Such facilities may be useful for solvent flushing of soft seated valves in service where experience has shown this to be beneficial.

If drain and vent connections are provided, it may be worth fitting them with valving since this permits the valve cavity to be accessed with the system pressurised should the need arise (e.g. for hot oil flushing to get a jammed seat to move).

- f. Ball valves having double sealing piston type seats may be used to provide two seals in series. If ESD valves have a preferred isolation direction it is recommended that only the “downstream” seat should have this feature.
- g. Balanced, lubricated plug valves may be used if periodic relubrication can be guaranteed and are particularly suited to gas service applications where maximum compactness is required.
- h. Sleeved plug valves should not be used for ESD applications because of the tendency for operating torque to increase.
- i. Double or triple offset butterfly valves may also be used in clean gas or liquid service up to Class 600 (PN 100) rating. In high temperature service metal seated, graphite sealed versions may be the best choice.
- j. Expanding type gate valves and wedge type gate valves should not be used in shut-down service. High operating force requirements at the beginning and end of the operating stroke make these valve types unsuitable for shut down service.

Emergency shut-down valve actuators

- a. The actuator and associated control system have a major influence on the performance of ESD valves and should be chosen with care.
- b. ESD valve actuators should normally be fail-safe hydraulic type or, for smaller size, low pressure applications in which their greatly increased size can be accommodated, fail-safe pneumatic type.

- c. ESD valve actuators in hazardous areas should shall be protected against fire and blast to ensure that during a limited fire they can function as required.
 - i. Protection may be provided by screens, casings, or the application of intumescent coatings.
 - ii. Access requirements (for maintenance, testing, etc.) should be considered during selection.
- d. In high temperature service applications it may be necessary to mount actuators on extended spools or yokes or to provide extended valve bonnets to ensure an acceptable operating temperature.

Actuator safely factor

Actuators of valves should be capable of applying a torque/force of at least 1,5 times the maximum requirement advised by the manufacturer (and recorded during factory acceptance tests) throughout the open/close cycle.

High Integrity Pressure Protection System (HIPPS) valves

These valves are used as the final part of an instrumented system intended to prevent an unacceptably high pressure occurring in downstream equipment. They are always arranged to fail closed and spring/hydraulic actuators are usually the only practical alternative for operation.

- a. In general, closure times should be maximised or, if times have to be short, tests should be undertaken
Required closure speed depends on the closed-in volume downstream and the working fluid (e.g. if there is a high volume, gas filled system downstream, valve closure speed need not be fast).
- b. HIPPS applications have the following characteristics:
 - 1. High pressure always available at time of emergency closure.
 - 2. Low differential pressure during closure;
 - 3. High differential pressure after closure;
 - 4. Requirement for periodic closure (or partial closure) and seat leakage testing;
 - 5. (Occasionally) fast closure.

The first two make for particularly benign operating conditions and the temptation to specify an unnecessarily high differential pressure during closure should be resisted.

- c. Hard metal seated, slab type gate valves should be the first choice for this application if pipe size is less than DN 400 (NPS 15).

Designers of slab type gate valves can utilise the high internal pressure to close the valve by designing the valve stem as a piston. This means that the closure spring is only necessary during operations at very low or zero pressure and increases reliability of closure.

- c. Hard metal seated slab type gate valves and trunnion mounted ball valves should be selected if pigging is required.

Speed of operation

- a. Fast operation is not required by most shut down applications and should be avoided if possible. As a general rule of thumb the operating time of ball and slab gate valves should equal or exceed DN/25 (NPS) in seconds; i.e. a DN 250 (NPS 10) valve should not close faster than 10 seconds.
- b. If faster closure than specified in is required and a manufacturer does not have directly comparable and thoroughly tested experience of the material/load/speed/operating environment combination proposed then pin and disk abrasion testing should be commissioned from an appropriate laboratory.
- c. Fast closure times also mean that some form of hydraulic damping is necessary at the end of travel. This should ideally be arranged as an integral part of the piston/cylinder design.
- d. Contact load/operating speed combinations arising during factory acceptance testing of a valve should not exceed those which will occur in service.

The limitations of test arrangements can sometimes impose conditions which are more onerous than those which will

Testing

- a. Shutdown valves should be periodically closure tested.
 - 1. The frequency of testing, to some extent, determines the level of reliability that can be claimed but it is necessary to balance the desire for high reliability against the detrimental effects (wear, etc.) of too high a closure test frequency.

2. A test frequency of 2 times per year is usually defensible and frequencies greater than 4 times per year should be avoided.

Partial closure testing can be advantageous in that it demonstrates that all parts of the control and actuation system are functioning correctly without interrupting production. Test facilities are easy to incorporate into actuator control systems at the design stage and there are also commercially available add-on devices for valves already in service. It is still necessary to carry out a complete closure from time to time in order to demonstrate that this can be achieved and to facilitate seat leak testing.

- b. System design should make provision for periodic seat leak tests of HIPPS valves and import/export pipeline isolation valves to support a safety case or meet regulatory requirements. There are only two possible methods:

1. Monitoring pressure decay from or pressure rise in a known closed volume over time.
2. Acoustic leak detection.

The former method assumes that all other isolations (such as block valves) of the closed volume are 100% effective. Acoustic leak testing is less accurate (order of magnitude), but extremely quick in comparison and very useful for establishing trends.

Automatic blow down valves

Requirements

Gas blow-down duty requires that the valve:

- a. Be quick opening type.
- b. Be normally closed and fail open.
- c. Open against a differential pressure equal to the normal system operating pressure.
- d. Withstand sonic velocity across the seat during opening.
- e. Be mechanically robust and insensitive to vibration.

If there are two restriction orifices in series during the early stages of valve opening, flow velocities may be supersonic.

Valve types for blow down

At relatively low pressures (e.g. up to Class 600), standard ball valves (soft or metal seat according to fluid conditions) and metal seated butterfly valves may be specified, but in high pressure service a single seated valve design such as an axial flow type or a balanced, lubricated plug valve should be specified. If a trunnion mounted ball valve is selected the downstream seat ring should be omitted.

During opening of a trunnion mounted ball valve against a high differential gas pressure, a continuous, high differential pressure is applied across the downstream seat to body seal in the opposite direction to that in which it is designed to work with resulting permanent damage (This is likely to occur even if lip seals are provided with support rings). For the same reason, if top entry ball valves are provided with two part seat rings to facilitate removal, the seals between these can be blown inwards into the pipe bore.

If there is no controlling orifice in the downstream pipe or high pressure drops could exist across the valve for long periods, a control valve having a low noise trim should be specified. In this case, the degree of seat tightness that can be obtained and maintained should be ascertained as it may be necessary to fit a fail open actuated block valve in series to achieve the required shut-off.

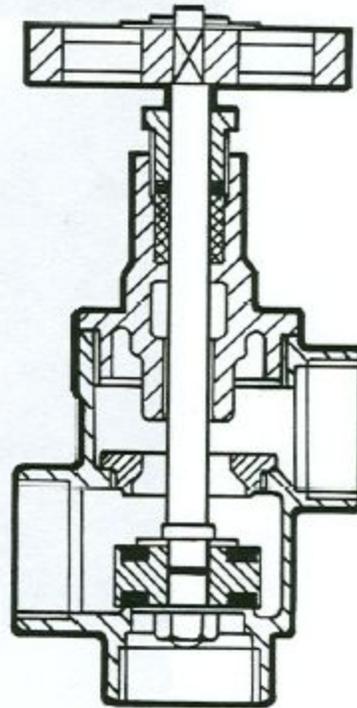
Flow diversion

Multi-port valves

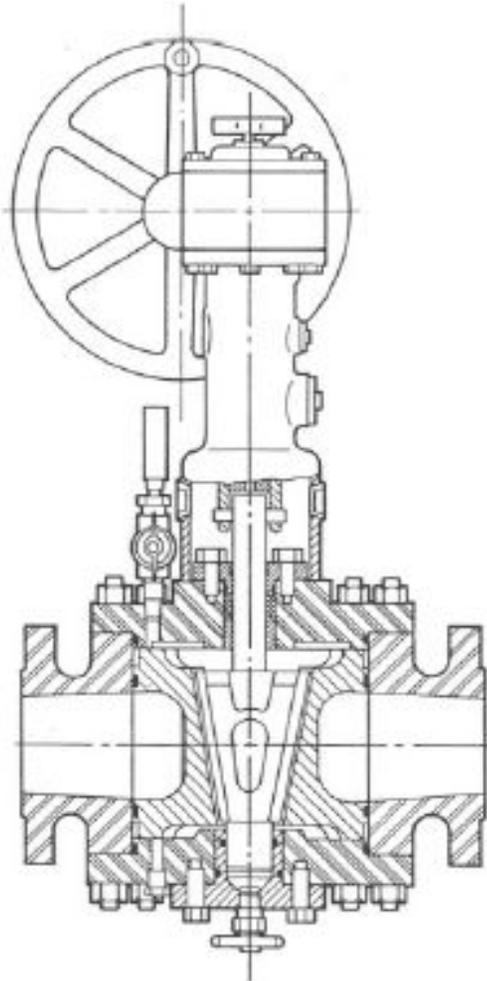
- a. Special, multi-port designs of globe, plug, and ball valves are available which allow the diversion of a common source to two different outlets or crossover switching of flow streams. The multiple port arrangement may be such that one channel closes before another begins to open, preventing mixture of fluids or loss of pressure. Alternatively, some valves have greater port width so that in turning the plug, a new channel begins to open before the former channel is completely closed. This alternative may be used where it is necessary to carry out switching operation without stopping the flow at any time.
- b. In some cases these designs can provide good isolation as well but this should not normally be relied upon except where the manufacturer includes good isolation as a principal design feature.

- c. Common applications include:
 - 1. Spared pressure relief valve isolation
 - 2. Meter loop switching
 - 3. Coker plant switching
- d. Requirements will vary widely depending on the nature of the service and normal selection procedures should be used for materials, seals, hard coatings, etc.

Diverter globe valve

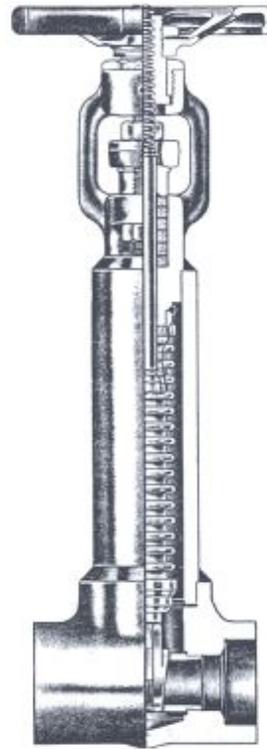


4-way diverter expanding plug valve



Bellows sealed valves

Bellows seal gate valve



Bellows sealed valves should be used if escape of any fluid to the atmosphere is undesirable for health, safety, or economic reasons.

- i. A bellows provides the primary sealing of the stem during opening and closing, but a packed gland or other appropriate stem seal should always be provided for secondary sealing in case of bellows failure.
- ii. The bellows is housed in an extended bonnet that may be welded or bolted to the valve body.
- iii. The bellows should be welded to the valve stem at its lower end and sealed to the valve bonnet at its upper end.

Bellows should be used in linear action valves of the gate and globe design DN 150 (NPS 6) and smaller, but may also be applied to special ball valve designs.

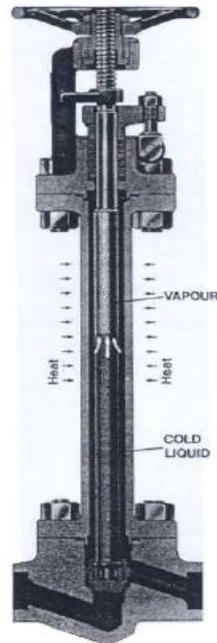
Bellows fail as a result of fatigue (operating and pressure cycles) and, as a general rule, the longer the bellows for a given valve size, the longer the expected life. In practice, manufacturing tolerances, etc. mean that bellows cycles to failure conform to a standard distribution so a good margin is needed (ideally a factor of 2 times) between the required number of cycles and the demonstrated cyclic life of a small number of tested bellows samples.

Bellows seal gate and globe valves should be procured in accordance with ISO 15761 which includes minimum requirements for bellows life and a type qualification test.

Valves for cryogenic service

Valves for cryogenic applications (below -50°C (-58°F)) should be type qualification tested in accordance with BS 6364 or an acceptable alternative and should normally be provided with extended bonnets.

Cryogenic globe valve



Valve types normally employed are gate, globe, ball, or butterfly manufactured in austenitic stainless steel, Monel, bronze, or cupro-nickel.

The extended bonnet allows a reasonable temperature gradient up to the stem seal and handwheel or actuator and allows a liquefied gas to reach a vaporising temperature.

- a. Seats and seals are normally manufactured in KEL-F, PTFE, and similar materials and need careful selection for temperatures below -65°C (-85°F).
- b. Soft seated floating ball valves or other valves having a closed body cavity should be required to demonstrate automatic relief of cavity overpressure caused by thermal expansion of fluids or should be fitted with external relief valves.
- c. Valves should normally be installed with stems at not more than $\pi/4$ radians (45 degrees) to the vertical to maintain a low thermal conductivity vapour lock in the bonnet.
- d. Valves for cryogenic service should be cleaned to a high standard (free of moisture and grease) and assembled in clean conditions.
- e. Bronze stem bushing, polymer or hard faced seats, special coatings, and solid film lubricants should be specified to prevent galling.
Cryogenic liquids are generally non-lubricating and therefore galling may occur between relatively soft metal mating parts.

Vacuum service valves

- a. If valves may be subject to vacuum this should be made clear to the supplier at time of procurement. Many valves in pressurised service may be subjected to vacuum occasionally e.g. during certain commissioning operations such as vacuum drying of piping systems.
- b. Stem seals or packing should be capable of sealing atmospheric pressure in the reverse direction and bellows stem seals may be specified if the cycle life is compatible with the application. Secondary stem packing should be specified in such cases. Valves specified to shut off against vacuum are usually soft seated types such as ball valves, butterfly valves, or soft seated wedge gate valves.

Valves associated with pig launchers/receivers

Kicker valves and vent valves should be capable of withstanding the resultant high velocities (e.g. on gas service) when partially open as well as providing tight shut-off.

These valves may be used in throttling mode against a differential pressure.

Soft seated ball valves should not be used for this duty.

Lubricated balanced plug valves should be used for this duty.

For low-pressure applications (Class 600 or lower rating) triple offset, metal-seated butterfly valves may be considered.

Globe valves may be used for gas vent duty, but ideally require an on/off shut-off valve (e.g. soft seated ball) in series

Soft-seated ball valves are not recommended for this duty. Lubricated balanced plug valves are eminently suitable and for low-pressure applications (Class 600 or lower rating) triple offset, metal-seated butterfly valves can be considered. Globe valves may be appropriate for gas vent duty, but ideally require an on/off shut-off valve (e.g. soft seated ball) in series.

Receiver drain valves should be capable of coping with highly abrasive service.

Quarter turn valves having a high degree of abrasion resistance such as tungsten carbide coated balls, stellite/carbide coated balanced plugs, etc. are the most suitable choice.

2. Service description

General

- a. The characteristics and condition of the process fluid shall be carefully defined.
The characteristics and condition of the process fluid are often the most significant factors in selecting the correct type of valve e.g. clean fluids generally permit a wide choice of valve types, whereas for dirty or abrasive fluids the choice is restricted; hazardous (flammable, toxic) and searching fluids require special consideration to be given to stem, body, and seat seals.
- b. A fluid's characteristics may fit one or more categories of service.

i. Clean service

Clean service is a term used to identify fluids free from solids or contaminants.

- Clean fluids include instrument air, nitrogen and other manufactured gases, potable and demineralised water, steam, lube oil, diesel oil, methanol, and most dosing and injection chemicals. Valves for fluids such as oxygen, hydrogen peroxide, and sometimes treated water or lube oil require special attention to cleanliness of the valve. Valves for potable water must meet local regulations.
- Process fluids may be defined as clean depending on which part of the process is being considered e.g. dry hydrocarbon gas downstream of scrubbers and dryers.
- Clean services are generally less damaging to valves resulting in long term performance and reliability. Selection from a wide range of valve types is possible for most applications allowing greater freedom of choice.
- If the fluid service is basically clean, attention should be given to protecting valves during construction and during flushing operations which are unlikely to be clean. This may require the temporary replacement of valves by spool pieces. Alternatively select a valve type that is suitable for dirty service.

ii. Dirty service

Dirty service is a general term used to identify fluids with suspended solids that may seriously impair the performance of valves unless the correct type is selected.

1. This type of service is often of major significance since many valves are very sensitive to the presence of solids.
2. Dirty service may be further classified as generally abrasive or sandy.

iii. Generally abrasive service

- a. Generally abrasive service is a term used to identify the presence of abrasive particulate in piping systems including pipe rust, scale, welding slag, sand, catalyst fines and grit. These materials can damage seating surfaces and clog working clearances in valves resulting in excessive operating force, sticking, jamming, and through seat leakage. Such damage may be caused by particulate for quite low concentrations and of a size as low as 10 microns. Abrasive conditions are commonly found during construction, flushing, and line clearing operations.
- b. If abrasive conditions are likely to persist during normal operation, a valve suitable for dirty services should be selected.

iv. Sandy service

Sandy service is a term identifying severe abrasive and erosive conditions occurring in oil and gas production in which formation sand is carried through from the well. Sand particle sizes are typically 50 micron to 450 micron and relatively low concentrations can result in wear and jamming of inappropriately selected valves.

Severe erosion of valve trims and bodies may occur if pressure drop and velocity is high (e.g. in chokes and separator level control valves). In the case of block valves, damage is usually as a result of abrasion (wear of seat inserts, bearings, etc.) Soft seated ball valves shall not be used in this service. Note that, in some cases, very fine sand can be carried right through the process to oil export and that produced water systems almost always contain sand.

v. Fouling/scaling service

Fouling or scaling services are general terms used to identify liquids or elements of liquids that form a deposit on surfaces. Such deposits may vary widely in nature, with varying hardness, strength of adhesion and rates of build up.

- a. Components for valves in fouling or scaling service shall be selected to resist fouling or scale build-up. This is particularly important if thick, hard, strongly adhesive coatings occur. Flexible surfaces and components (e.g. rubber) can be effective in some cases. Valves which employ a sliding/scraping action between obturator and seat may also be suitable.
- b. Chemical injection, heat tracing, steam jacketing, or steam purging should be considered to mitigate scaling tendency in this service.

vi. Slurry service

Slurry service is a general term used to define liquids with substantial solids in suspension. Often the product is the solid and the fluid is primarily the means of transportation, e.g. coal slurries and catalyst services.

Slurries vary widely in nature and concentration of solids. Hard abrasive solids of high concentration can cause severe abrasion, erosion, and clogging of components. Soft, non-abrasive solids can cause

Careful consideration should be given to valve designs for slurry services.

vii. Solids

Solids may be present in the form of hard granules, crystals, soft fibres, or powders. The transporting media may be liquid or gas. Air or fluidised bed systems may be used for some particulates. Specialised valves are available for many of these services, but development work may sometimes be necessary.

viii. Hazardous service

The term 'hazardous service' can usually be assumed to include the following, any of which may exist in combination with other services listed above. Specific classification of fluids for the purposes of health and safety legislation requires specialist advice. This information is often provided on the fluid data sheet.

- a. Liquids above their auto-ignition temperature (AIT), or 210°C if the AIT is not known.
- b. Flammable liquids flashing on leakage to form a substantial vapour cloud. This includes LPG, LNG and NGL condensate.
- c. Flammable fluids at Class 900 rating and above (e.g. hydrocarbon gas).
- d. Fluids liable to cause a hazard by blockage due to hydrate formation, solids deposition, or coking.
- e. Toxic substances (e.g. chlorine, hydrofluoric acid, hydrogen sulphide, sodium hydroxide, etc.).
- f. Hydrogen service - defined as service in contact with hydrogen or gaseous mixtures containing hydrogen in which the partial pressure of hydrogen is 5 bar (abs), (72,5 psia) or more.
- g. Highly corrosive fluids such as acids and caustic alkalis.

ix. Corrosive service

1. Corrosive service is a term generally used to identify fluids containing corrosive constituents that, depending on concentration, pressure, and temperature, may cause corrosion of metallic components. Corrosive fluids include sulphuric acid, acetic acid, hydrofluoric acid (HFA), wet acid gas (wet CO₂), wet sour gas (wet H₂S), and chlorides (e.g. seawater). Many chemicals are highly corrosive including concentrations of some corrosion inhibitors.
2. Corrosion resistant materials or overlays for valve pressure containing components and trim should be chosen to prevent the integrity or performance of the valve from being impaired. Valves are usually manufactured to standard patterns so specifying a particular corrosion allowance in carbon steel is often not an option. Most valves will have ceased to function correctly long before the corrosion allowance commonly specified for piping systems has been used up.
3. The judicious use of overlays (e.g. in the seat pockets and seal surfaces of trunnion mounted ball valves and slab gate valves) is recommended and can be extremely economical and effective even if the service conditions are not normally corrosive. Corrosive conditions may exist before the valve enters a nominally non-corrosive service, e.g. if untreated test water is left inside.

4. The following types of corrosion should be considered when selecting valve materials and designs:
- i. Corrosion resulting in general wastage (typical with wet CO₂).
 - ii. Crevice corrosion.
 - iii. Galvanic corrosion between dissimilar materials.
 - iv. Pitting corrosion.
 - v. Sulphide stress corrosion cracking (e.g. of components in wet H₂S) and chloride stress corrosion cracking (depending on concentration, pressure, and temperature).
5. Materials for sour (H₂S) service shall conform to ISO 15156 (NACE MR0175).

x. Vacuum service

Vacuum service is a term used to identify systems in which the pressure is permanently or intermittently below atmospheric.

- a. Valves in vacuum service should be capable of sealing in both directions with regard to glands, body joints, etc.
- b. Systems that have the potential to create an unwanted vacuum (e.g. condensing vapours, tanks, etc.) should normally be fitted with a vacuum breaker valve that admits air automatically whenever a vacuum occurs.

xi. High temperature service

This is a relative term with different definitions in different contexts.

Temperatures between 120°C and 200°C (248°F and 392°F) (High temperature in exploration and production applications). Care should be taken in the selection of polymer and elastomer seals and seats particularly towards the high temperature end of the range in which most grades are unusable and where valve pressure ratings may be reduced. 200°C (392°F) is the effective limit of PTFE.

Temperatures above 200°C (392°F) and below 400°C (752°F). The only polymer or elastomer materials that can be used are PEEK and Kalrez and then only at the lower end of the range. Valve seat sealing should normally be hard faced metal to metal and graphite stem etc. seals are the norm.

Temperatures above 400°C (752°F).

Temperatures above 400°C (752°F). For high temperature (generally above 400°C (752°F)) e.g. power station steam services, creep resisting steels must be chosen e.g. 2 ¼% Cr 1% Mo or ½% Cr, ½% Mo, ¼% V. Seats and disks require hard facing with alloys of cobalt, chromium, and tungsten and a difference between the hardness of the disk and seat is recommended to avoid galling. Stem seals are normally graphite except in situations in which this is likely to oxidise (at temperatures above 450°C (842°F) if there is access to air or oxygen).

xii. Low temperature service (0°C to –50°C (32°F to –58°F))

i. Impact testing

- a. At temperatures between 0°C and –29°C (32°F and –20°F) consideration should be given to Charpy impact testing ferritic, martensitic, and duplex alloys in order to demonstrate adequate toughness at the minimum design temperature or below. At temperatures below –29°C (–20°F) these materials should always be tested. The piping design code, ASME B31.3, allows untested carbon and alloy steels to be used down to –29°C (20°F) and, historically, there have been no problems arising from this.

The following points should be considered when making a decision:

1. Will the plant be depressurized/shut-down or at operating pressure when the low temperature occurs?
2. Is the source of raw materials for pressure boundary parts one which has historically been shown to be able provide non-brittle materials without testing?

- b. Impact testing should always form part of welding procedure qualifications if impact testing of the material to be joined is required or, for ferritic and duplex materials, if the minimum design temperature is below 0°C (32°F).
- c. The following is a guide to the minimum Charpy V-notch impact energy values that should be expected from carbon and alloy steel material.
- d. Most non-ferrous materials such as copper, copper alloys, aluminium, and nickel alloys may be used for low temperature service and need not be tested. 2 ½% nickel steels may be used down to –57°C (–71°F), lower temperatures being obtained with increased nickel content
- e. Austenitic stainless steels retain acceptable properties even under cryogenic conditions and need not be tested.
- f. Duplex stainless steels generally exhibit relatively high toughness.

ii. Cast Iron

Cast iron should not normally be used for low temperature service. If this is unavoidable (e.g. gearbox cases at low ambient temperature) only nodular (SG) grades of iron should be used which incorporate impact testing in the material specification.

iii. Elastomers

- a. The practice of specifying a minimum system design temperature equal to the impact test temperature of the piping material, frequently adopted by process engineers, should be avoided. The object should be to specify the highest minimum temperature consistent with safe operation. Definition of valve minimum design temperatures needs the maximum possible refinement when elastomer sealing materials are involved, including consideration of whether the condition is transient (which usually does not affect the seals) or long term.
- b. When a choice has to be made between explosive decompression resistance and low temperature resistance in gas service it is usually safest to go for decompression resistance except if low temperatures are persistent or permanent. Elastomer sealing materials present a particular problem at low temperatures, especially in gas service where selection is complicated by the need for resistance to explosive decompression (e.d.).

iv. Cryogenic service (below -50°C (-58°F))

- a. Valves for cryogenic applications should comply with and be type tested to BS 6364 or an equivalent standard.
- b. Carbon, low alloy, and duplex steels should not be used.
- c. Non-metallic materials should be restricted to PTFE and graphite

There are very few non-metallic materials that can be used, PTFE and graphite being the most common. The only elastomer that is usable below -50°C (-58°F) is silicone rubber and this has poor mechanical properties.

3. Frequency of operation

Selection of valves which are frequently operated should take into account the fact that shut off capability is likely to deteriorate and the fitting of another valve (normally open) in series may be necessary to ensure adequate isolation.

Most isolation valves are not operated frequently although some may be (valves on regenerative processes, diverter service, etc.). If operation is infrequent there is likely to be an increase in the required operating force with time.

4. Isolation requirements

Very few valve types can maintain completely tight shut-off over a significant period of operation and this number is reduced still further if the working fluid is gas or if it contains abrasive particles. This should be taken into account in selection (e.g. some valve types offer a double isolation in a single body) and in system design (multiple valves, provision of adequately sized venting facilities, etc).

The need for intervention in a “live” system determines the seat leak tightness requirements for valves isolating equipment. Shut down valves are rarely required to shut off tight and is often acceptable with a significant through seat leak rate. Check valves rarely if ever shut off tight and should be assumed not to do so in process design.

5. Maintenance requirements

The location and available facilities etc. affects the possibility for valve maintenance and therefore affects valve choice.

6. Environmental considerations

The required degree of control of emissions to the environment is usually determined by the nature (flammability, toxicity, searching tendency) of the process fluid or by the sensitivity of the environment (marine, etc.). Valve stem seals are the most frequent source of emissions. In general, valves having rotary, quarter turn operation are inherently less prone to emissions than those with rising stems and the fewer flanged etc. joints a valve incorporates, the better.

7. Past experience

This should always be taken into account (good and bad) as it relates to comparable service conditions. Sometimes, however, local expectations are conditioned by a lack of knowledge of available alternatives.

8. Weight and size

These factors should not be allowed to determine valve type if they do not represent a constraint e.g. in new, onshore construction. In some applications, though, it is necessary to try to minimise one or both.

9. Cost

Whole life cost should be considered, not just the purchase price.

Higher priced valve options frequently turn out to be cheaper on this basis, particularly if unscheduled plant shut-down can be avoided.

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