Introduction

Valves are integral components in piping systems they are the primary method of controlling the flow, pressure and direction of the fluid. Valves may be required to operate continuously e.g. control valves, or they may be operated intermittently e.g. isolation valves, or they may be installed to operate rarely if ever e.g. safety valves. A valve can be an extremely simple, low cost item or it may be and extremely complicated, expensive item. In piping design the valves probably require more engineering effort than any other piping component.

Valve Classifications

Isolation / Stop valve-

The isolation of the downstream system from the upstream system by use of and isolation /stop valve is a critically important function..The prime requirements of this valve are tight shut off when closed and minimum restriction to flow when open.

Valves used for this function include gate valves, globe valves, ball valves, plug valves, butterfly valves, diaphragm valves and pinch valves

Regulation of flow

Many applications require the flow of the fluid be regulated (throttled) at some fixed or variable level between fully zero and maximum flow limits. This is achieved by introducing resistance to flow, or by bypassing flow or by changing the direction of the flow. An important feature for control valves is that the output variable (flow) is related to the input variable (valve position). An ideal operating characteristic of a hand operated flow control valve is that the flow is directly proportional to the position of the handwheel

Valve types for this function include globe, needle, ball, butterfly. Globe and needle valves are best suited for this duty but ball valves are also easily adapted to give reliable flow control..

Back flow prevention

In some circumstances it is important to prevent reversed fluid flow. The type of valve for this duty is a non-return-valve (NRV) or check valve. The important criteria when selecting these valves are, tight shut off against reverse flow, low resistance to flow for forward flow, fast response. The valve can be operated to close by gravity, fluid flow , or spring.

Two main valve types are available for this function lift check valves or swing check valves.

Pressure Regulation

In many applications, more generally associated with gases, there is a need to reduce the supply press to a set fixed value. It is also necessary to maintain this reduced pressure over a range of fluid flow conditions. The pressure regulator valve is engineered for this application. The valve is basically a globe valve biased open by an adjustable spring force with the feedback pressure tending to move the valve to a closed position such that at the set pressure the feedback pressure force just exceeds the spring force

The pressure regulator valve operates using the downstream fluid pressure as feedback. This is mostly taken from within the valve (self acting). For more accurate control a feedback connection can be taken from the downstream piping.

The pressure regulation at low near zero flows is difficult and it is often necessary to include internal or external relief valve functions to ensure no high pressures in the downstream system.

Pressure Relief Valves- Safety valves

A very important valve for safety is the pressure relief valve. This valve is used in applications where excessive pressure in the system can cause damage or failure or can introduce a safety risk. Uncontrolled excessive pressures can result in disastrous accidents e.g. when potentially explosive gases are being controlled. Relief valves are mainly spring loaded but they can also be gravity operated and other more specialised designs are available.

The bursting /ruputure disc must be included under the general heading of safety valves. This is simply a disc which ruptures when a set pressure is exceeded. The fluid then escapes through the ruptured disc. If the bursting disc operates the system has be be closed down and vented and the bursting disc is then replaced

Relief valves when used for safety applications are engineered in line with safety regulations and require regular inspections to confirm the settings and the operation. An important part of the relief valve installation is the routing of the relieved fluid. This pipe route must be to a safe location and must be engineered such that it is always fully open.

Special and miscellaneous valves

There are a wide variety of special valves developed for specific industries.

Types of Valves

Valves can be classified by:

The operative of the valve closure member

The kind of closure member movement defines both the geometry and operative of the valve.

• **Multi-turn valve** (linear motion valves):
The closure member has a linear displacement generally by turning its threaded stem several times.
This operation is slow, but it gives accuracy and stability to position the closure member, which is necessary in some control valves.

Types of valves: Gate valve, Globe valve, Fixed cone valve, Needle valve and Pinch valve.
• **Quarter-turn valve** (rotary valve):
The closure member as well its shaft turn 0º-90º; from the fully-open position to the fully-closed position.
They are quick opening/closure valves.

Types of valves: Ball valve, Butterfly valve, Plug valve, Spherical valve.

Valve type based on Connections

There are a number of methods of connecting valves into the piping systems- as follows

- Flanges .. The valve is provided with suitable rated flanges.
- Wafer .. The valve is provided with suitable sealing faces and is trapped between line flanges.
- Butt Welded ..The valve is provided with butt weld end and welded into the piping system using high integrity joints.
- Socket Welded ..Socket welds allow and welded into the piping system using fillet welds.
- Screwed Ends .. Ends can be provided with female or male screwed ends . The threads can be taper or parallel
- Compression Fittings .. Ends can be provided with compression fittings

Valve Containment

An important requirement in valve design is to minimise the leakage of fluids into the surrounding environment. This is very important in the nuclear industry and when transferring toxic or flammable fluids. The possible leakage points on valves are listed below.

- The end connections with the piping.-
- The spindle gland seals -allowing axial and rotary motion.
- For top entry valves the sealed top closure joint
- For three piece ball valves - the two split joints
- Valve drain connections and vent connections

The best option for minimising risk of leakage from the pipe connections is to use butt welded joints which can be verified by non-destructive-testing(NDT). This option obviously eliminates the valve types which have to be removed for maintenance.
The options for eliminating risk of gland leakage is to use bellows sealed valves. The risk can also be reduced by incorporating dual seals with a test point between. Pinch valves and diaphragm valves do not include gland sealing and are therefore not at risk of gland leakage.

VALVE DESCRIPTIONS

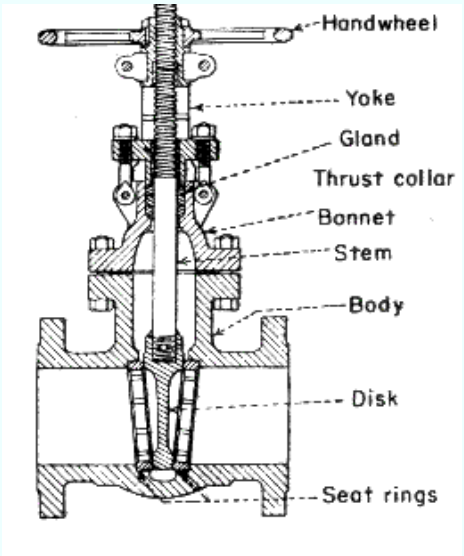
Gate Valves

Gate valves are generally used in the process industry for on-off service. The design is not suitable for throttling duty because the sealing surfaces can easily suffer from wire drawing (erosion) when low flows are being maintained against high differential pressures and the design give very poor flow control characteristics..

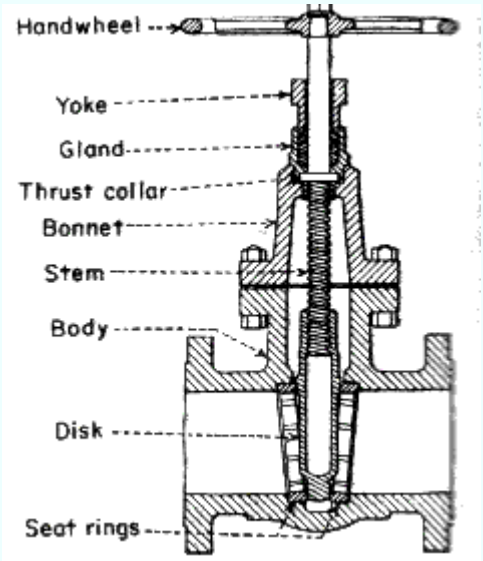
The gate valve can be manufactured in a wide range of sizes from 5mm to above 2000mm dia. The designs are proven and well tested. There is a tendency to move to butterfly valves as a lower cost option.

The valve can be based on a solid wedge, a wedge which can adjust to suit the seal faces, or a parallel faced based on two discs which slide between parallel sealing faces with a mechanism form forcing the discs out on the last part of the spindle travel. The valve can be based on a simple rising spindle design or a fixed spindle which screws into the gate..

There are a large number of gate valve variations including slide valves, knife valves, penstock valves, sluice valves, and venturi valves.



Rising Spindle Gate Valve



Fixed spindle Gate Valve

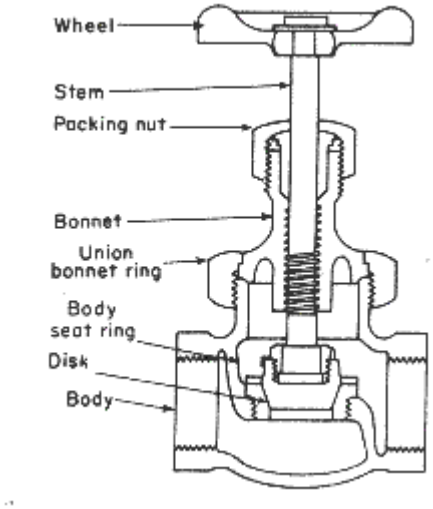
Globe Valves

The globe valve includes an orifice set into the body through which the fluid flows. A disc located on the end of the spindle is engineered to move in and out along the axis of the orifice. When the disc is moved to sit in the orifice the flow path is shut-off. The flow path is progressively increased as the disc is moved away from the orifice.

The surface of the orifice (seat) is generally engineering as a replaceable item made from erosion resistant material with a polished surface finish. The disc can be fitted with a soft seat if a tight shut-off is required. For flow control duties the disc is supplied with an engineered shape often with a contoured skirt.

For manually operated valves the spindle screwed so that rotation of the handle moves the disc in and out. For actuated control valves the spindle is moved in and out using a linear actuator which can be pneumatic, hydraulic or electric..

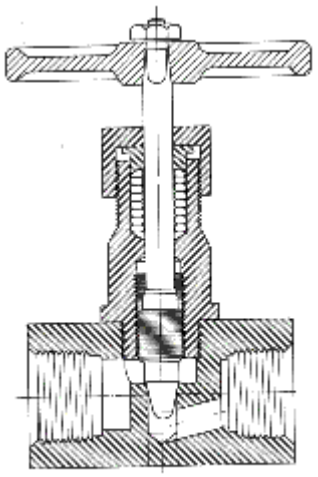
The fluid flow path through globe valves is such that there is normally a high fluid head loss through the valve. The inline body design has the highest head loss, the angle pattern body design has a lower head loss. There are certain designs of globe valves which have been engineered to have low head loss characteristics. (Ref Dynamic Controls cartridge valves).. Globe valves are supplied in sizes from 3mm bore through 400mm and can be used, size limiting at pressures up to 450 barg. Depending on the sealing systems the valves can be used at temperatures up to 600 ^{o}C.



Small Size Screwed Globe Valve

Needle Valves

The needle valve is used specifically for accurately controlling the flow of fluids at low flows. The valve is basically a globe valve without the disc. It is generally used provided in small sizes of up to 20mm bore..

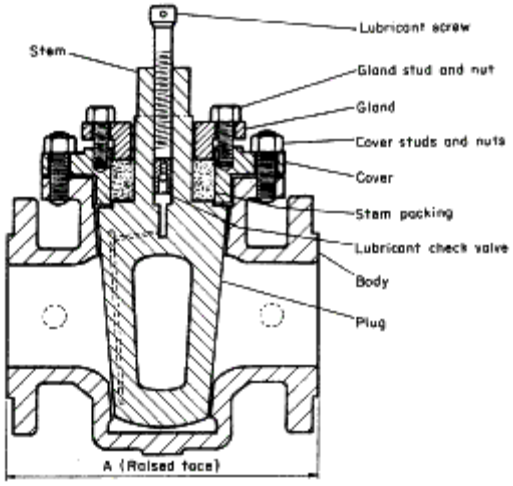


Needle Valve

Plug Valves

The plug valve is the oldest of the valves. Plug valves have been in use for over 2000 years. This valve has been in continuous development over recent years. The plug valve is basically and on-off valve based on a plug with a rectangular hole through which the fluid flows. The plug is either tapered or cylinderical and is located in the valve body and can be rotated through a quarter turn to line the hole up with the pipe when open or across the pipe when closed. The plug can be adapted for multi-port use allow the valve to be used for diverting flow. The valve can be engineered with a lubricated plug which uses the lubricant to enable convenient operation over a wide range of pressures. The lubrication film also provides a seal.
The unlubricated design includes seals in the plug and requires plastic bearing systems. The valve can include a cage between the plug and the body which includes the bearing a sealing systems and allow convenient maintenance. These valves have be specially developed for use in industries requiring high performance operation under arduous conditions and allowing remote maintenance e.g. the nuclear industry.

The valve is a full bore and has virtually no internal cavities..



Lubricated Plug Valve

Ball Valves

The ball valve is basically a plug valve with a spherical plug and a round hole. Over recent years the materials of construction of the ball valve have been developed such that the ball valve is becoming the most popular valve for most process applications. There are two primary options for the ball valve design

- Floating Ball Design- This is low cost option for the lower duties
- Trunnion Ball Design- This is a more costly option for the higher duties

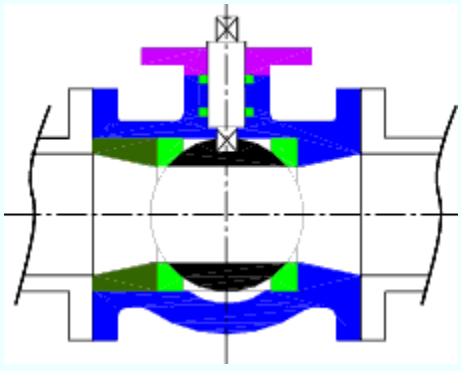
The ball valve is generally provided as a reduced bore design allowing a smaller body but still with relatively low head loss compared to most other valve options e.g 25nb valve has a 20mm reduced bore,. The full bore option has a larger body but provides zero restriction to flow. The valve can be supplied as a multi-port design for flow diverting but only with the reduced bore option

The engineering of the ball valve has to include for fitting and removing the ball and seat system. Ideally this has to be engineered to enable the valve to be maintained inline.. One method of achieving this is to use the top-entry version - all of the internals are accessible by removing the top flange. Another method is to use a three piece body based on a central piece sandwiched between two pieces connecting the valve to the pipework. The central piece can be released and pivotted away from the two outer pieces allowing access to all of the valve components.

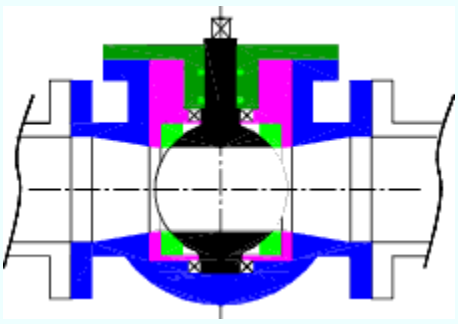
The ball valve can be engineered as a multi-port valve for flow diverting duties.

An important advantage of all full bore valves is that the valve allows certain pipe cleaning operations e.g rodding . Ball valves can also be used on branches to enable instruments to be fed into pipe systems during operating periods.

Ball valves are available in all materials in sizes from 5mm to over 600mm. The valves can be used at pressures up to 700 bar. The main components limiting the performance of ball valves are the ball seals and valves are available with metallic seals.



Ball Valve - With Floating Ball



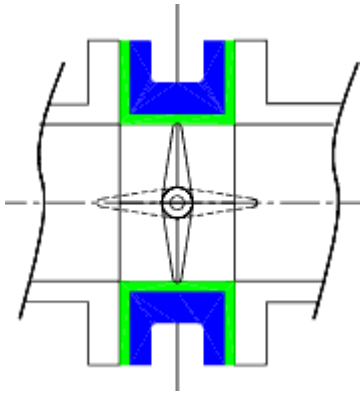
Ball Valve Trunnion Mounted

Butterfly Valves

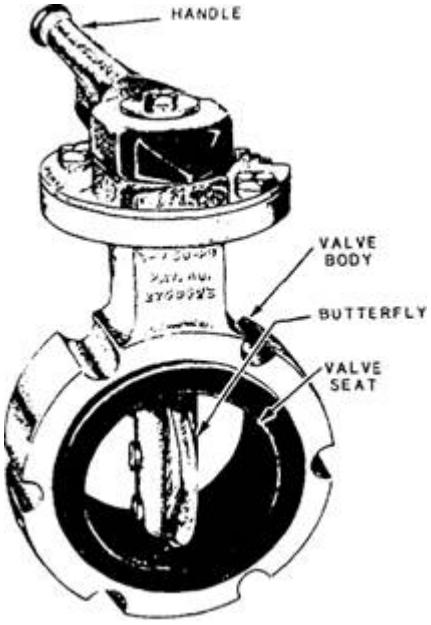
The butterfly valve has head loss characteristics of a full bore valve. The design is based on use of an engineered disc of the same dia as the bore of the pipe arranged to pivot such that when it is across the bore is closes off the flow path. When turned through 90^{o} the disc provides minimum resistance to the flow. The valve is a quarter turn valve.

The main variations for this valve are the methods of sealing the perimeter of the disc in its closed position. The simplest variation is to use an elastomer lined bore which is an interference fit on the disc. The other variations are based on offsetting the disc plane from the axis of rotation allow the disc to close against a circular face seal such that the fluid pressure increases the seal effect. Metallic seals are available allowing the valve to be used for a wide range of fluids at high temperatures

The butterfly valve has been developing such that for many duties it now provides optimum solution for a leak tight on-off valve supplanting the gate valve. The butterfly valve can be engineered as a small valve of 25mm bore and can be made for extremely large sizes above 5000mm bore. Depending on the valve size working pressures up to 100 bar can be handled



Butterfly Valve – Lined



Diaphragm Valves

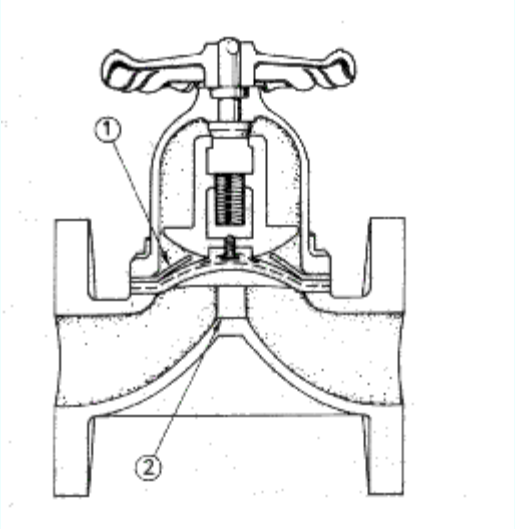
The diaphragm valve has a significant advantage over most of the other available designs, apart from the pinch valve, in that there is no gland seal requirement. The fluid flows straight through the valve via a chamber over which is an elastomer diaphragm. This diaphragm is normally arranged to provide no resistance to the flow. The perimeter of the diaphragm is simply clamped to a seal face of the valve body as a static seal.

To close off the valve the diaphragm is simply forced down into the chamber to block off the flow. The chamber can include a weir across the flowpath against which the diaphragm can be pressed to affect a more efficient seal with reduced diaphragm distortion.

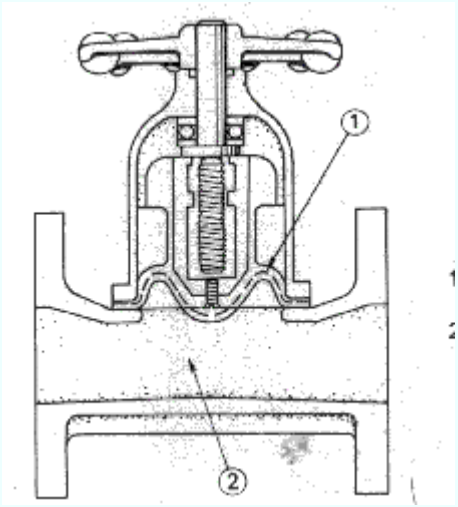
The straight through variation is effectively a full bore valve design with all the associated benefits. However this option results in a much more arduous duty on the diaphragm which has to be a softer material

This type of valve is manufactured in sizes from 6mm to 400mm and is generally limited to relatively low fluid pressures (less than 7 barg). However in the smaller sizes (up to 50mm) valves can be specially engineered for use at pressures up to 30barg. The diaphragm must be chosen to be compatible with the fluid. Whatever the fluid the diaphragms must be replaced at regular intervals and it is advisable to operate the valves frequently.

These valves are often used for duties which require a high degree of cleanliness as they can be supplied lined, and polished and can be very conveniently cleaned.



Diaphragm Valve - With weir



Diaphragm Valve - straight

Check Valves

Check valves are automatic in operation and designed to prevent reversal of flow in fluid piping systems. The valves are maintained open by the flow of fluid in the forward direction and are closed by back pressure of the fluid or by the weight of the closing mechanism or by a spring force. Various designs are available as listed below..

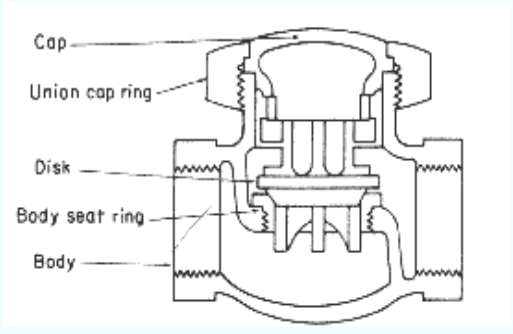
- Swing check
- Tilting disc
- Ball lift type
- Disc lift type
- Piston check
- Stop check

The range of check valve sizes range from 6mm to massive units of 3000mm dia and more.

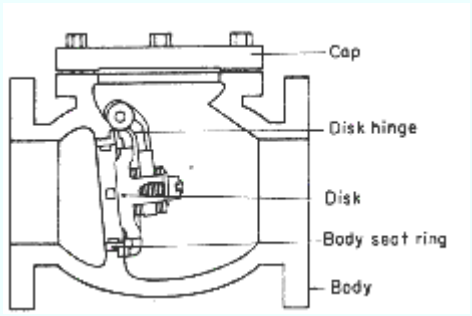
The swing check variation is a low pressure drop unit based on a hinged disc. This type of valve is suitable for low velocity applications with infrequent velocity reversals. The valve can be fitted with external weights to allow faster closure to reduce water hammer or shock pressure on flow reversal. External systems can also be included to force the valve closed in the event of a local fire...

The lift check valve and piston check variation are used for higher duty applications. The valve is forced open by the fluid flowing up through the valve and is closed on fluid reversal by gravity, back pressure or by spring force.

The tilting disc variation on the swing check valve provides improve speed of operation and pressure performance and is probably the most popular design of check valve used in the process industry..



Lift Check Valve



Swing Check Valve