FUNDAMENTALS OF PIPING

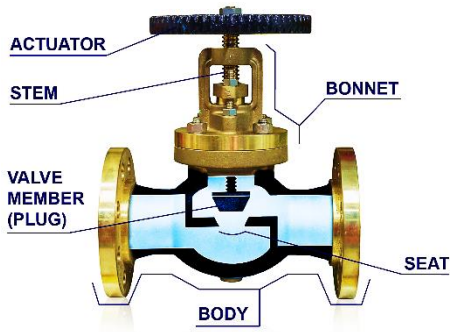
Overview of Valves

By / Mostafa Mahmoud

What is valve?

A Valve is a device that regulates the flow of gases, liquids or loose material through an aperture, such as a pipe, by opening, closing or obstructing a port or passageway. A valve controls system or process fluid flow and pressure by performing any of the following functions:

- Stopping and starting fluid flow
- Varying (throttling) the amount of fluid flow
- Controlling the direction of fluid flow
- Regulating downstream system or process pressure
- Relieving component or piping over pressure



Types of Valves

In piping following types of valves are used depending on the requirements. The cost of Valve in the piping system is up to 20 to 30% of the overall piping cost. And the cost of a given type and size of the valve can vary 100%. It means that if you choose ball valve over butterfly valve for the same function. It can cost you more. So, the selection of valves is essential to the economics, as well as operation, of the process plants.

- Gate Valve
- Globe Valve
- Plug valve
- Check Valve
- Butterfly Valve
- Ball Valve
- Needle Valve
- Pinch Valve
- Pressure Relief Valve

Although all valves have the same basic components and function to control flow in some fashion, the method of controlling the flow can vary dramatically.

In general, there are four methods of controlling flow through a valve.

1. Move a disc, or plug into or against an orifice (for example, globe or needle or some types of check valves).

2. Slide a flat, cylindrical, or spherical surface across an orifice (for example, gate and plug valves).

3. Rotate a disc or ellipse about a shaft extending across the diameter of an orifice (for example, a butterfly or ball or some types of check valves).

4. Move a flexible material into the flow passage (for example, diaphragm valves).

Each method of controlling flow has characteristics that makes it the best choice for a given application of function.

Valve Body or Shell

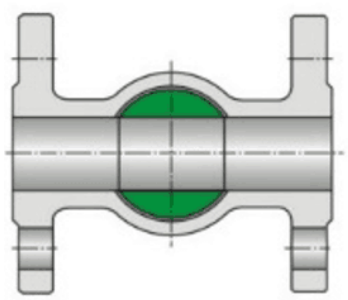
The body is Main Pressure retaining part and accommodate valve trim. It provides the passage for fluid flow. The body may be cast, forged, or fabricated. Sometimes valve bodies are manufactured by a combination of cast, forged, or fabricated parts. A variety of metals, alloys, and non-metals are used to manufacture valve body. The valve body is also known as a shell.

Ends of the valve are designed to connect the valve with pipe or equipment. Ends connections can be a butt, socket, threaded, flanged type and sometimes it simply sandwiches between two pipe flanges that are known as a wafer ends.

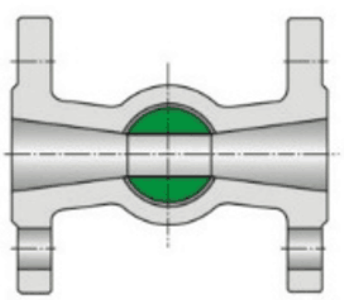
A valve body has different types of passages through which fluid pass. Design of this passages depends on the function of a valve

- First body type is Reduced bore, in this type, passage diameter of the valve is smaller than the connecting This is most common design as it will reduce overall valve cost at the same time it narrows the fluid flow.
- The second type is a Full bore, in this type inside passage diameter of the valve is same as connecting pipe. This type of body is used when pigging is required. Pigging is used for a various purpose such as cleaning and inspection of the pipeline.
- The third type is Crossflow or Split section body, this kind of body is used mainly in globe valve, piston or plug type check valve.

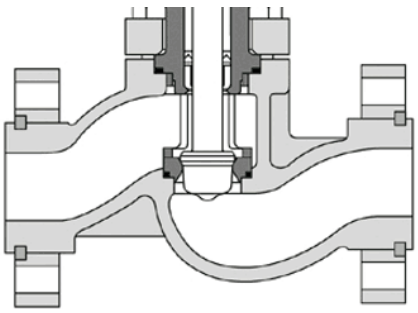
You can see the images of all three types of body.



Full Bore



Reduced Bore



Cross Flow

Bonnet or Cover

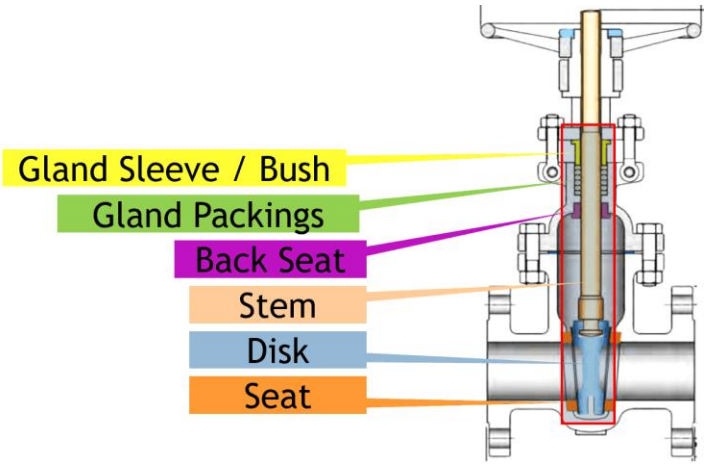
The cover for the valve body is known as a bonnet. Like valve bodies, bonnets are also available in many designs.

Some bonnets function simply as a valve cover. For example, swing check valve as shown in the photo. While others support valve internals and accessories such as the stem, disk, and actuator. In the case of the gate, globe, stop check, and diaphragm valves, bonnet contains an opening for the valve stem to pass through. Usually, stuffing box is also a part of the bonnet.

Some valves have a bonnet-less design in which valve body and bonnet are combined into one. You can see the bonnet-less valve photo. In split body ball valve, there is no bonnet at all, because a body itself is split into two sections. There are many ways to connect bonnet with a body such as bolting, threading, and welding. The body-bonnet joint is one of the primary sources of the leak, that is why it should be a pressure tight. The bonnet is cast or forged of the same material as the body.

What is Valve Trim?

The removable and replaceable internal parts of the valve that come in contact with the flow medium are collectively known as valve trim. Disc, valve seat, and stem are common for all the valve. Valve Trim components will change with types of valve. Valve specific trim includes back seat, glands, spacers, guides, bushings, retaining pins and internal springs. Here in the image, you can see the gate valve trim parts. Because of the trim parts, disk movement and flow control are possible.



Valve Disk

The disc is the part that allows, throttles or stops fluid flow depending on its position. Types of disk define the name of the valve such as gate, ball, plug and needle valve's disk are also of the same shape as the name.

A valve disc could be cast, forged, or fabricated. Valve disk is sometimes required hard facing to improve wear resistance. Disk needed smooth machine surface to reduce the friction with a seat. Valve disk is a pressure retaining part. That means disk hold the pressure. When the valve is open, the disc does not perform pressure-retaining or -containing functions. However, when the valve is closed, the disc performs pressure-retaining functions.

A disc rested against the stationary valve seat when the valve is in the closed position. It can be moved away from the seat by the movement of the stem. However, in check and safety-relief valves, disc is moved away from the seat, by fluid flow and pressure.

Valve Seat

The seat provides the seating surface for the disk. Here, you can see the gate valve seat in the above image. A valve may have multiple seats. In the case of globe valve and swing-check valve, there is one seat. Whereas, a gate valve and ball valve has two seats; one on the upstream side and the other on the downstream side.

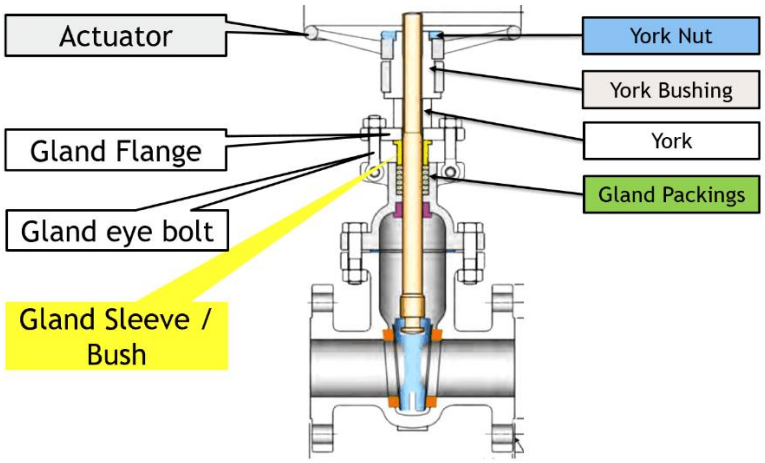
The valve leakage rate is directly proportional to the effectiveness of the seal between the valve disc and seat(s). Valve seats may be integral or replaceable rings. Valves are generally provided with screwed, welded, or integrally cast or forged seat and hardened by heat treatment or by hard facing of Stellite weld overlay. A fine surface finish of the seating area is necessary for proper sealing. Some ball valve & plug valve used the non-metallic seat for non-critical services. Valve manufacturers have developed several designs of combination valve seats involving elastomer and metal seats that are effective in achieving the desired leak tightness, which cannot be achieved only by metal seats.

Back Seat

The back seat is comprised of a shoulder on the stem and a mating surface on the underside of the bonnet. You can see in the image. It forms a seal when the stem is in the fully open position. It prevents leakage of flow medium to the packing chamber and consequently to the environment. Back seat enables the replacing of the gland packing when the valve is in service.

Stem

The stem connects the actuator and disk. It moves and positions the valve disk. The valve stem transports the required motion to the disc, plug, or the ball for opening, closing or positioning the valve. The stem connects actuator, hand-wheel or the lever of the valve at one end and the disc on the other end. In gate and globe valves, linear motion of the disc open or close the valve, while in the plug, ball, and butterfly valves, the disc rotates to open or shut the valve. Stems are typically forged from stainless steel and connected to the disk by threaded or welded joints.



Bonnet Bolt & Gland eyebolt

Bonnet bolt or stud, hold the bonnet and body to create presser tight seal between them. Gland eyebolt serves two functions.

First, it connects gland flange and bonnet.

Second, when you tighten the bolt, it pushes the gland bush to retain gland packing in the stuffing box.

York, Yoke Bushing, Yoke Nut

The yoke is also called arms. It connects the valve body or bonnet with the actuating mechanism. The yoke and bonnet are designed as a one-piece construction in many valve designs. A yoke must be sturdy enough to withstand forces, moments, and torque developed by the actuator.

The top of the yoke holds a yoke nut. The valve stem passes through the York. It converts the rotary motion of the actuator into the linear motion and moves the valve stem.

Yoke Bushings which is also known as stem nut is an internally threaded nut held at the top of a yoke through which the valve stem pass.

Usually, the yoke nut and bush are made of softer material than the stem to reduce the effort of valve opening.

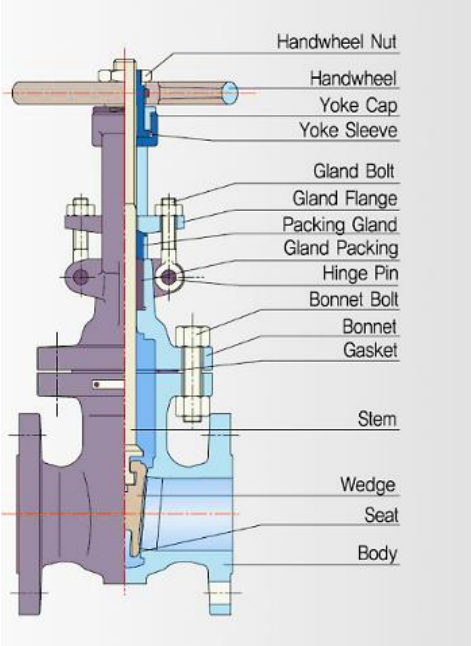
Valves which require greater effort to open or close are provided with anti-freeze yoke-sleeve bearings that minimize the friction between the hardened stem and the yoke bushing.

Non-pressure Retaining Parts of a Valve

Gland Flange is used to provide support to gland bush to keep the gland packing under tension in the stuffing box.

Gland sleeve or bush is used to keep gland packing inside the stuffing box.

Gland packing or steam packing contained in the stuffing box. Gland packing are made from graphite or PTFE as required by services. Proper compression of gland packing is required to prevent the leak from the stem. With the help of gland flange and sleeve, you can compress the gland packing. Gland packing is one of the primary sources of fugitive emission in a process plant. Regular maintenance is required to ensure proper function of packing.



Valve Trim Chart

Trim material such as Disk, seat, stem, back sheet and sleeves are grouped together and assigned one number called Trim No. or Combination number. This will element the requirement of defining material grade for each component.

- API 600 & 602 gives the list of Trim material that can be used in the valve.
- Most common trim grades are ASTM A410(13Cr), ASTM A316, Alloy 20 (19Cr-29Ni), and Monel (CuNi Alloy).

Here in the image, you can see the simplified chart of the trim material. Against trim number, material for seat, disc, backseat and stem is specified. This makes easier to order the valve as you just have to specified trim no based on the requirements and need not specify the material for each of the parts. This list is included in the resource section.

API Trim Number	Material	Seat	Disc	Backseat	Stem	Notes
1	410	410	410	410	410	
2	304	304	304	304	304	
3	F310	310	310	310	310	
4	Hard 410	Hard 410	410	410	410	Seas 750 BHN min.
5	Hardfaced	Stellite	Stellite	410	410	
5A	Hardfaced	Ni-Cr	Ni-Cr	410	410	
6	410 and Cu-Ni	Cu-Ni	Cu-Ni	410	410	
7	410 and Hard 410	Hard 410	Hard 410	410	410	Seats 750 BHN min.
8	410 and Hardfaced	Stellite	410	410	410	
8A	410 and Hardfaced	Ni-Cr	410	410	410	
9	Monel	Monel	Monel	Monel	Monel	
10	316	316	316	316	316	
11	Moneland	Stellite	Monel	Monel	Monel	
12	316 and Hardfaced	Stellite	316	316	316	
13	Alloy 20	Alloy 20	Alloy 20	Alloy 20	Alloy 20	
14	Alloy 20 and Hardfaced	Stellite	Alloy 20	Alloy 20	Alloy 20	
15	304 and Hardfaced	Stellite	Stellite	304	304	
16	316 and Hardfaced	Stellite	Stellite	316	316	
17	347 and Hardfaced	Stellite	Stellite	347	347	
18	Alloy 20 and Hardfaced	Stellite	Stellite	Alloy 20	Alloy 20	

Classification of Valves

Different types of valves serve these functions. These valves can be classified or categorized based on;

- Function
- End connection
- How it operates
- Types of Actuator it used

Classification of Valves Based on Function

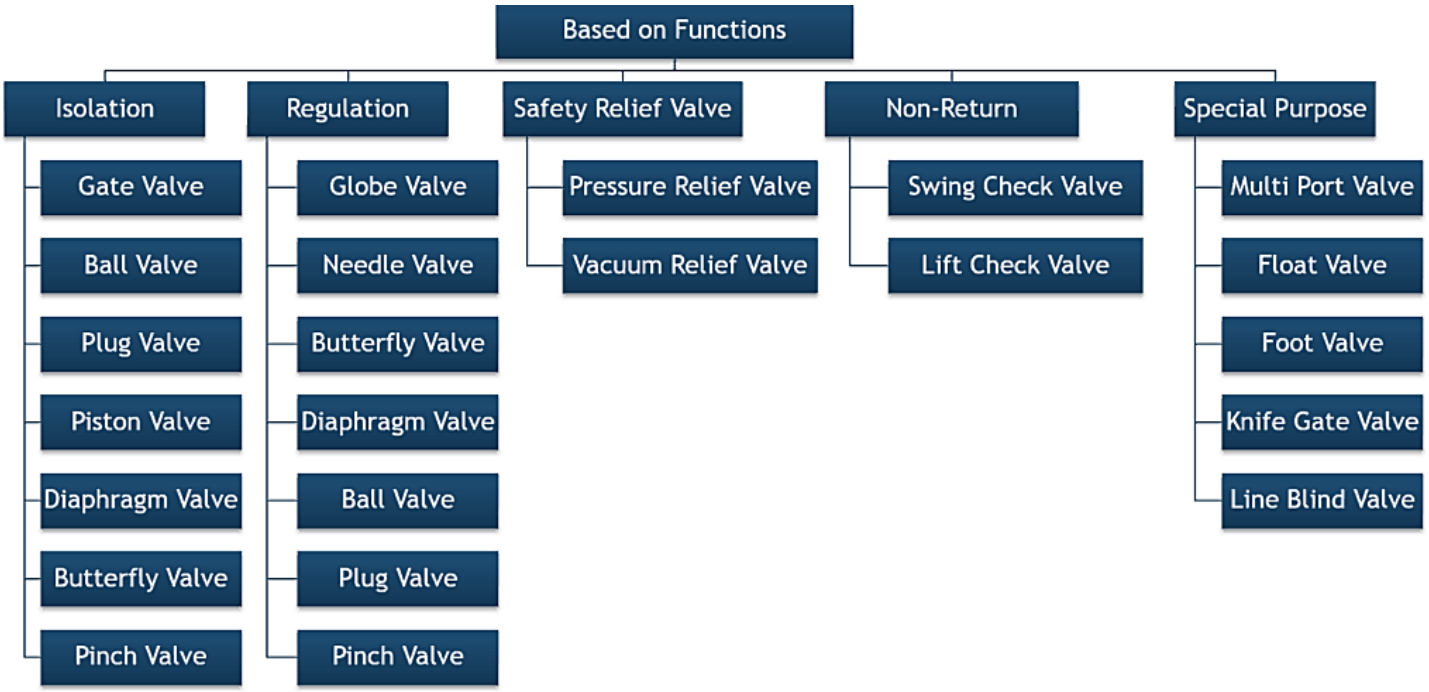
1- Isolation valve isolates or cuts the supply of fluid when needed. Gate, ball, plug, piston, diaphragm, butterfly and pinch valve falls under this category.

A control valve that regulates the flow of fluid falls in the regulation category. Globe, needle, butterfly, diaphragm, ball, plug, and pinch valve are used as a control valve. You can see that; some valves serve dual purposes such as globe and ball valve can be used as an isolation as well as a control valve.

Pressure and vacuum relief valve used to prevent overpressure and vacuum with the system that can damage the piping and equipment.

Non-return valve such as swing and lift check valve prevents backflow within the system.

Whereas, some valves are designed to serve a special purpose. Such as multiport, knife, and line blind valve.



Classification of Valves Based on End Connections

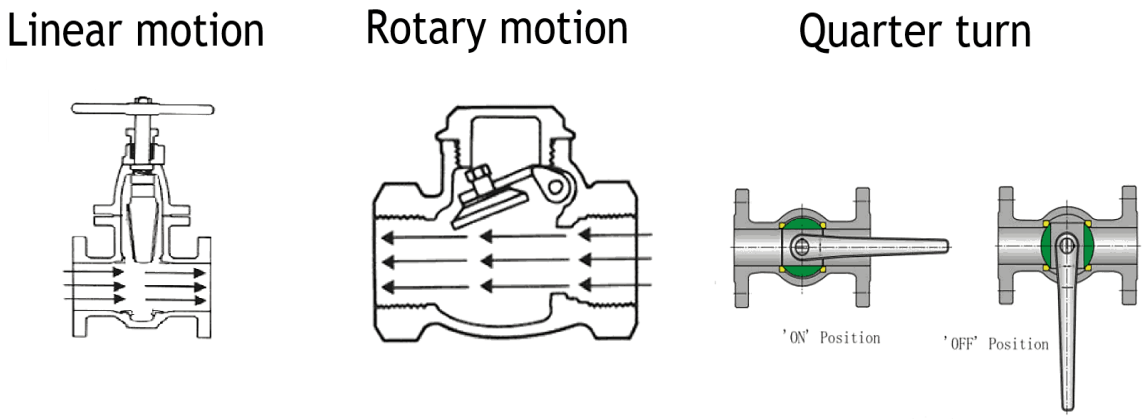
Based on the end connection, valve ends can be

- Screwed or threaded that connect with matching thread on the pipe. Small-bore valve used in instrument connection or as a sample point has a threaded end
- Majority valve used in piping has a Flanged type ends.
- Butt welded valves are used in very high pressure and temperature services.
- Socket Welded valves are used in low-pressure
- Check valve and butterfly valves are available in wafer and lug end construction. These types of ends are used when space is constrained.

Classification of Valves Based on The Way it Open and Closed

Another way to classify the valve is the way it open and close. Each valve opens and closed by either Liner or rotary motion or by quarter turn which is nothing but a rotary motion.

In the image below, you can see the difference between opening methods of the valve.



Linear motion valves use a closure member that moves in a straight line and cut the flow to start, stop, or throttle the flow. The closure device could be a disc, or flexible material, such as a diaphragm. Linear motion valves are slower in operation, but they provide a higher level of accuracy and stability in the position of the closure member.

Rotary motion valves rotate a disc or swing it from the hinge pin that holds the disk.

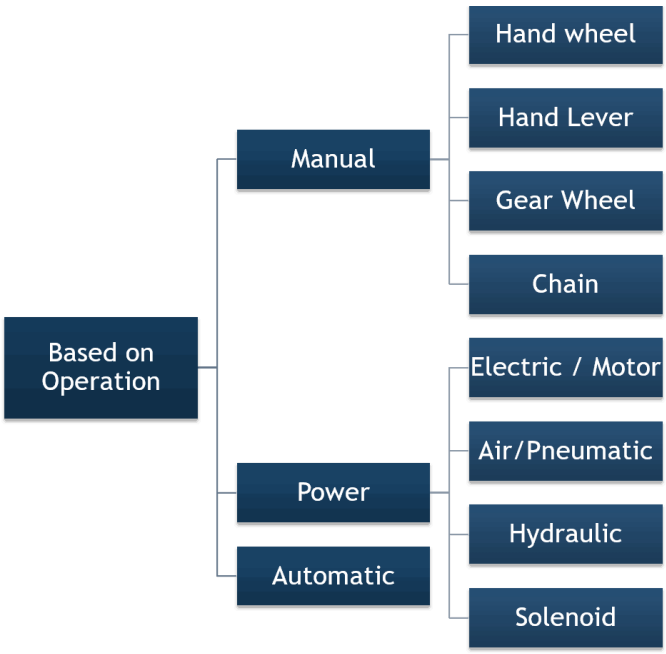
A 90° turn of the stem in Quarter turn valves fully open or fully closed the valve. Because of this quick turn, the operation of Quarter turn valve is much faster than linear motion valves. Some rotary motion valves are also known as Quarter turn valve.

In the table, you can see that ball valve, butterfly valve, and plug valve are both rotary and quarter turn valve. Whereas swing check, tilting disk, and other rotary motion valve are not a quarter turn valve.

Valve type	Linear motion	Rotary motion	Quarter turn
Gate valve	X		
Globe valve	X		
Swing check valve		X	
Lift check valve	X		
Tilting-disc check valve		X	
Folding-disc check valve		X	
In-line check valve	X		
Stop check valve	X	X	

Valve type	Linear motion	Rotary motion	Quarter turn
Stop check valve	X	X	
Ball valve		X	X
Pinch valve	X		
Butterfly valve		X	X
Plug valve		X	X
Diaphragm valve	X		
Safety valve	X		
Relief valve	X		

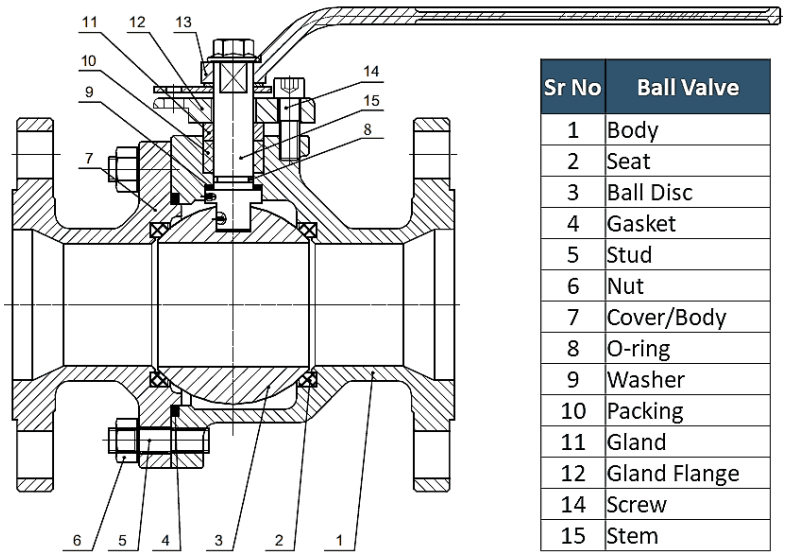
Classification of Valves Based on Types of Actuator it used



Ball Valve

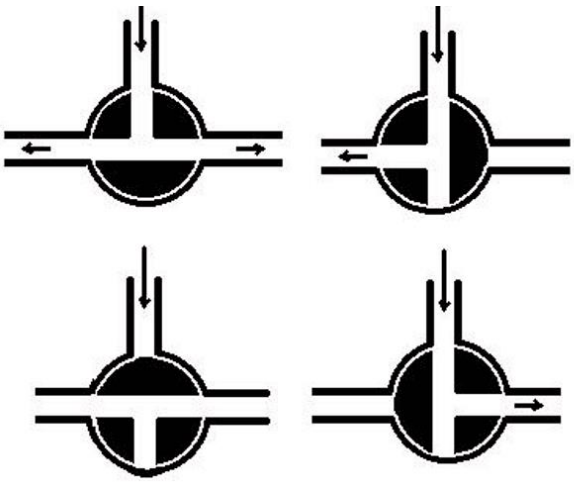
A Ball valve is a quarter-turn rotary motion valve that uses a ball-shaped disk to stop or start the flow. It resembles a plug valve in many ways. When a port in the ball is in line, it allows flow whereas when you rotate the valve 90 degrees, solid part of the ball stop the flow.

Most ball valves are of the quick-acting type, which requires a 90° turn of the valve handle to operate the valve. But in case large size valve which required considerable force to open or close the valve, the gear-operated actuator is used. With this arrangement, a small hand-wheel is enough to operate a fairly large valve.



Sr No	Ball Valve
1	Body
2	Seat
3	Ball Disc
4	Gasket
5	Stud
6	Nut
7	Cover/Body
8	O-ring
9	Washer
10	Packing
11	Gland
12	Gland Flange
14	Screw
15	Stem

Major components of the valve are the body, spherical ball, steam, and seats. It can be metal seated or soft seated. This valve may be unidirectional, bidirectional, or multidirectional, depending on the number of valve ports and the number of valve seats. Same as multiport plug valve. In the image below, you can see the 3-way ball valve.



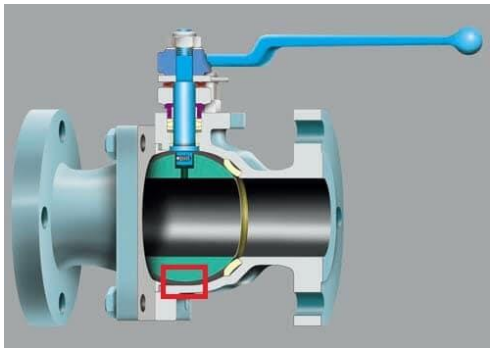
Depending on your requirements, you can arrange the port of valve in the three-way.

- One inlet and two distribute
- One inlet and one outlet with diverting a flow
- Straight pass the fluid without No inlet

Three patterns are available. Venturi port type, full port type, and reduced port type. The full-port ball valve has an inside diameter equal to the inside diameter of the pipe. This design allows pigging. In the venturi and reduced-port types, the port is generally one pipe size smaller than the line size.

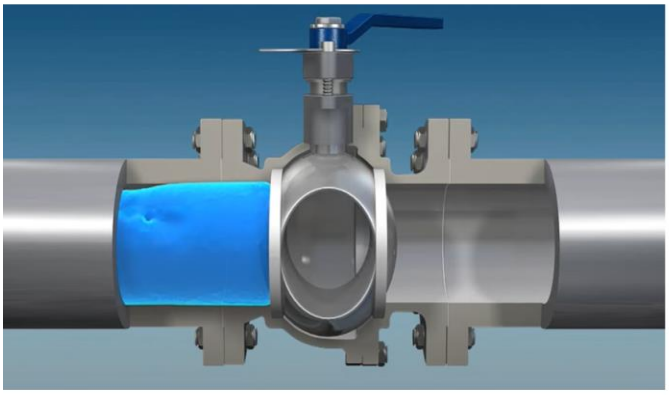
The ball type disc can be a free float or fixed in the valve body. A free-floating valve is known as a floating type whereas a fixed type valve is known as a trunnion mounted valve.

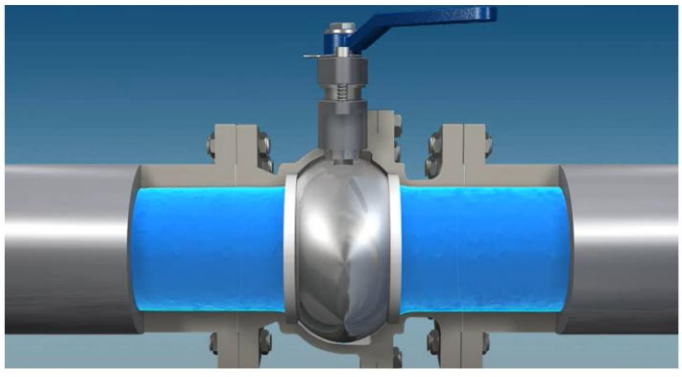
Floating Ball Valve



In a floating ball valve, the ball is held in the position by the compression of the two elastomeric seats against the ball. The ball is free to float inside the valve body. See the highlighted portion in the image and remember as you will see the difference when I will explain to you about the trunnion mounted valve.

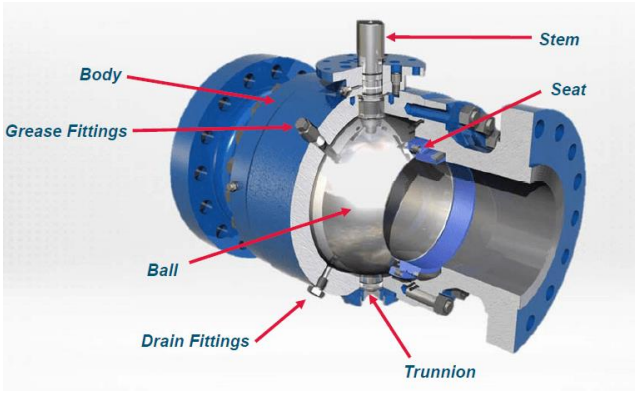
The stem is connected to a slot at the top of the ball which allows the ball to rotate a quarter turn (90 degrees). The shaft allows for a certain amount of lateral movement of the ball that is generated from the upstream pressure acting on the ball. This small lateral movement, in fact, produces a load on the ball that presses it against the downstream seat which improves leak tightness of valve. This type of valve design is capable of bi-directional shut-off. The floating valve is very difficult to operate when upstream pressure is high. You can see the image of a floating type valve.





Trunnion Mounted Ball Valve

Trunnion mounted valve is a solution to the problem of excessive torque required by a floating type valve in high-pressure service. A short shaft like an extension that called trunnion set in the body. You can see this in the image. In this design steam and ball work as a single unit. The ball is supported by two floating or spring-loaded seats that remain in constant contact with the ball.



Trunnion ball design required a lower operating torque. Hence, reduces the size of the actuator and overall costs of the valve. This cost difference becomes an important factor when the pressure class and valve size increases. Check the video below for an animation of this type of valve.

Types of Ball Valves

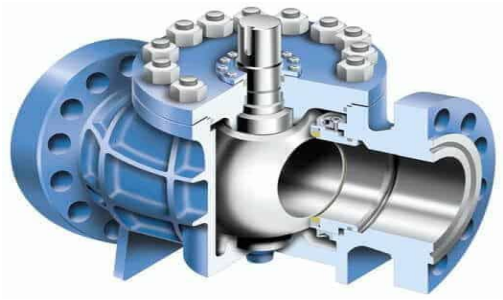
Ball valves are manufactured in different body arrangements. Based on this valve can be classified in the following ways;

- Top entry
- Side entry or split body
- Three-piece body

For Extremely high pressure and temperature services, the full welded body is also used.

Top-Entry Ball Valve

As you can see in the image above, removing bonnet cover of top entry valves, allows access to valve internals for assembly, disassembly, repair, or maintenance without removing the valve from the pipeline.



Split-Body Ball Valve

In this design, a valve body is divided into two or three body parts. A ball, seat rings, stem, and other internals set inside the larger body part and held together with smaller parts by bolting. For a split body, two pieces valve, refer floating ball valve image. Refer below image for split body three pieces type valve.

Applications of the Valve

- It can be used in different types of fluid services as an on-off stop valve that provides bubble-tight shutoff.
- It can be used in air, gaseous, and vapor services as well as hydrocarbon services.
- Metal seated valves can be used in high-pressure & temperature applications.
- It is widely used with instrument tubing to connect instruments.

Advantages

- It is quick to open and close type that provides bubble-tight reliable sealing in high-pressure temperature applications.
- It is smaller and lighter than a gate valve of the same size and rating.
- Several designs of ball valves offer the flexibility of selection so that you can choose the valve that suits your requirements.
- Easy to operate and Cost-effective maintenance.

Disadvantages

- It cannot be used in service that required throttling.
- In slurry or other similar applications, the suspended particles can settle and become trapped in body cavities causing wear, leakage, or valve failure.
- Due to rapid opening and closing, surge pressures may arise which could damage downstream equipment.

Butterfly Valve

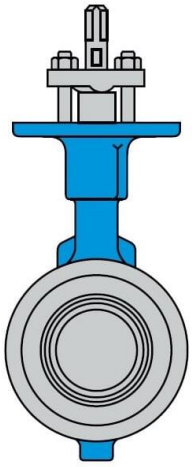
A Butterfly valve is a quarter-turn rotary motion valve that is used to stop, regulate, and start the flow. Butterfly valves are a quick open type. A 90° rotation of the handle can completely close or open the valve. Normally, they are used in systems where positive shut-off is not required.

Large Butterfly valves are usually equipped with gearbox type actuator, where the hand-wheel is connected to the stem via a gearbox. This will reduce the force but at the same time reduce the speed of the operation. This type of valve should be installed in the open position. If the valve is closed during installation, the rubber seat will wedge against the valve disc and make it difficult to open.

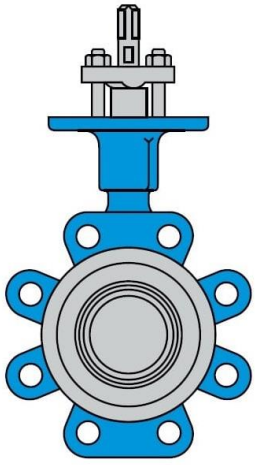
Types of Butterfly Valves

Based on the type of ends of the body butterfly valves are available in following types.

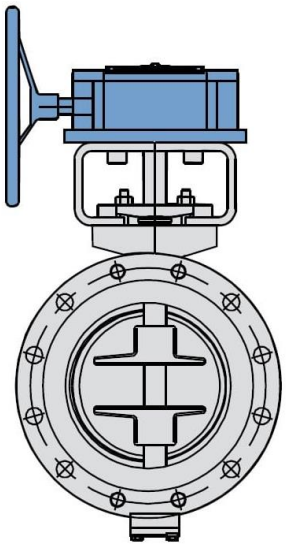
- **Wafer Butterfly Valve** The wafer body is placed between pipe flanges, and the flange bolts surround the valve body. A wafer type butterfly valve is easy to install but it cannot be used as an isolation valve.
- **Lug Style Butterfly Valve** The lug body has protruding lugs in the periphery of a body that provides passage to bolt holes that match with those in the flanges.
- **Flanged Butterfly Valve** In this types, the body has flanged that match with pipe flange dimension.
- **Butt Welded Ends** Types This types of ends are used in high-pressure services and it directly welded to the pipe.



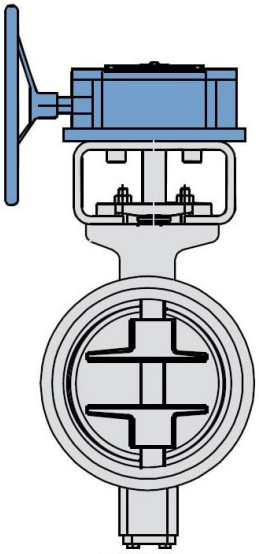
Water Type



Lug Type



Double Flanged



Butt Weld

Seat Types

Butterfly valves can be metal-to-metal seated, soft seated, or with a fully lined body and disc. The first image is of soft seated fully lined body and disc valve. Second, is a soft seat with metal disk and the third is metal to metal seat type valve. The disk of butterfly valve can be concentric or eccentric with the valve body. Here I have shown three different arrangements of the disk with respect to a center of the valve body.

Butterfly Valve Applications

- A Butterfly valve is used in many different fluid services and they perform well in slurry applications also. They can be used in liquids, steam, cryogenics, cooling water, air, gasses, firefighting & vacuum services.
- Butterfly Valve is used in all type of industries application even in High-pressure and temperature services.

Butterfly Valve Advantages

- Butterfly Valve is suitable for large valve applications due to compact, lightweight design that requires considerably less space, as compared to other valves
- Due to a quick operation, it needs less time to open or close
- The maintenance costs are usually low compared to other valve types
- A pressure drop across a butterfly valve is small
- Valve with Non-metallic seating can be used in chemical or corrosive media.

Butterfly Valve Disadvantages

- Throttling is limited to low differential pressure services and that too with a 30- to 80-degree disc opening.
- There is a chance for cavitation and choke as the disk is always in the flow Turbulence flow can affect the disc movement.

Global Valve

What is Globe Valve?

A globe valve is a linear motion valve used to stop, start, and regulate the fluid flow. The globe valve disk can be removed entirely from the flow path, or it can completely close the flow path. During the opening and closing of the valve, the disc moves perpendicularly to the seat.

This movement creates the annular space between the disk and seat ring that gradually closes as the valve closed. This characteristic provides the globe valve good throttling ability required for regulating the flow.

Leakage from the globe valve seat is less as compared to the gate valve, mainly due to right angle contact between the disc and seat ring, which allows tighter seal between seat the disk.

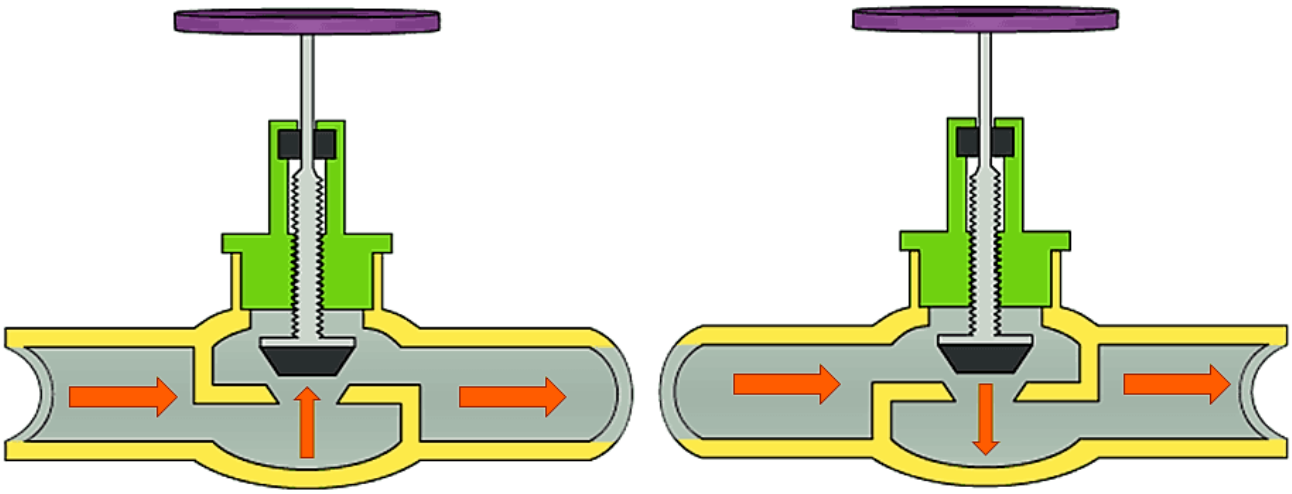
Globe Valve Diagram

In the below globe valve diagram, you can see how the globe valve functions. The image also shows flow direction.

Globe valves can be arranged in such a way that the disk closes against the flow or in the same direction of flow.

When the disk closes in the direction of flow, the kinetic energy of the fluid helps closing but obstructs the opening. This characteristic is preferable when a quick-acting stop is required.

When the disk closes against the direction of flow, the kinetic energy of the fluid obstructs closing but helps to open the valve. This characteristic is preferable when quick-acting start is required.



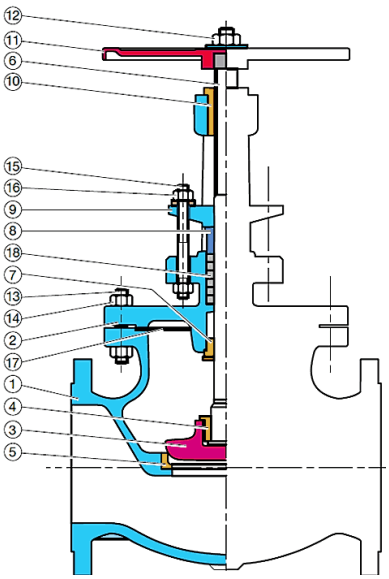
Disk Close Against the Flow Direction

Disk Close In Flow Direction

Globe Valve Parts

Here in below image, you can see the globe valve parts such as Body, Bonnet, Stem, Seat, Disk, etc.

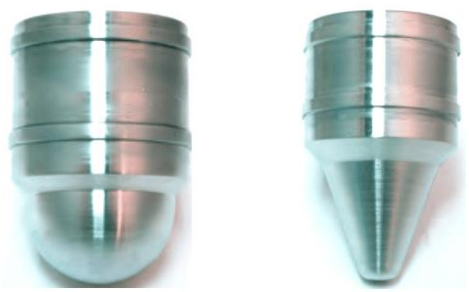
Sr No	Globe Valve
1	Body
2	Bonnet
3	Disc
4	Disc nut
5	Body seat ring
6	Stem
7	Back seat
8	Gland follower
9	Gland flange
10	Yoke nut
11	Handwheel
12	Handwheel nut
13	Stud bolts
14	nuts
15	Stud bolts
16	nuts
17	Bonnet gasket
18	Packing



Globe Valve Disk Types

Globe valve is available in many different types of disc arrangement. The most used disk designs are listed below.

- **The ball disk** design is used in low-pressure and low-temperature systems. It is capable of throttling flow, but in principle, it is used to stop and start the flow.
- **Needle disk** design provides better throttling as compared to ball or composition disk design. A wide verity of long and tapered plug disks are available to suit different flow conditions.
- **Composition disk** is used to achieve better shutoff. A hard, non-metallic insert ring is used in composition disk design.



Ball Type

Needle Type

Types of Globe Valve

Depending on the type of body there are three types of globe valves;

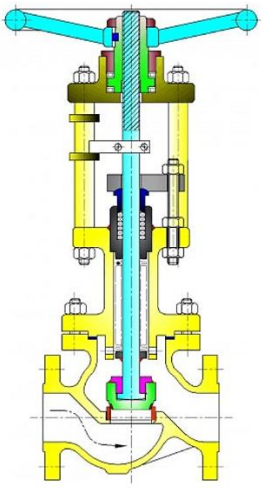
- Z types
- Y types
- Angle Types

Z types Globe Valve

The simplest design and most common type is a Z-body. The Z-shaped partition inside the globular body contains the seat. The horizontal seating arrangement of the seat allows the stem and disk to travel at a perpendicular to the pipe axis resulting in a very high-pressure loss.

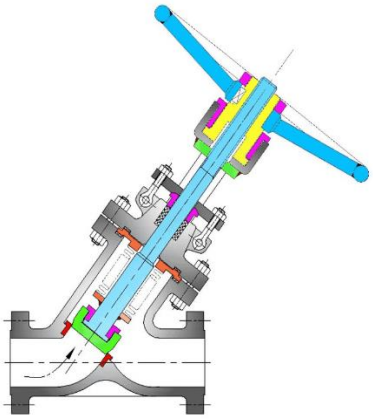
The valve seat is easily accessible through the bonnet which is attached to a large opening at the top of the valve body. Stem passes through the bonnet like a gate valve.

This design simplifies manufacturing, installation, and repair. This type of valve is used where pressure drop is not a concern and throttling is required.



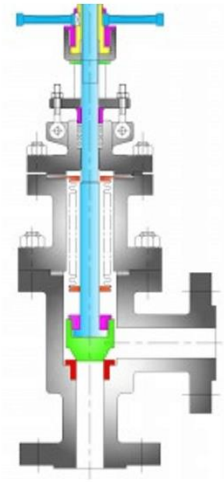
Y types Globe Valve

The Y-type design is a solution for the high-pressure drop problem in Z-type valves. In this type, seat and stem are angled at approximately 45° to the pipe axis. Y-body valves are used in high pressure and other critical services where pressure drop is concerned.



Angle types Globe Valve

Angle globe valve turns the flow direction by 90 degrees without using an elbow and one extra pipe weld. Disk open against the flow. This type of globe valve can be used in the fluctuating flow condition also, as they are capable of handling the slugging effect.



Globe Valve Types based on Body Bonnet Connection

- Screwed bonnet: This is the simplest design available and it is used for inexpensive valves.
- Bolted-bonnet: This is the most popular design and used in a large number of globe valves. This requires a gasket to seal the joint between the body and bonnet.
- Welded-Bonnet: This is a popular design where disassembly is not required. They are lighter in weight than their bolted-bonnet counterparts.
- Pressure-Seal Bonnet: This type is used extensively for high-pressure high-temperature applications. The higher the body cavity pressure, the greater the force on the gasket in a pressure -seal valve.

Application of Globe valve

- Globe Valves are used in the systems where flow control is required and leak tightness is also important.
- It used in high-point vents and low-point drains when leak tightness and safety are major concerns. Otherwise, you can use a gate valve for drain and vent.
- It can be used in Feed-water, chemical, air, lube oil and almost all services where pressure drop is not an issue
- This valve is also used as an automatic control valve, but in that case, the stem of the valve is a smooth stem rather than threaded and is opened and closed by lifting action of an actuator assembly.

Advantages

- Better shut off as compared to gate valve
- Good for frequent operation as no fear of wear of seat and disk
- Easy to repair, as seat and disk can be accessed from the valve top
- Fast operation compares to gate valve due to shorter stroke length
- Usually operated by an automatic actuator

Disadvantages

- High head loss from two or more right-angle turns of flowing fluid within the valve body.
- Obstructions and discontinuities in the flow path lead to a high head loss.
- In a large high-pressure line, pulsations and impacts can damage internal trim parts.
- A large valve require considerable power to open and create noise while in operation.
- It is heavier than other valves of the same pressure rating.
- Costlier compared to the gate valve.

Gate Valve

What is Gate Valve?

A gate valve can be defined as a type of valve that used a gate or wedge type disk and the disk moves perpendicular to flow to start or stop the fluid flow in piping.

A gate valve is the most common type of valve that used in any process plant. It is a linear motion valve used to start or stop fluid flow. In service, these valves are either in fully open or fully closed position. When the gate valve is fully open, the disk of a gate valve is completely removed from the flow. Therefore virtually no resistance to flow. Due to this very little pressure drops when fluid passes through a gate valve.

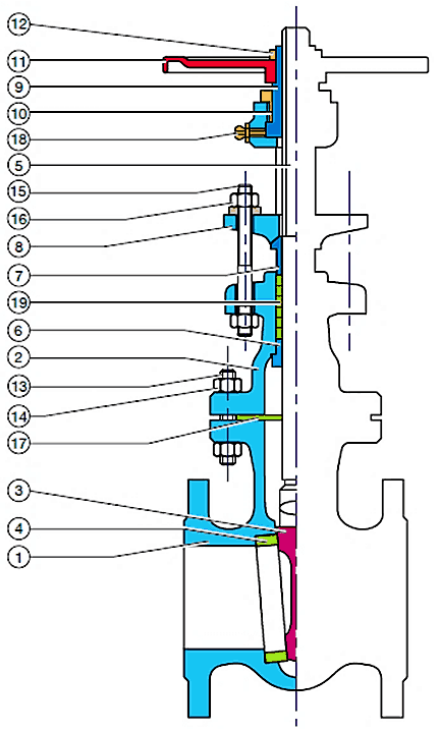
To achieve proper sealing, when the valve is fully closed, 360° surface contact is required between disk and seats.

Gate valves should not be used for regulation or throttling of flow because accurate control is not possible. The high velocity of the flow in the partially open valve may cause erosion of the disc and seating surfaces and also creates vibration and noise.

Gate Valve Parts

Here you can see the main parts of the gate valve. The disk of a gate valve is also known as a wedge. To learn about each of this part read complete guide of valve parts.

Sr No	Gate Valve
1	Body
2	Bonnet
3	Solid wedge
4	Body seats
5	Stem
6	Back seat
7	Gland follower
8	Gland flange
9	Stem nut
10	Yoke nut
11	Handwheel
12	Handwheel nut
13	Stud bolts
14	nuts
15	Stud bolts
16	nuts
17	Bonnet gasket
18	Lubricator
19	Packing



Types of Gate Valves

There are three ways to classify the gate valve.

1- Types of Disk

- Solid taper wedge
- Flexible wedge
- Split wedge or Parallel disks Valve

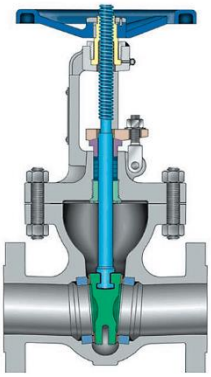
2- Types of Body Bonnet Joint

- Screwed Bonnet
- Bolted-Bonnet
- Welded-Bonnet
- Pressure-Seal Bonnet

3- Types of Stem movement

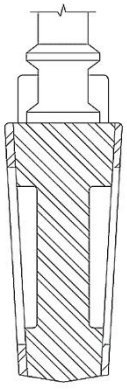
- Rising Stem or OS & Y Type (Outside Stem and Screw Type)
- Non-rising Stem type

Solid Wedge Gate Valve



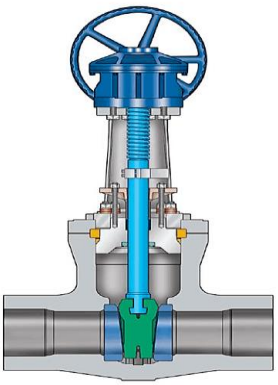
Solid wedge is most common & widely used disk types because of its simplicity and strength. A valve with solid wedge may be installed in any position, and it is suitable for almost all fluids. It can be used in turbulent flow also.

However, it does not compensate for changes in seat alignment due to pipe loads or thermal expansion. So, this type of disk design is most susceptible to leakage. Solid wedge is subjected to thermal locking if used in high-temperature service.



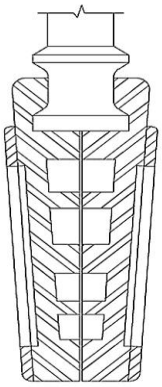
Thermal locking is a phenomenon in which wedge is stuck between the seats due to the expansion of the metal. Solid-wedge gate valves are generally used in moderate to lower pressure-temperature applications.

Flexible Wedge Gate Valve



The flexible wedge is a one-piece solid disk with a cut around the perimeter. These cuts vary in size, shape, and depth. A shallow, narrow cut on wedge perimeter gives less flexibility but retains strength. A cast-in recess or deeper and wider cut on wedge perimeter gives more flexibility but compromises the strength.

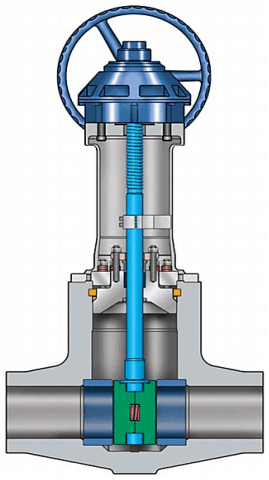
This design improves seat alignment and offers better leak tightness. It also improved performance in situations where thermal binding possible. Flexible wedges Gate valves are used in steam systems.



Thermal expansion of steam line sometime causes distortion of valve bodies which may lead to thermal blinding. The flexible gate allows the gate to flex as the valve seat compresses due to thermal expansion of steam pipeline and prevent thermal blinding.

The disadvantage of flexible gates is that line fluid tends to collect in the disk. These may result in corrosion and ultimately weaken the disk.

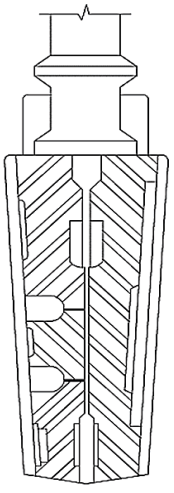
Split wedge or Parallel disks Gate Valve



Split wedge Disk consists of two solid pieces and holds together with the help of special mechanism.

You can see the same in images. In case, one-half of the disk is out of alignment; the disk is free to adjust itself to the seating surface. The split disk can be in a wedge shape or a parallel disk type.

Parallel disks are spring loaded, so they are always in contact with seats and give bi-directional sealing.



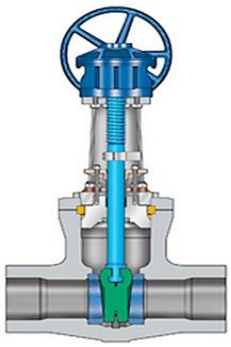
Split wedge is suitable for handling noncondensing gasses and liquids at normal and high temperature.

Freedom of movement of the disk prevents thermal binding even though the valve may have been closed when a line is cold.

This means when a line is get heated by fluid and expand it does not create thermal blinding.

Types of gate valve based on body, bonnet connection



1st is screwed bonnet: This is the simplest design available and it is used for inexpensive valves.

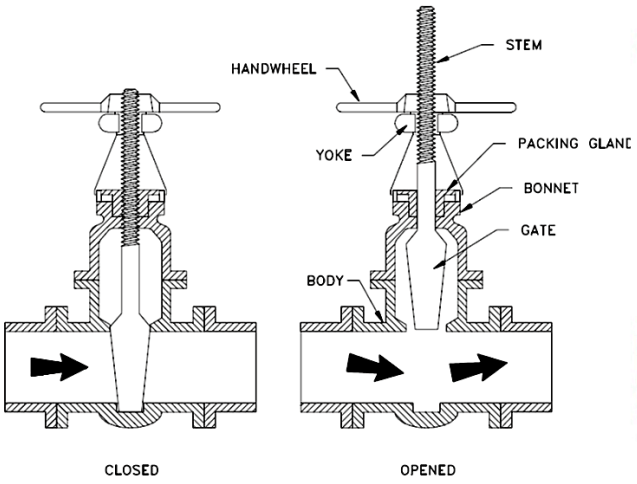
2nd is bolted-bonnet: This is the most popular design and used in a large number of gate valves. This requires a gasket to seal the joint between the body and bonnet.

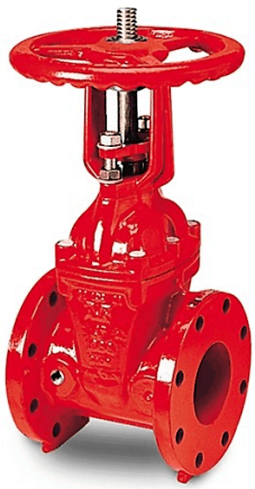
3rd is Welded-Bonnet: This is a popular design where disassembly is not required. They are lighter in weight than their bolted-bonnet counterparts.

4th one is Pressure-Seal Bonnet: This type is used extensively for high-pressure high-temperature applications. The higher the body cavity pressure, the greater the force on the gasket in a pressure -seal valve.

<u>OS & Y Gate Valve or Rising Stem (Outside Stem and Screw Type)</u>

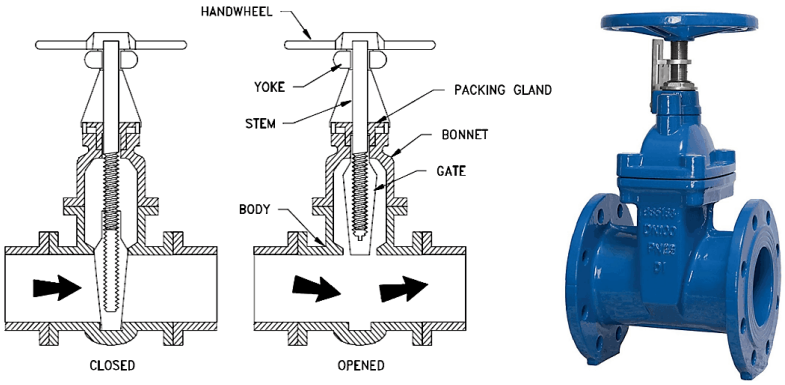
For a rising stem valve, the stem will go up while opening the valve and move down when you close the valve. You can see in the image. In inside screw design, the threaded portion of the stem is in contact with the flow medium and when you open the valve, hand-wheel rise with the stem. Whereas in the case of outside screw design, the only smooth portion is exposed to the flow medium and stem will rise above the hand-wheel. This type of valve is also known as OS & Y valve. OS & Y means outside steam and York.





Non-rising Stem Gate Valve or Insider Screw Valve

There is no upward movement of the stem in a non-rising stem type. The valve disk is threaded internally. The disc travels along the stem like a nut when the stem is rotated. You can see the image. In this type of valve, stem threads are exposed to the flow medium. Therefore, this design is used where space is limited to allow linear stem movement, and the flow medium does not cause erosion, corrosion, or wear and tear to stem material. This type of valve also known as insider screw valve.



Gate Valve Applications

- Gate valves are used in almost all fluid services such as air, fuel gas, feed-water, steam, lube oil, hydrocarbon, and all most any services.
- Some special gate valve is used in slurry and powder product also such as knife gate valve

Advantages of Gate Valve

- Gate valve provides good
- Pressure drop during operation is very less.
- Most of the gate valve can be used as bi-directional
- They are suitable for high pressure and temperature application and required less maintenance

Disadvantage of Gate Valve

- It cannot be used to control the flow.
- A gate valve is slow in operation. Opening and closing take times which is good also as it reduces the chance of hammering.
- When partially open it creates vibration and noise.
- Repairs, such as lapping and grinding of seats are more difficult due to limited access.

Plug Valve

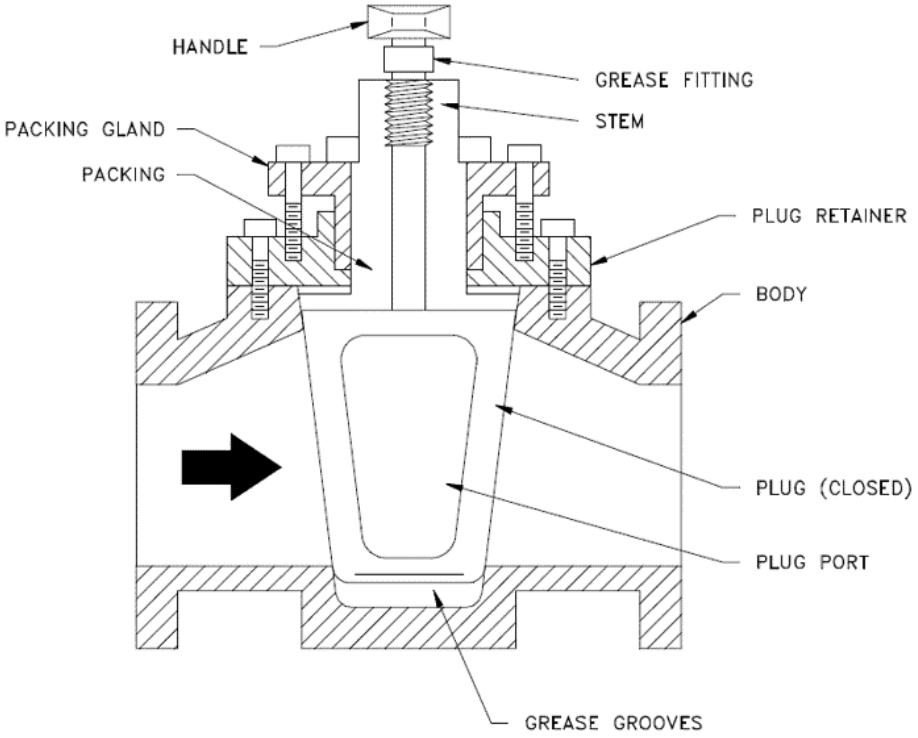
What is Plug Valve?

Plug valve is Quarter-turn rotary motion Valve that uses a tapered or cylindrical plug to stop or start the flow. The disk is in plug shape, which has a passage to pass the flow. In open position, this bored passage is in line with the flow. When the plug is turned 90° from the open position, the solid part of the plug blocks the flow.

Plug valve is used in place of gate valve where a quick operation is required. It can be used in high-pressure temperature services.

Plug Valve Parts

Typical plug valve is consisting of body, bonnet, stem and plug. The seat is an integral part of the body in case of lubricated plug valve. For non-lubricated plug valve, a non-metallic seat is used to improve leak tightness of the valve.



Plug valve disk: Plugs are either round or taper cylinder. They may have various types of port openings, each with a varying degree of the opening area.

Plugs are available with

- Rectangular Port
- Round Port and
- Diamond Port

- **Rectangular Port** is the most common for plug valve. The rectangular port represents at least 70% of the corresponding pipe's cross-sectional area.
- **Round port** plug has a round opening through the plug. It is available in full bore and reduced bore design. Valves with reduced ports are used only where restriction of flow is not important.
- **Diamond Port** plug has a diamond-shaped port through the plug. All diamond port valves are venturi restricted flow type. This design is for throttling service.

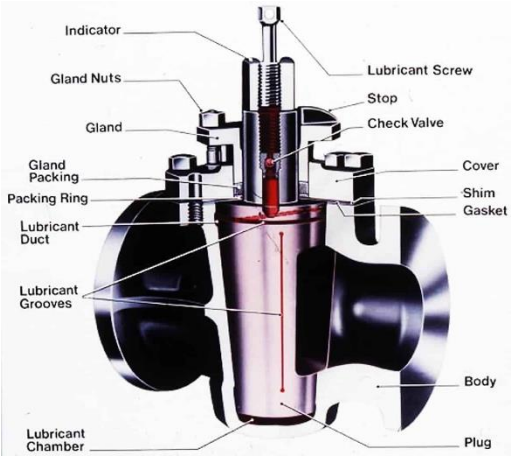
Types of Plug Valves

Plug valves are available in either a lubricated or non-lubricated design and with different styles of port openings through the plug.

Lubricated Plug Valve

The plug in a lubricated plug valve has a cavity in the middle along its axis. You can see this in the image. Lubricant chamber at the bottom and the sealant injection fitting at the top ensure the supply of lubricant.

Small check valve below the injection fitting prevents the sealant from flowing in the reverse direction once the sealant is injected into the cavity.



Plug surface gets constantly lubricated by the sealant that moves from the center cavity through radial holes into lubricant grooves on the plug surface. Now why we required all this? Many plug valves are of all metal construction.

The narrow gap around the plug may allow leakage, and if you reduce the gap further, it will increase the friction and plug may get stuck inside the valve body.

The lubricant reduces the force required to open or close the valve and allows smooth movement of the plug. The lubricant also prevents corrosion of the plug.

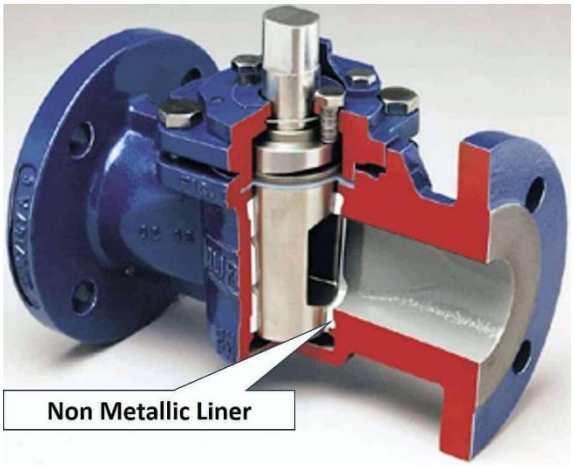
The lubricant material must be compatible with the fluid of the pipeline. It should not dissolve or wash away by the flow medium as this could contaminate the fluid, and damage the seal between

the plug and the body, resulting in leakage. Also, the sealant used must be able to withstand a temperature of the flow medium.

Lubricated plug valves are available in the large size range, and they are fit to work in high-pressure temperature services. These valves are subject to less wear and provide better corrosion resistance in some service environments.

Non-lubricated Plug Valves

A non-metallic elastomeric sleeve or liner is used in this type of plug valve. This sleeve is installed in the body cavity of the valve. The polished tapered plug acts as a wedge and presses the sleeve against the body.



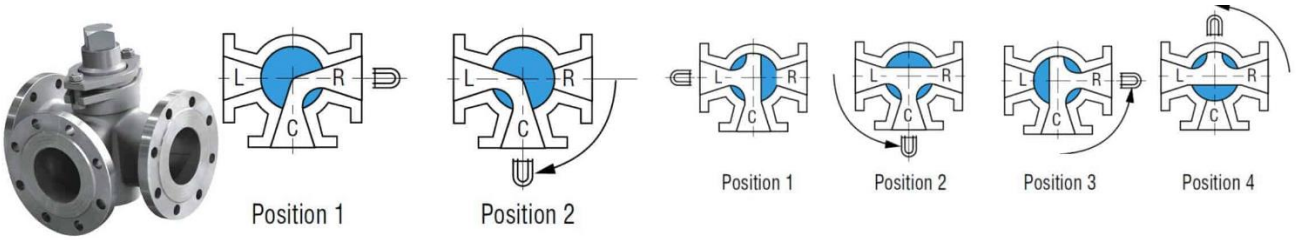
This nonmetallic sleeve reduces the friction between the plug and the valve body. Non-lubricating plug valves required minimum maintenance. Due to the non-metallic seat, these valves are not used in high-temperature services.

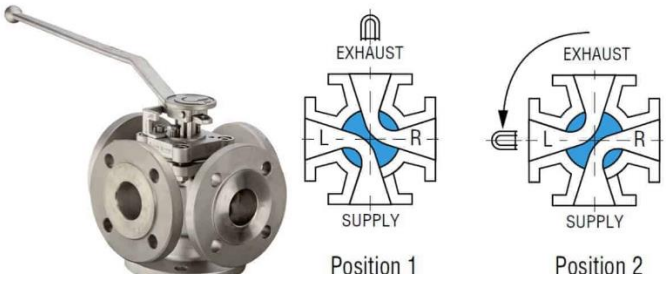
Lubricating and non-lubricating plug valves are capable of providing a bubble-tight shutoff and are of compact size.

Multi-Port Plug Valves

Here you can see the 3-way multiport plug valve. The top image is of 3-way 3-port design and bottom is 3-way 2-port design.

Multiport valves are used in transfer lines and for diverting services. A single multiport valve may serve the purpose of three or four gate valves or other types of the shutoff valve. However, sometime multiport valve does not completely shut off flow. Great care should be taken in specifying the particular port arrangement for proper operation.





Plug Valve Application

- Plug valve used as on-off stop valves and capable of providing bubble-tight shutoff.
- It can be used in different types of fluid services such as Air, gaseous, vapor, Hydrocarbon, slurries, mud, and sewage applications.
- Plug valve can be used in a vacuum to high-pressure & temperature applications

Plug Valve Advantages

- Simple design with few parts
- Quick to open or close
- inline maintenance possible
- Offers minimal resistance to flow
- Provides reliable leak-tight service
- Multiple port design helps reduce the number of valves needed and permits a change in flow direction

Disadvantages of Plug Valve

- It requires greater force to operate, due to high friction
- Larger valves cannot be operated manually and required an actuator
- Pressure drop due to reducing port
- Cost of Plug valves may be more than ball valves for given size and class

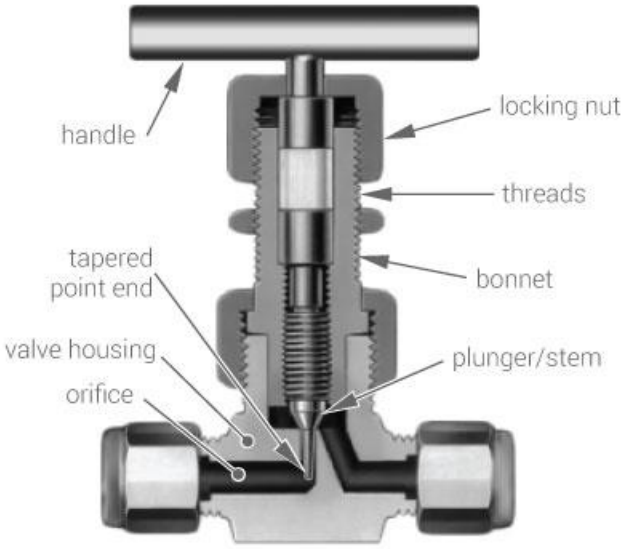
Needle Valve

What is Needle Valve?

A needle valve is a manual valve that used where continuous throttling of flow is required for regulation. Needle valves are similar to the globe valve in design with the biggest difference is the sharp needle like a disk. Needle valves are designed to give very accurate control of flow in small diameter piping systems. They get their name from their sharp-pointed conical disc and matching seat.

Needle Valve Parts

Fluid flowing through the valve turns 90 degrees and passes through an orifice. Due to needle shape disk, a certain portion of the disk will pass through seat opening before disk comes in contact with the seat, which has matching tapered design as a disk. This arrangement permits a very gradual increase or decrease in the size of the opening.



Needle valve has forged and machined body. This body can be of forged carbon steel or stainless steel depending on the services requirements. A seat can be a soft, metal or composite, same as globe valve. Normally needle valves are used in smaller sizes and are provided with either screwed or socket weld end.

All the aspect of needle valve are same as a global valve except its size and pointed needle like disk. You can refer globe valve for more detail.

Needle Valve Application

- All field analog instruments are fitted with a needle valve to control flow entry, where sudden surges of fluid under pressure can damage the instruments.
- Needle valves can be used in situations where the flow must stop gradually and in an application where precise adjustments of flow are required or where a small flow rate is desired such as sample points in the piping
- Needle valves can be used as both on/off and throttle valves
- Used in all type of industries for controlling and metering applications of fluid such as steam, air, gas, oil, water or other non-viscous liquids.