Introduction to Valves

Learning Outcome
When you complete this module you will be able to:
Discuss the design, application and maintenance of the most common types of valves used in power piping systems.

Learning Objectives
Here is what you will be able to do when you complete each objective:

1. Sketch and describe the standard valve designs.

2. Describe the design and operation of specialized boiler valves.

3. Sketch and describe the piping arrangement, the design and operation of steam system pressure-reducing valves.

4. State the common materials of construction for valves and describe valve identification markings.

5. Describe typical valve maintenance requirements.
INTRODUCTION

Various types of valves are required in any piping system in order to regulate the fluid flow within that system.

Valves can be manually operated or they can have an actuator to change and control the valve opening. The actuator may be pneumatically, hydraulically, or electrically operated. The valves represent a considerable percentage of the overall cost of the system and, therefore, must be carefully selected. Consideration must be given to the following details: working pressure and temperature, type of fluid (corrosive or erosive), rate of flow, valve characteristics desired (percentage valve travel to rate of flow), whether for isolation purposes only (wide open or closed), and the cost of installation and maintenance.

VALVE DESIGN

There are a number of basic designs of valves, and these include the gate valve, globe valve, needle valve, butterfly valve, ball valve, plug valve, and check valve. A special service valve, the boiler nonreturn valve, will also be discussed in this module.

Gate Valves

The gate valve is illustrated in Fig. 1 and consists of a gate-like disc, actuated by a screwed stem and handwheel, which moves up and down at right angles to the path of flow. In the closed position, the disc seats against two faces to shut off the flow.

Gate valves are not suitable for throttling service because excessive wear due to wire drawing (erosion) occurs on the gate and gate seats. They are suitable as stop (or isolating) valves, where conditions require either full flow or no flow. They have the advantage that, when fully opened, the resistance to flow is low with a minimum of pressure drop, as the fluid flow moves in a straight line.
Globe Valves

The globe valve, shown in Fig. 2, is constructed in such a way as to cause the flow of the fluid passing through it to change direction twice. The disc and the seat are parallel to the main flow path, and the disc is moved toward, or away from, the seat by means of a threaded stem.

Due to its construction, the globe valve is ideal for throttling or regulating flow with a minimum of wire drawing and seat erosion. Another advantage of the globe valve compared to the gate valve is that it is cheaper to manufacture. On the other hand, the globe valve offers much more resistance to flow than does the gate valve. The unbalanced single disc type of globe valve shown in Fig. 2 is seldom used in sizes larger than 305 mm (12 in.) due to difficulty in opening and closing against fluid pressure.
Needle Valves

Needle valves are designed to allow precise flow control. Its name is derived from the sharp pointed disc and matching seat. They are extensively used for continuous blowoff or chemical feed control services. The stem threads are finer than usual so that considerable movement of the hand wheel is required to increase or decrease the opening through the seat.

Usually, these valves have a reduced seat diameter in relation to the pipe size. See Fig. 3
Butterfly Valves

A butterfly valve consists of the valve body, disc, shaft, and the necessary packing and bushings for shaft support. The body is frequently a solid ring type, which is mounted between pipe flanges. The disc is generally cast in one piece. Correct alignment of this valve is required to prevent binding of the swing-through disc. The thickness of the disc is determined by the pressure drop across the valve (throttling or closed position).

Butterfly valves come in sizes from 25 to 3800 mm (1 to 152 inches) and are designed for pressures up to 13 800 kPa and temperatures up to 1100°C.

The flat disc can be rotated through 90° from the wide open to the fully closed position. The valve shown in Fig. 4 is fitted with a lever for manual operation. A power actuator is required to position the disc for bigger sizes because large pressure differentials can exist across the disc. The valve shown in Fig. 5 can be manually or electrically operated.

The butterfly valve is commonly used in thermal and hydroelectric power stations, oil and gas processing industries, oil and gas transmission, and in water and sewage plants. They have the following advantages: relatively light weight, ease of operation, self cleaning, and negligible pressure drop across the valve when it is fully open.
Ball Valves

The ball valve contains a spherical plug with a passage bored through it, as illustrated in Fig. 6, which controls the fluid flow through the valve body. The basic type of ball valve requires a quarter turn from the fully open to the fully closed position. The valve can be operated by means of a lever, which also serves as an open or shut indicator, or by the use of an automatic actuator.
The spherical plug not only gives precise control of the flow through the valve, but also gives a tight shutoff when in the closed position. The valves are designed so that no internal lubrication is required and the torque required to rotate the ball is negligible. The ball and stem are generally machined from one piece.

For larger sizes and higher pressure ratings, the ball is constructed with a double stem and is supported by bearings. This construction requires a seal for one end and a packing box for the opposite end. Fig. 7 shows such an arrangement.

![Figure 7](image)

**Figure 7**

*“V” Ball Valve*

Fig. 8 illustrates the alternative manual-automatic operation for this particular valve. The ball valves are manufactured in sizes from 3 to 1000 mm (1/8 to 40 in.) and for pressures up to 69 000 kPa with service temperatures from -185°C to 550°C.
Ball valves are suitable for handling slurries and fluids with a high solid content, and for this reason have found wide applications in the paper industry, chemical plants, and sewage treatment plants.

**Plug Valves**

The plug valve is a quarter turn valve, as are butterfly and ball valves. The plug valve consists of a tapered or straight cylinder containing a hole, which is inserted into the cavity of the valve body. The hole in the plug lines up with the axis and opening in the valve body. The valve, illustrated in Fig. 9, has a tapered plug which is secured in the valve body by the valve cover. A packing box is recessed in this cover, with packing held in place by the gland, thus preventing leakage along the valve stem.
The tapered plug has a tendency to jam in the tapered seat and can cause scoring if forced to turn. Most plug valves are lubricated to eliminate this problem. The lubricant is supplied through the center of the stem and is distributed through channels to the seating surfaces. Other valves are equipped with a flexible, smooth liner which eliminates the need for lubrication. The pressure drop across this valve when it is in the wide open position is very low. This type of valve is self-cleaning.

Plug valves are used as quick opening valves in gas supply lines, low pressure steam lines, water treatment plants, pulp and paper, and chemical industries.

Check Valves

The check valve is a valve which prevents reversal of flow in piping. The flow of fluid keeps the check valve open while gravity and reversal of flow will cause the valve to close. The two basic types of check valves are the swing check and the lift check. See Fig. 10.

![Figure 10](image1.png)

*Figure 10*
*Check Valves*

The swing check valve features an almost straight line flow, and therefore offers little resistance to flow. The disc, which is hinged at the top, swings freely in an arc from the fully closed to the fully open position.

The flow through the lift check valve undergoes two changes in direction as it passes through a horizontal section upon which the disc seats. The disc moves upward to allow the fluid to pass through and moves downward to close if the flow should reverse. A dashpot is used to cushion the action of the disc in this design.
BOILER VALVE TYPES

The ASME Code, Section I, states that each outlet from a power boiler (except safety valve connections) be fitted with a stop valve located as close as practicable to the boiler.

The two types of valves commonly used on the steam outlet of a boiler are the gate valve and the globe valve, as illustrated in Figs. 1 and 2, respectively. The connections may be threaded, flanged, welded, or brazed. The gate valve is more likely to be used since it offers the least resistance to flow, and because it will be wide open during operation, no throttling is involved.

It is generally recommended to use a stop valve of the outside-screw-and-yoke type with rising spindle when the outlet is 51 mm (2 in.) pipe size and over. This type of valve has the advantage that the operator can see, even from a distance, whether the valve is open or closed. Also, since the threaded part of the spindle is outside the valve body, it is not exposed to the corrosive action of steam or water, and the thread can be easily lubricated as illustrated in Figs. 1 and 2.

The stop valve (gate valve) in Fig. 1 features an outside-screw-and-yoke with rising spindle. The handwheel is carried on the yoke and does not rise with the spindle.

The stop valve (globe valve) in Fig. 2 also features an outside-screw-and-yoke with a rising spindle. However, the handwheel is carried on the spindle and rises with it.

Nonreturn Stop Valve

The nonreturn stop valve, also referred to as a stop-and-check valve, is installed at the boiler outlet in cases where the boiler is connected to a common main with other boilers.

In principle, it is a stop valve which includes a device for preventing a reversal of flow through the pipe line when the valve is open. The check valve will prevent a reverse flow of steam into the boiler from the common main.

When the valve is opened, the valve head, or piston, not being connected to the spindle, is lifted from its seat by the steam pressure at the inlet and is free to reseat itself independently. In the event of a reversal of flow, as illustrated in Fig. 11, the pressure in the header is greater than that in the boiler; thus the valve or disc is shown in the closed position.
This valve is designed for one-way flow only. If a boiler tube were to rupture, the pressure in the damaged boiler would drop and the nonreturn stop valve would automatically close, thus preventing steam from the other boilers connected to the header from entering the damaged boiler. The nonreturn stop valve may be secured in the closed position by turning the spindle down against the valve.

The stop valve in Fig. 12 features an outside-screw-and-yoke with rising spindle.

Figure 11
Nonreturn Stop Valve

Figure 12
Angle Type Outside-Screw-and-Yoke Stop Valve
Piping Arrangements

Various arrangements of piping from boiler to header are illustrated in Fig. 13. Each arrangement features a nonreturn valve closest to the boiler, a stop valve at the header, and drains are provided in each case to drain the piping between the two valves. (Ref. ASME Code, Section I).

![Figure 13](AK_2_0_33.jpg)

**Figure 13**  
*Nonreturn Stop Valves and Header Valve Arrangements*

PRESSURE REDUCING VALVES

Quite often the supply pressure of utilities such as city water, natural gas, and compressed air is considerably higher than the service pressure desired for certain types of equipment. Pressure reducing valves are used to lower the supply pressure to the equipment and to maintain it at the required pressure.

A description of two of the many different types of pressure reducing valves follows.

**Spring-Operated Reducing Valve (Internal Diaphragm)**

This valve, illustrated in Fig. 14, consists of two main parts, the valve housing and the bonnet, separated by a flexible diaphragm.
The bonnet is open to the atmosphere. A compression spring acts downward on the diaphragm forcing the valve to open. The space below the diaphragm is connected to the low pressure side of the valve and the fluid (liquid or gas) exerts an upward force against the diaphragm counteracting the force of the spring. At a set outlet pressure these two forces are balanced and the valve is held open a certain distance allowing a certain level of flow through the valve. When the demand for fluid increases, the pressure on the outlet side drops slightly resulting in a reduced upward force on the diaphragm. The spring force moves the diaphragm downwards which, in turn, forces the valve to open more. More fluid is allowed to pass through and the outlet pressure is restored. The opposite happens when the demand for fluid decreases.

![Diagram of a Spring-Operated Pressure Reducing Valve (Internal Diaphragm)](AK2_fig14.gif)

**Figure 14**  
*Spring-Operated Pressure Reducing Valve (Internal Diaphragm)*

The outlet pressure can be adjusted by changing the compression of the spring by means of the adjusting screw through the top of the bonnet. Turning the screw downwards increases the spring compression and raises the outlet pressure. Turning the screw upwards results in a reduced outlet pressure. The adjusting screw is secured by a locknut after the final adjustment has been made.

The valve can be either directly connected to the diaphragm or, as is illustrated in Fig. 14, be separate from the diaphragm, in which case a small spring plus the pressure of the fluid on the high pressure side of the valve force the valve to follow the upward movement of the diaphragm.
Spring-Operated Reducing Valve (External Diaphragm)

The reducing valve, illustrated in Fig. 15, operates on the same principle as a valve with an internal diaphragm. However, it differs in basic design. The diaphragm and spring are mounted outside the valve housing on a yoke and they operate the valve by means of an extended valve stem. A control line connects one side of the diaphragm casing to the low pressure side of the valve. With this arrangement the diaphragm is not affected by the temperature of the fluid, which can have a harmful effect on the condition and life span of the diaphragm. The fluid in the control line and the diaphragm casing assumes the temperature of the surrounding air. When used in steam lines, the line and casing are filled with condensate.

![Diagram of Spring-Operated Pressure Reducing Valve (External Diaphragm)](AK2_fig15.gif)

**Figure 15**

*Spring-Operated Pressure Reducing Valve (External Diaphragm)*

All reducing valves should be installed with isolating valves on either side and with a by-pass valve and pass-by line so that the valve can be removed for repairs without a complete interruption of the supply. They should also be equipped with a pressure gage and safety valve on the low-pressure side of the reducing valve. This equipment is needed to ensure safe and continuous operation of the system.
Since the isolating valves are either wide open or fully closed (and are thus not subjected to throttling), gate valves are preferred since they offer minimum resistance to flow. The by-pass valve, which throttles the flow when the reducing valve is out of service for maintenance or repair, should be a globe valve.

**VALVE DETAILS**

**Materials of Construction**

Materials of construction for valve bodies will be determined mainly by the pressure, temperature, and type of fluid in the application. For example:

- Cast iron is used for low pressure and temperature applications.
- Bronze is used for moderate pressures and temperatures up to 280°C.
- Carbon steel is used for services up to 425°C.
- Alloy steel is used for high pressure applications and temperatures up to 650°C.
- Special alloy steels are used for temperatures in excess of 650°C.
- Stainless steel is used for corrosive services.

The body can have screwed or flanged ends or be welded into the piping system.

Valve trim, consisting of disc, seat ring, valve stem, and guide bushings, if applicable, are manufactured from bronze, mild steel, alloy, or stainless steel.

Valve packing material, depending on the service, is made of Teflon, Teflon impregnated asbestos, graphitized asbestos, or semimetallic packing.

**Nonrising Stem**

In the case where a gate valve is to be used and head room is limited, then the nonrising stem, inside screw design is used.

With this type, as the stem is turned, the gate climbs up the threaded part of the stem which is inside the valve body. See Fig. 16.
IDENTIFICATION OF VALVES

It is extremely important that the proper type of valve is used for a particular service. Accidents have frequently occurred when a valve of the wrong material has been installed in a pipe line. Therefore:

All valves must be properly identified as to the material of construction and service conditions for which they are designed.

All valves not properly or clearly identified should be rejected.

All markings shall be legible, and must indicate at least the following:

1. Manufacturer’s name or trademark.
2. Service designation, e.g., pressure-temperature for which the fitting is designated.
3. Material designation, e.g., steel or cast iron, ASTM Number, etc.
VALVE MAINTENANCE

Valve Leaks

Visually inspect valves frequently and repair small leaks immediately. A leak in a valve often can be remedied in a simple and fast way. Neglect in doing so can result in a mess and may lead to damage to bonnet and flange surfaces, which in turn may require costly and time consuming repairs.

1. Stem Leaks

These can normally be fixed by slightly tightening the packing nut or gland. Always tighten up bolted glands evenly, otherwise the gland will bind the valve stem. If insufficient packing is left to stop leakage, renew the packing. The procedure for renewal of packing in stuffing boxes of valve stems is similar to the procedure used for renewing the packing in stuffing boxes of pump shafts.

The only difference is that the valve stem packing may be tightened enough to stop all leakage since no constant flow of liquid is required for lubrication. Never tighten more than necessary to stop leakage since over tightening causes extra friction resulting in wear and added effort in opening and closing the valve.

Wear on stem packing is mainly due to the rising and turning motion of the valve stem. New packing contains sufficient lubricant to reduce the friction to a minimum but older packing may have exhausted its lubricant. A few drops of oil on the valve stem occasionally will reduce friction and extend the life of the packing.

2. Bonnet and Flange Leaks

These leaks can be caused by insufficient tightening of the bolts or by bolts loosening under service strain. Try tightening the bolts first to stop the leak but do not over stress them. If tightening the joint does not stop the leak, the gasket should be replaced as soon as possible. Neglecting to stop flange leaks will result in “wiredrawing” on the faces of the flanges. Wiredrawing is the forming of deep grooves, running from the center of the flange to the outside, caused by the scouring action of the escaping fluid.

Lubricate the external thread of the valve stem. This will cut down friction, wear and effort in operating the valve. Valves equipped with a grease nipple should receive a shot of grease periodically to supply the threaded bushing in the top part of the yoke with lubricant.
Internal Inspection

Most valves are designed to permit internal inspection without removing the valve body from the line. Periodic inspection of the valve disc and seat is the best preventive maintenance. The complete bonnet and disc assembly can be removed for cleaning and inspection. Check the seating surfaces in the body at the same time.

If inspection of the valve disc or the wedge and the seat shows damage such as grooving and wire-drawing, the seating surfaces should be refaced.

Globe valves equipped with a composition disc should have the disc replaced as soon as a seat leak is discovered. It is a simple procedure and early replacement will prevent damage to the seat.

To repair damaged valve discs and seats of globe valves the following procedures can be used:

1. Slightly damaged surfaces can be refaced by grinding the valve disc in on the valve seat in combination with a grinding compound.

2. If damage is more extensive, the seat should be refaced with a reseating tool. The valve disc should be refaced by either carefully filing down the damaged seating surface or by taking a slight cut off on the lathe or grinding machine. Then disc and seat should be ground in together to obtain matching seating surfaces.

3. When the valve is equipped with a renewable seat, and the disc and seat are extensively damaged, it will be cheaper to replace both rather than trying a repair.

The seating surfaces of gate valves are much harder to reface than those of a globe valve. Special equipment is required to do a satisfactory job.

An operator will be able to reface seating surfaces of smaller size valves without too much trouble. However, he/she should not attempt to repair badly damaged or large sizes valves. It is far better to ship such valves to one of the special valve repair shops which have all the required equipment and people with the experience to do a proper repair job.
References and Reference Material

For more information on this topic, the following are recommended:


