18 Valves

Pipe carries fluid. Fittings direct it. Valves control it.

A valve is a mechanical device installed in a piping system to start, stop, regulate, direct, or prevent the flow of a fluid. In steam systems, valves are used for isolation, throttling, pressure control, overpressure protection, and preventing reverse flow.

Selecting the correct valve is critical. A valve intended for on-off service may perform poorly when used for throttling, while a valve designed for regulation may be damaged if used as a simple stop valve.

Understanding the purpose and limitations of each valve type is an essential skill for anyone working with steam systems.

18.1 Basic Valve Components

While valve designs vary, most valves contain the same basic parts.

Body
: The body is the main pressure-retaining component of the valve.
  It contains the flow passage and connects the valve to the piping system.

Bonnet
: The bonnet forms the cover of the valve body and provides support for the stem.

Stem
: The stem transfers motion from the handwheel, lever, or actuator to the internal closure element.

Seat
: The seat is the sealing surface against which the closure element closes.

Disc, Plug, or Ball
: The closure element blocks, permits, or regulates flow.
  The name depends on the valve type.

Packing
: Packing prevents leakage around the moving stem. Packing glands can often be adjusted to compensate for wear.

18.2 Valve Position Indication

An operator should be able to determine whether a valve is open, closed, or partially open without having to guess. Many valve designs provide a visible indication of valve position.

Understanding these indications helps prevent operating errors and improves safety during maintenance and isolation procedures.

18.2.1 Valve Handles

Quarter-turn valves, such as ball valves and plug valves, typically use a lever handle.

The position of the handle indicates the position of the internal closure element.

When the handle is perpendicular to the pipe, the valve is closed. When the handle is parallel to the pipe, the valve is open.

Because the handle provides an immediate visual indication of valve position, ball valves are often preferred where quick verification is important.

18.2.2 Rising-Stem Valves

Many gate valves and globe valves use a rising stem.

As the valve opens, the stem moves outward from the valve body.

The amount of exposed stem indicates approximately how far the valve is open.

Advantages:

- Easy visual confirmation of valve position.
- Valve position can often be determined from a distance.

18.2.3 Non-Rising-Stem Valves

Some valves use a non-rising stem design.

In these valves, the stem rotates but does not move outward as the valve opens.

Because the stem does not change position, the operator must rely on the handwheel position, valve indicator, or operating records to determine the valve's status.

Non-rising stems are often used where headroom is limited.

18.2.4 Position Indicators

Some valves incorporate dedicated position indicators.

These may include:

- Pointer plates
- Mechanical indicators
- Colored markers
- Electrical limit switches

Position indicators are commonly found on:

- Actuated valves
- Motor-operated valves
- Control valves
- Remote-operated valves

18.2.5 Why Valve Position Matters

Many operating incidents occur because a valve is believed to be in one position when it is actually in another.

Before starting equipment or placing a system into service, operators should verify:

- The correct valve.
- The intended valve position.
- The actual valve position.

Never assume a valve is open or closed based solely on previous operation or labeling.

18.2.6 Key Takeaway

Good valve designs provide a visible indication of position. Lever-operated valves typically show position through the orientation of the handle, while rising-stem valves show position through stem movement. Operators should always verify valve position rather than relying on assumptions.

18.3 Bonnet Designs

The bonnet provides access to the internal components of a valve and supports the valve stem. Several bonnet designs are used in steam service.

18.3.1 Screwed Bonnet

In a screwed-bonnet valve, the bonnet threads directly into the valve body.

This design is simple and economical, and it is commonly found on smaller valves.

One disadvantage is that the bonnet usually provides only a limited wrenching surface. After years of service at elevated temperatures, the bonnet may become difficult to remove.

18.3.2 Union Bonnet

In a union-bonnet valve, the body screws into the bonnet and is secured by a union nut. The union nut provides a larger wrenching surface and greater mechanical advantage during disassembly.

Many steam operators and restorers prefer union-bonnet valves because they can usually be dismantled more easily after years of service.

18.3.3 Why Bonnet Design Matters

Steam valves often operate at temperatures approaching 400°F (200°C) or higher. Repeated heating and cooling cycles can cause threaded components to become extremely tight.

Periodic disassembly is often required for:

- Inspection
- Cleaning
- Seat maintenance
- Packing replacement
- Long-term layup

With a screwed-bonnet valve, the relatively small wrenching surfaces may require considerable force during disassembly. Excessive force can damage wrench flats or, in extreme cases, distort the valve body.

Union-bonnet valves typically provide larger wrenching surfaces and allow disassembly with less risk of damage to the valve body.

For this reason, many experienced steam operators regard the union-bonnet design as more service-friendly, particularly on valves that are inspected regularly or exposed to repeated thermal cycling.

18.3.4 Practical Considerations

When evaluating a valve, consider not only how it performs in service but also how it will be maintained.

A valve that is easy to inspect, repair, and reassemble may provide significant advantages over its service life, especially in steam applications where periodic inspection is required.

18.4 What Valves Do

Most valves perform one of five functions:

- Isolate flow

- Regulate flow
- Prevent reverse flow
- Control pressure
- Protect equipment from overpressure

Although some valves can perform more than one function, every valve is designed with a primary purpose in mind.

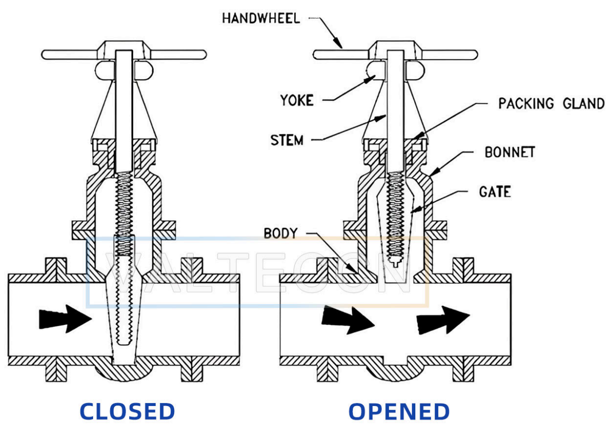
18.5 Isolation Valves

Isolation valves are intended primarily for fully open or fully closed service.

18.5.1 Gate Valves

Gate valves use a wedge-shaped or parallel gate that moves perpendicular to the flow.

When fully open, the gate is completely removed from the flow path.



Typical characteristics:

- Excellent isolation
- Low pressure drop when open
- Poor throttling performance

Advantages:

- Minimal flow restriction
- Good shutoff capability

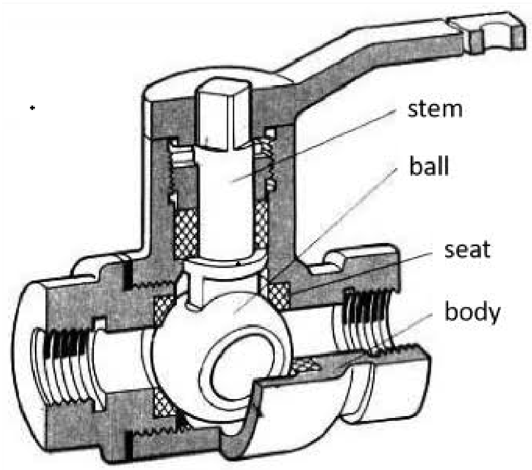
Disadvantages:

- Slow operation
- Can be damaged when partially open

Gate valves should generally be either fully open or fully closed.

18.5.2 Ball Valves

Ball valves use a drilled spherical ball that rotates within the valve body. A quarter-turn rotates the ball between fully open and fully closed positions.



Advantages:

- Quick operation
- Excellent shutoff
- Compact design

Disadvantages:

- Not ideal for precise flow control

Ball valves are among the most common valves found in modern steam and utility systems.

18.5.3 Plug Valves

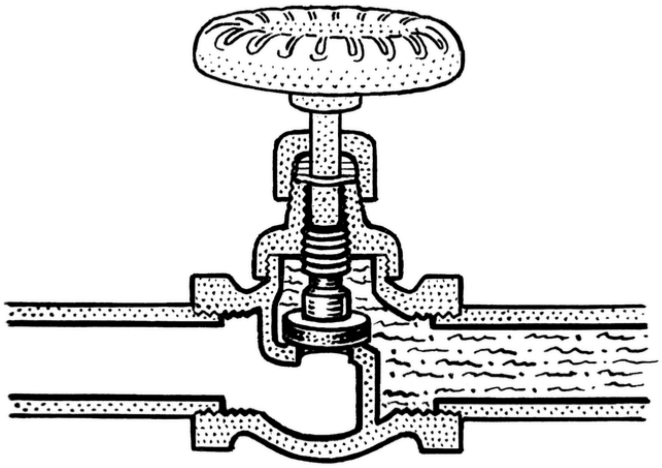
Plug valves use a tapered or cylindrical plug with a flow passage drilled through it. Like ball valves, they are typically quarter-turn valves. Plug valves are commonly used where quick operation and positive shutoff are required.

18.6 Flow Regulation Valves

Regulating valves are designed to control flow rate rather than simply stop flow.

18.6.1 Globe Valves

The globe valve is one of the most common throttling valves. Flow passes through the valve seat while a disc moves toward or away from that seat.



Advantages:

- Excellent throttling capability
- Good flow control
- Reliable operation

Disadvantages:

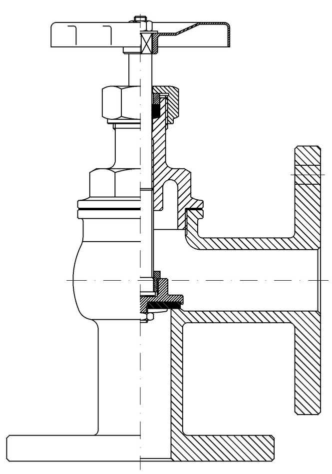
- Higher pressure drop
- More tortuous flow path

Many globe valves are designed to operate with flow entering beneath the disc. Manufacturers often cast an arrow on the valve body to indicate the intended direction of flow. Valve orientation should always be verified before installation.

Globe valves are frequently used where steam flow must be adjusted or controlled.

18.6.2 Angle Globe Valves

An angle globe valve performs the same function as a standard globe valve but changes the direction of flow by 90 degrees.



By combining a valve and an elbow into a single component, an angle globe valve can reduce the number of fittings required in a piping system.

Advantages:

- Good throttling capability
- Eliminates the need for a separate elbow
- Compact installation

Disadvantages:

- Higher pressure drop than straight-through valves

18.6.3 Flow Direction

The direction of flow is particularly important for globe valves and angle globe valves.

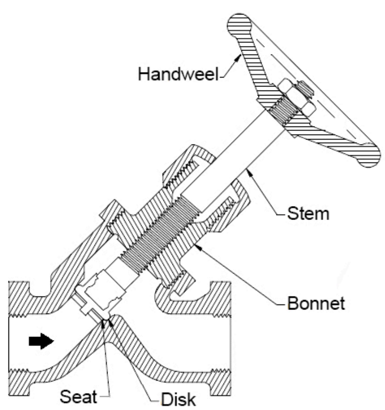
In most applications, pressure should enter beneath the disc and seat rather than above them. When pressure acts beneath the seat:

- Valve operation requires less force.
- The stem packing experiences less pressure.
- The valve is easier to control.
- Wear is reduced.

For this reason, globe valves are usually marked with a flow-direction arrow and should be installed according to the manufacturer's recommendations.

18.6.4 Y-Valves

A Y-valve is a specialized form of globe valve in which the seat and stem are positioned at an angle to the flow path.



The more direct flow path reduces pressure loss compared with a conventional globe valve while still providing positive shutoff.

Advantages:

- Lower pressure drop than a standard globe valve
- Excellent resistance to wire drawing and erosion
- Well suited to high-temperature service
- Self-cleaning design

The inclined body and more direct flow path make Y-valves less prone to sediment accumulation than conventional globe valves. Scale, rust, and suspended solids are more easily carried through the valve rather than collecting beneath the seat.

Because sediment is less likely to interfere with the seating surfaces, Y-valves maintain reliable shutoff even in services where deposits may be present.

Common applications include:

- Boiler blowdown lines
- Continuous blowdown systems
- High-pressure steam service

Y-valves are frequently used for boiler blowdown because they can withstand the high velocities, erosive conditions, and suspended solids that occur when hot water and steam are discharged from a boiler.

18.6.5 Needle Valves

Needle valves are a specialized form of globe valve. The closure element is shaped like a needle, allowing extremely precise flow control.

Common applications include:

- Instrument connections
- Gauge lines
- Sampling systems

18.6.6 Why Valve Selection Matters

A common mistake is using a gate valve to throttle flow.

Partially open gate valves can experience:

- Vibration
- Erosion
- Seat damage

For flow regulation, a globe or needle valve is generally preferred.

18.7 Check Valves

Check valves allow flow in one direction while automatically preventing reverse flow. No operator action is required. Check valves must be installed with the flow arrow pointing in the correct direction.

18.7.1 Swing Check Valve

A hinged disc swings open when flow moves in the desired direction. When flow reverses, the disc closes against the seat.

18.7.2 Lift Check Valve

A lift check valve uses a vertical moving disc. Flow lifts the disc from the seat. Reverse flow forces the disc back onto the seat.

18.7.3 Why Check Valves Matter

Reverse flow can cause:

- Equipment damage
- Pump damage
- Water hammer
- Process upset

Check valves are commonly installed downstream of pumps and other critical equipment.

18.8 Pressure Control Valves

Some valves are designed to maintain a desired pressure automatically.

18.8.1 Pressure Reducing Valves (PRVs)

A pressure reducing valve lowers a higher inlet pressure to a lower controlled outlet pressure. For example, a 150 PSI steam supply can be reduced to a a 30 PSI supply. PRVs are widely used in steam distribution systems but are seldom found in steam traction applications.

Benefits include:

- Improved safety
- More efficient equipment operation
- Better process control

PRVs reduce pressure, but they do not provide overpressure protection. A separate safety valve may still be required downstream if the protected equipment could be exposed to excessive pressure.

18.9 Safety Valves

Safety valves protect equipment from dangerous overpressure conditions.

18.9.1 How a Safety Valve Works

A safety valve remains closed during normal operation. The valve disc is held against its seat by a calibrated spring. As system pressure increases, an upward force is applied to the disc.

When the pressure reaches the valve's set pressure, the force exerted by the fluid overcomes the spring force and the disc begins to lift.

The action of a safety valve is more sophisticated than simply opening and closing at a single pressure. As the disc initially lifts, additional areas of the valve are exposed to system pressure. This increases the upward force acting on the disc and allows the valve to open rapidly to a greater lift.

As a result, the valve "pops" open rather than merely cracking open. Once open, the valve remains fully lifted until the pressure falls below the set pressure by a predetermined amount.

This intentional pressure difference between opening and closing is known as **blowdown**.

For example, a safety valve set at 150 psi may not reseat until the pressure falls to approximately 147 psi. The valve is therefore allowed to discharge enough steam to reduce system pressure before closing.

Without blowdown, the valve could repeatedly open and close in rapid succession, a condition known as **chatter**. Chattering causes excessive wear on the valve seat and can reduce the reliability of the safety device.

18.9.2 Key Concepts

- **Set Pressure**: The pressure at which the valve begins to open.
- **Blowdown**: The difference between the opening pressure and the reseating pressure.
- **Chatter**: Rapid repeated opening and closing of a valve due to unstable operating conditions.

A properly functioning safety valve opens quickly, remains open long enough to relieve excess pressure, and then reseats only after the system pressure has fallen sufficiently below the set point.

18.9.3 Why Safety Valves Are Critical

Without overpressure protection:

- Boilers may be damaged.
- Pressure vessels may fail.
- Piping systems may rupture.

Safety valves are among the most important protective devices in any steam system.

Safety valves should never be isolated from the equipment they protect unless specific approved procedures are followed.

18.9.4 Safety Valve Set Pressure

The set pressure of a safety valve is not selected arbitrarily. It is determined by the Maximum Allowable Working Pressure (MAWP) of the equipment being protected.

For boilers, pressure vessels, and other pressure-retaining equipment, the safety valve set pressure must be coordinated with the MAWP so that the equipment cannot be subjected to pressures exceeding its allowable limits.

For historical boilers, the MAWP is often determined through a combination of:

- Non-destructive examination (NDE)
- Inspection of material condition
- Measurement of remaining thickness
- Engineering calculations using applicable boiler formulae and code requirements

Once the MAWP has been established, the safety valve set pressure is selected to ensure that the boiler remains protected from overpressure conditions.

A safety valve must not be adjusted above the MAWP of the equipment it is intended to protect.

In jurisdictions where boilers are subject to periodic inspection and certification, adjusting a safety valve above the boiler's certified MAWP may result in the boiler being declared non-compliant. An inspector may withdraw or refuse certification until the condition is corrected and the safety valve is returned to an approved setting.

18.9.5 Safety Valve Adjustment and Sealing

The set pressure of a safety valve is adjusted and certified by qualified valve technicians working under an approved quality assurance program. After testing and adjustment, the valve is sealed so that any subsequent adjustment is immediately evident.

The seal provides assurance that the valve remains set at its certified pressure and has not been altered in service. A broken or missing seal typically requires the valve to be removed from service and reinspected.

Under normal operating conditions, a modern boiler safety valve should rarely, if ever, operate. Frequent lifting of a safety valve usually indicates a problem with boiler operation, pressure control, or valve sizing.

18.9.6 Historical Boiler Operation

Steam traction engines and other historical boilers often operate differently from modern industrial boilers.

In many cases, inspections and engineering assessments have resulted in a modern MAWP that is lower than the boiler's original design pressure. Operators may therefore work relatively close to the safety-valve set pressure during normal operation. For example, a traction engine driving a sawmill may experience occasional safety-valve operation when steam demand suddenly decreases while the boiler is still producing steam at a high rate.

Frequent operation can affect a valve's ability to reseat properly and may increase wear on the seating surfaces.

Some jurisdictions permitted the use of an antique "pop valve" as a regulating device. In such arrangements, the regulating valve was set to open at a lower pressure than the primary safety valve. This allowed pressure control to occur without repeatedly lifting the certified safety valve, sometimes called the "government valve." The term "government valve" reflects its role as the officially certified overpressure protection device for the boiler.

The certified safety valve remained the final overpressure protection device and would operate only if the regulating valve failed to control the pressure.

18.9.7 Safety Valve Key Takeaway

A safety valve is the final line of defense against overpressure. It is a protective device, not a pressure-regulating device, and its set pressure is determined by the MAWP of the equipment it protects.

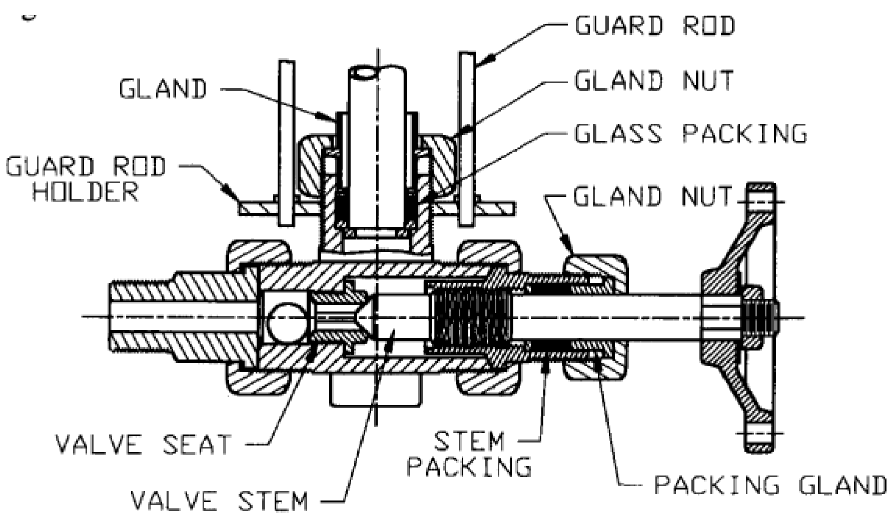
18.10 Protective Valves

Some valves are designed not to control normal operation, but to protect equipment and personnel during abnormal conditions.

18.10.1 Automatic Gauge Glass Valves

Water-column and gauge-glass installations commonly utilize automatic gauge-glass valves. These valves contain a small ball checks that normally remain clear of the flow passage during operation.

If the gauge glass breaks, the sudden increase in flow causes the ball to move against its seat, restricting or stopping the discharge of steam and water.



Automatic gauge-glass valves provide an additional measure of protection, but they should not be relied upon as the sole means of isolation. Manual gauge-glass shutoff valves must remain accessible so that a damaged gauge glass can be isolated safely.

18.11 Valve End Connections

Valves are manufactured with a variety of end connections.

Threaded
    Common on smaller piping systems.
Socket-Weld
    Frequently used for small-bore high-pressure service.
Butt-Weld
    Common on larger industrial piping systems.
Flanged
    Used where equipment may require removal or maintenance.

18.12 Valve Ratings and Markings

Valves are typically marked with information including:

- Manufacturer
- Size
- Material
- Pressure class
- Flow direction (where applicable)
- CRN (where applicable)

Examples include:

```
2
150
A216 WCB
```

or

```
1
800
A105
```

These markings help verify that the valve is suitable for the intended service.

18.13 Reading a Valve

A valve marked:

```
ABC
2
300
A216 WCB
```

can be interpreted as:

- Manufacturer: ABC
- Size: 2"
- Class: 300
- Material: Cast carbon steel (A216 WCB)

Like pipe and fittings, valve markings are an important part of quality control and traceability.

18.14 Why Pipefitters Should Care

Valves are among the most expensive and critical components in a piping system. Proper selection, installation, and operation directly affect system safety and performance.

Before installing a valve, verify:

- Size
- Material
- Pressure class
- Flow direction
- Intended function

Never assume two valves are interchangeable simply because they have the same pipe size.

18.15 Key Takeaway

Valves control the flow of fluids within a piping system. Different valve types are designed for different functions, including isolation, throttling, reverse-flow prevention, pressure control, and overpressure protection. Understanding how each valve operates and where it should be used is essential for safe and reliable steam system operation. ``