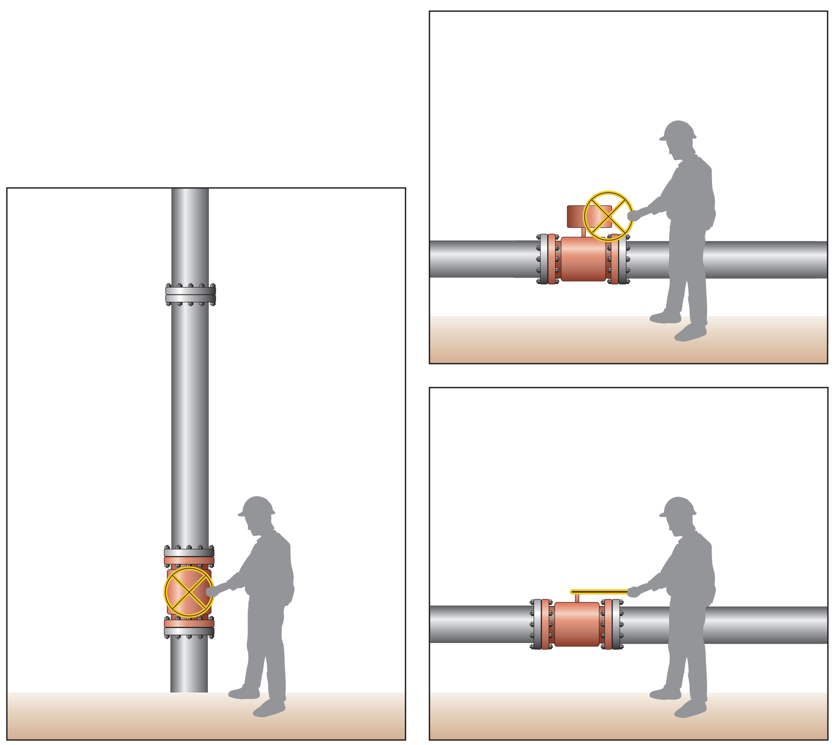
Training Module

Describe Valves and Manual Valve Adjustment



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- Job Aid

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Contents

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Training Objectives

Upon completion of this training kit, you will be able to:

- Describe the purpose and importance of manual valves
- Describe the types of actuators used for manual valves
- Describe the operation, features, and applications of:
  - ball valves
  - plug valves
  - butterfly valves
  - globe valves
  - gate valves
  - needle valves
- Describe a reliable and safe strategy to operate manual valves
- Describe the preventive maintenance of manual valves
- Describe manual valves troubleshooting techniques
- Describe the decision making criteria to repair/replace a valve

1 Introduction

In industry, valves are used to control the flow of fluids through piping. Manual valves allow personnel to start, stop, and adjust flow through piping.

A company's profit or loss can depend on the correct adjustment and knowledgeable operation of manual valves. Adjusting a valve affects operations both upstream and downstream of the valve in facilities and pipelines. Therefore, adjusting a valve can have a major impact on a company's operation. Correct adjustment and knowledgeable operation of manual valves:

- minimizes the risk of injury to personnel
- minimizes loss to equipment, materials, and the environment
- optimizes the company's operations

Industry also uses valves other than manual valves. Refer to the text box on the following page for a description of control valves, emergency shutdown valves, pressure safety valves, and check valves.

Non-Manual Valves

Non-manual valves used in industry include the following:

- **Control valves**, which are equipped with actuators to automatically position the valve in response to control signals (to maintain process variables at desired values). Examples of process variables include pressure, temperature, level, and flow.
- **Emergency shutdown (ESD) valves**, which are equipped with actuators to automatically position the valve in response to emergency shutdown signals:
  - an ESD valve can be triggered to close to isolate a process (i.e., stop the inlet and outlet flows)
  - an ESD valve can be triggered to open to relieve process fluids to safe disposal (i.e., to a flare or incineration system). Relieving the process fluids depressures process equipment and piping.
- **Pressure safety valves**, which are spring loaded to open if pressure rises above a preset limit. Pressure safety valves relieve overpressure to avoid rupture of piping and equipment.
- **Check valves**, which permit flow in only one direction. A check valve has an internal flapper or swivel piece that closes to prevent reverse flow.

In response to the need for greater reliability under a wide range of flows and a wide range of fluids, manufacturers have developed various types of manual valves. The different types of manual valves share the following basic types of components:

- the **valve element** is the barrier inside the valve that closes across the fluid path to stop flow through the valve
- the valve element is linked by a shaft-like **stem** to the actuator
- the **actuator** is the manually-operated device used to open, close, and adjust the valve
- the valve element seals against **valve seats** to prevent leakage through the valve when closed
- the **stem seal** prevents leakage from the valve body (past the stem) to the atmosphere
- the **valve body** is the assembly which contains the valve element, stem, seats, and seals. Valve bodies may be either a single-piece design or multi-piece assemblies.

The actual design of the components varies according to the type of manual valve. Manual valves are classified according to the movement of the stem—valves are classified as quarter-turn valves or rising-stem valves.

NOTE

Quarter-turn valves and rising-stem valves can be automated for use as control valves and emergency shutdown valves.

Quarter-Turn Valves

In a quarter-turn valve, the stem is rotated a quarter turn to operate the valve. The specific types of quarter-turn valves are classified according to the shape of the valve element. For example:

- ball valves
- plug valves
- butterfly valves

NOTE

Descriptions and examples of these quarter-turn valves are provided in Sections 3 to 5.

Rising-Stem Valves

In rising-stem valves, the stem is raised and lowered to operate the valve; the rising stem pulls the attached valve element from the fluid path to open the valve. The specific types of rising-stem valves are classified according to the shape of the valve element. For example:

- globe valves
- gate valves
- needle valves

NOTE

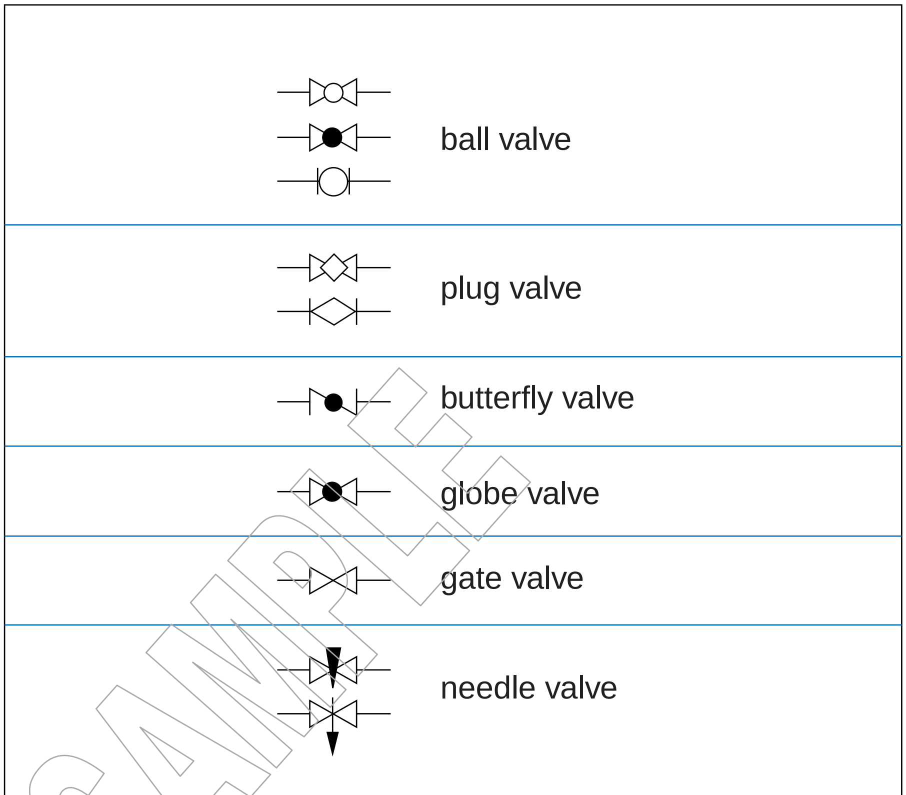
Descriptions and examples of these rising-stem valves are provided in Sections 6 to 8.

Valve Symbols

On technical drawings (such as process flow drawings and piping and instrumentation drawings), valves are represented by symbols (see Figure 1). Valve symbols vary amongst companies, industries, and countries.

Because symbols differ, refer to the lead sheet of your company's technical drawings; the lead sheet defines the specific valve symbols used in the technical drawings.

Figure 1—
Valve Symbols



Training Kit: Describe Valves and Manual Valve Adjustment

This training kit is for operators and maintenance personnel responsible for the safe and effective operation of manual valves. The kit describes:

- manual valve actuators
- types of valves
- informed decisions required to operate manual valves
- preventive valve maintenance
- troubleshooting of manual valves

NOTE

This kit provides instruction on manual valves. This kit does not endorse or promote any specific model, manufacturer, or supplier.

2 Manual Valve Actuators

Valve actuators are used to open, close, and adjust manual valves. Types of manual valve actuators include the following:

- hand levers/ T-handle wrenches
- handwheels
- gear actuators
- chainwheel actuators
- handwheel pedestals
- stem extensions

NOTE

Actuators are also referred to as *operators*. For clarity, this training kit uses the term *actuators.* This training kit uses the term *operators* to refer to the personnel who monitor and operate industrial facilities and pipelines.

Some valves that operate automatically (such as control valves and ESD valves) have automatic actuators that are equipped with handwheels to enable manual operation as a backup. To enable manual operation, the valve's automatic operating ability must be deactivated (so that the valve is no longer able to obey the remote signals).

CAUTION

Operators must observe the following precautions before deactivating a valve's automatic operating ability:

- review the decision in accordance with the company's safe work practices. The manual operation of the valve must not create unacceptable risks to personnel, facilities, the public, or the environment.
- obtain approval to deactivate the valve's automatic operating ability. The company's safe work practices may dictate that approval is required from supervisors, insurance underwriters, and regulatory agencies.

WARNING

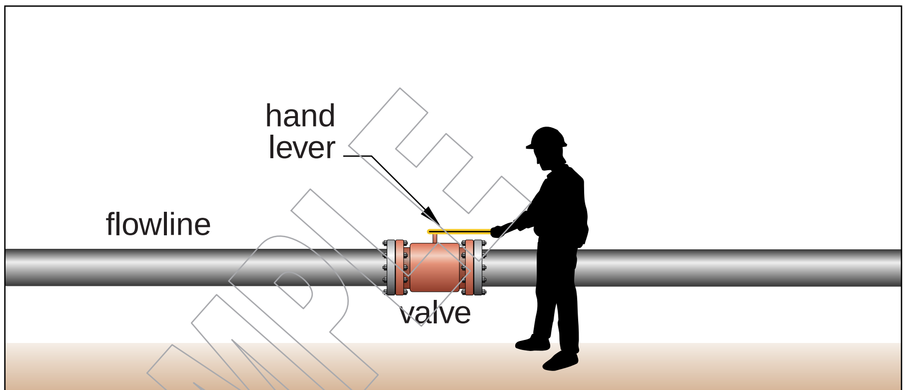
The valve's automated operating ability must be deactivated before using the valve's manual operating controls to prevent injury from sudden automated valve operation. If the automated operation is not deactivated, sudden automated valve operation may cause the valve handwheel to rotate rapidly, potentially injuring the operator.

Hand Lever/T-handle Wrench

Hand levers and T-handle wrenches can be used to manually operate quarter-turn valves:

- some valves have a fixed hand lever (see Figure 2) to operate the valve
- on some valves, only the stub of the stem is visible. A removable tool (such as a hand lever or T-handle wrench) must be used on the valve stem to open and close the valve—the stub of the valve stem is squared to accept the hand lever/T-handle wrench

Figure 2—
Hand Lever



Although it may be tempting to use a pipe wrench on the squared stub, first consult the valve's service/operating manual. Some valve manufacturers restrict the use of pipe wrenches because of the potential damage to the valve's squared stub.

On valves that require hand levers or wrenches to operate, the operator must only use the designated levers/wrenches and only normal physical effort to open/close the valve. Excessive force can damage the valve.

WARNING

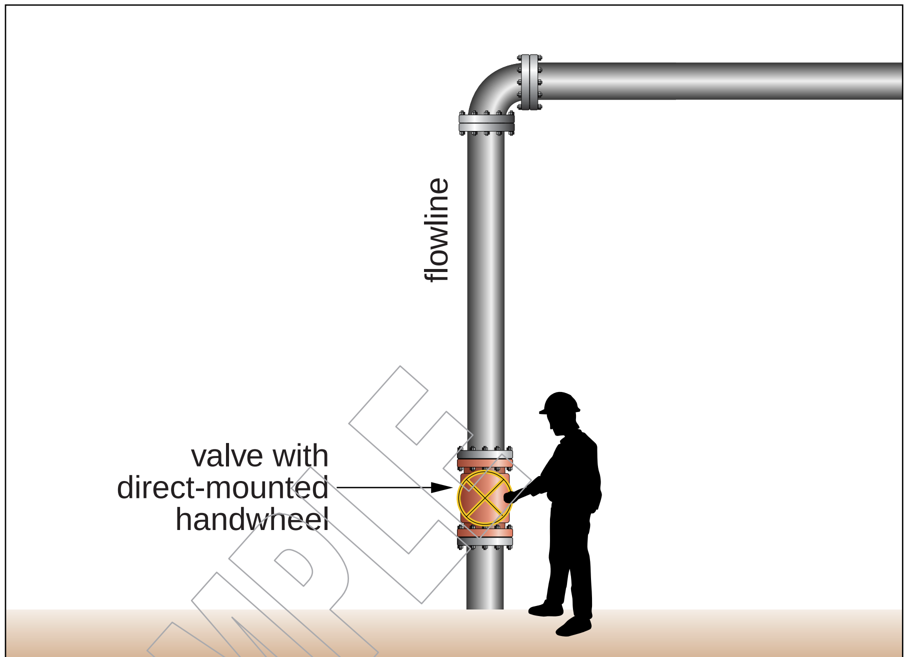
Operators must not use improvised extension handles (e.g., cheater bars) to operate manual valves because the excessive operating torque can result in valve/piping failure. Personal injury can then result from:

- loss of balance when the cheater bar suddenly gives way
- exposure to fluids when they suddenly leak from the failed valve/piping

Handwheel

On some manual valves, handwheels are directly threaded to the valve stem to open and close the valve (see Figure 3).

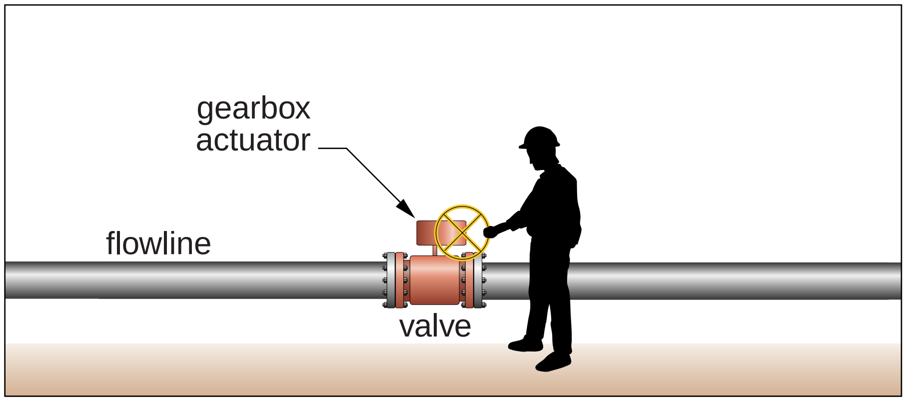
Figure 3— Handwheel



Gear Actuator

A hand lever or handwheel threaded directly to the valve stem may not provide sufficient force to manually operate larger manual valves. To reduce the physical effort required to operate these valves, the valves are equipped with a gear actuator (see Figure 4). The actuator has an external handwheel and a gearbox that provides the mechanical advantage. On gear actuators, the handwheel must be turned many times to adjust the valve.

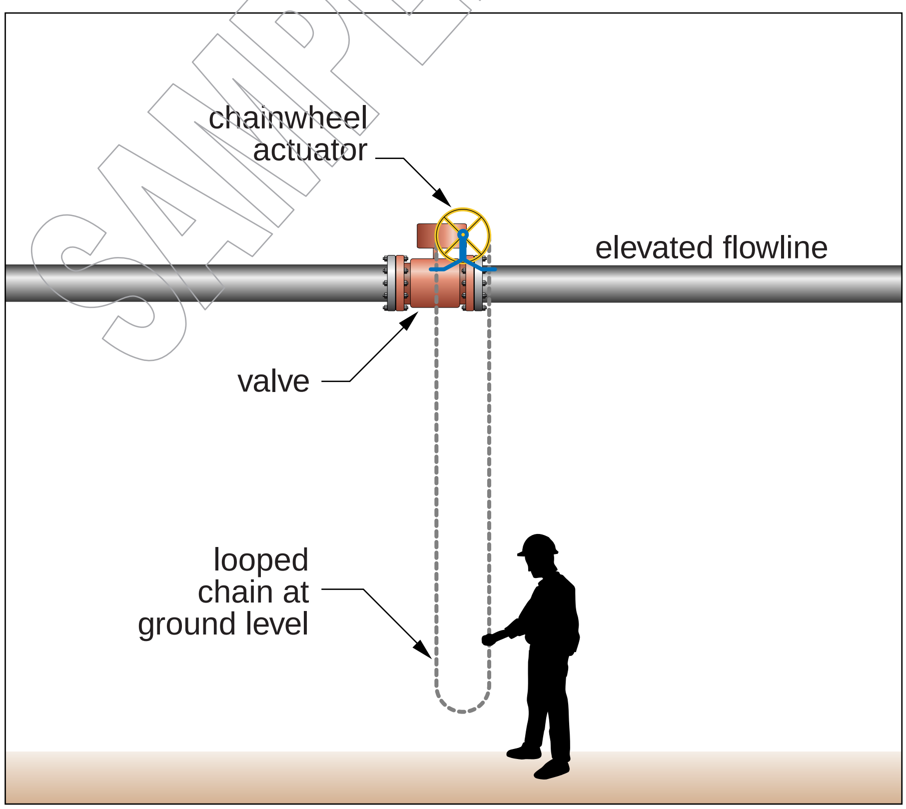
Figure 4— Gear Actuator



Chainwheel Actuator

To operate an elevated manual valve from ground level, the valve is equipped with a chainwheel actuator (see Figure 5). A chain-driven sprocket is mounted on the valve. A chain, formed into a loop, hangs from the sprocket to ground level. The operator pulls on the chain to open and close the valve.

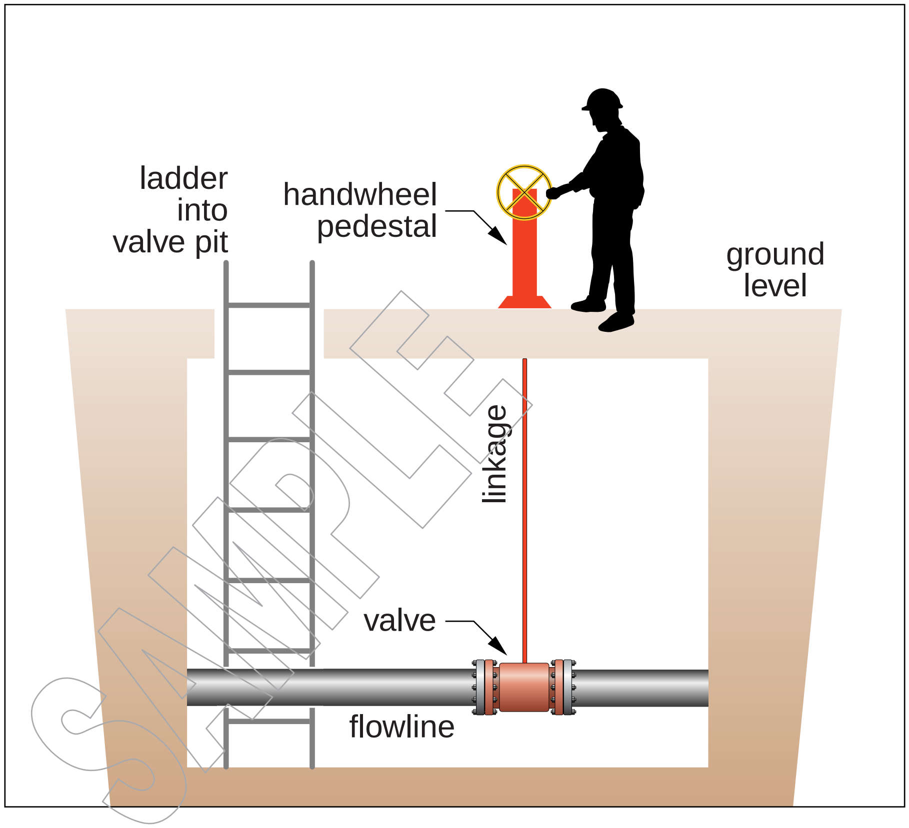
Figure 5— Chainwheel Actuator



Handwheel Pedestal

To operate valves located below ground level in concrete wells and valve pits, the valves are equipped with a handwheel pedestal (see Figure 6) at ground level. Handwheel pedestals are also known as floorstands.

Figure 6— Handwheel Pedestal

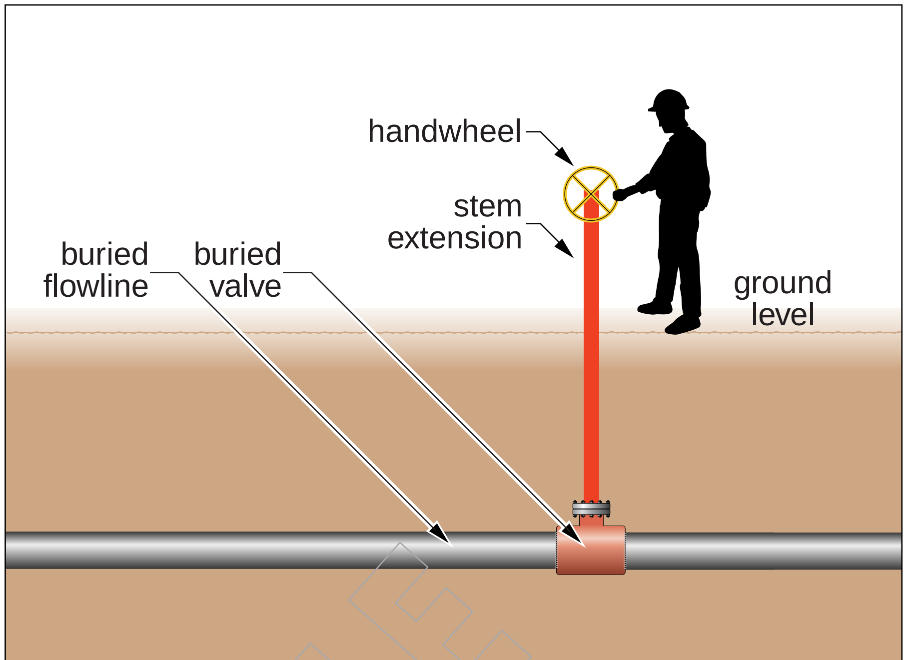


The actuator stem from the handwheel pedestal extends down to the valve. The valve is often not visible from the handwheel pedestal location. Refer to Section 9.2 for the precautions on correctly identifying a manual valve before operating that valve.

Stem Extension

To operate valves located below ground on buried pipelines, the valves are equipped with a handwheel extension (see Figure 7).

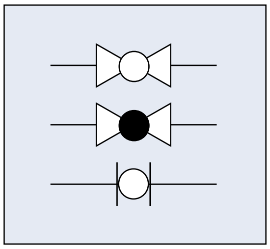
Figure 7—
Stem Extension

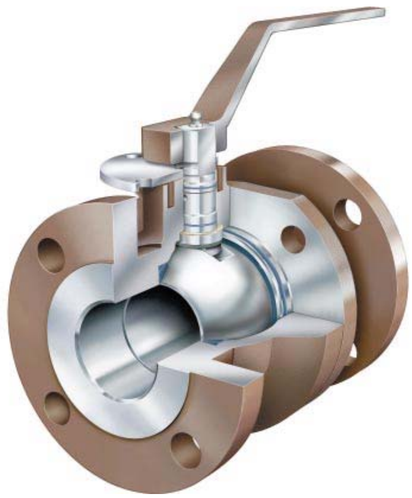


The stem extension is connected to the buried valve and rises above ground, where a handwheel is fitted. A long shaft passes through the stem extension and links the valve stem to the above-ground handwheel. Because the buried valve is not visible, the valve must be correctly identified before the valve is manually operated. Refer to Section 9.2 for the precautions on correctly identifying a manual valve before operating that valve.

3 Ball Valves

Figure 8—
Ball Valve





(Courtesy of KF Industries)

3.1 Operating Principle

A ball valve has a ball-shaped valve element within the valve body (see Figure 8). The ball is bored with a hole; rotating the ball a quarter turn opens or closes the valve:

- when the valve is open, the hole is in line with the flow to enable fluid to pass through the valve
- when the valve is closed, the hole is at right angles to the flow to prevent fluid from passing through the valve

To prevent leakage across the valve, the ball seals against upstream and downstream valve seats mounted within the valve body.

The mounting of the ball within the valve determines the type of ball valve:

- **floating ball**—the connection between the ball and stem allows the ball to move slightly (i.e., float) between its upstream and downstream seats. The fluid line pressure pushes the floating ball against the downstream seat to provide sealing. Floating ball valves are used for lower pressure applications. High fluid pressure would force the ball very tightly against the downstream seat, making the valve increasingly more difficult to operate.

- **trunnion ball**—the ball is held stationary by upper and lower trunnions (pivot pins). The ball pivots in place; the upstream and downstream seats are spring loaded (and assisted by fluid line pressure) to push against the ball. Trunnion ball valves are used in high pressure applications because the trunnions absorb the thrust forces of the fluid pressure.

Within a ball valve, the upstream/downstream seats are as follows:

- some ball valves require the injection of sealant at each seat to assist the sealing action at the seats. Because sealant is gradually used up during the opening/closing of the valve, the valve has fittings for injecting makeup sealant.
- seats may be made of resilient synthetic materials or non-resilient materials such as metals. Non-resilient seats are used in ball valves in high temperature and high pressure applications.

In a trunnion ball valve, the two seats prevent fluid leakage by sealing against the upstream and downstream surfaces of the ball. The body of the valve is therefore a cavity that is sealed from the fluid. Two seat designs are used in trunnion ball valves:

- **self-relieving**—in this design, high cavity pressure is relieved back into the flowline if the cavity pressure becomes too high. The cavity pressure temporarily overcomes the pressure with which the seats push against the ball; the seats retract and release the cavity overpressure into the flowline.
- **double piston**—in this design, the seats are unable to retract and cannot relieve cavity overpressure; instead the seats use fluid pressure to tightly seal the seats against the ball. In case of upstream seat leakage where fluid pressure enters the valve cavity, the downstream seat remains unaffected and will continue to seal tightly to prevent the flow from passing downstream. To relieve overpressure, the valve body must be equipped with a pressure relief valve.

Double Block and Bleed
A method used to redundantly isolate equipment for maintenance. Double block and bleed features two barriers to stop the passage of flow and a drain valve to bleed the middle space between the two barriers. If one barrier leaks, the leakage will be visible when it flows out of the drain valve. The leakage flow will drain and not pass through the other barrier.

For a closed trunnion ball valve, note the following difference between the self-relieving and double piston valve when the upstream seat leaks:

- the self-relieving valve will release the cavity pressure downstream
- the double piston valve will **not** release cavity pressure; if the pressure rises too high, the valve body's pressure relief valve will open

To allow the valve body to be manually depressured, both self-relieving and double piston trunnion ball valves can be equipped with a manual valve body bleed valve. The bleed valve, in combination with the two seats, gives the valve a double block and bleed ability.

WARNING

To prevent operating errors, do not make assumptions about the isolation features of ball valves. Refer to your company's valve documentation and records to determine whether a trunnion ball valve is equipped as follows:

- **double block and bleed valve**—not all trunnion-mounted ball valves are equipped as double block and bleed valves. When a non-double block and bleed valve is to be used for isolation, a blind or second valve must be used to provide the redundant isolation of the flowstream. An intermediate bleed valve must also be present to check that neither isolation barrier leaks.
- **self-relieving valves**—when a self-relieving ball valve is closed, be aware that the valve will release valve body overpressure back into the flowline—i.e., even though the valve is closed, fluid may enter the flowline downstream of the valve.

Pressure Drop
When fluid passes through piping, the fluid's pressure decreases because of friction against the piping walls and from restrictive pipe fittings (such as valves, flowmeters, and elbows). The greater the restriction to flow, the greater the pressure drop.

The port size of a ball valve is the relation of the ball's hole to the inner diameter of the pipe:

- A **full port** ball valve has a hole diameter equal to the inner pipe diameter. Because the hole size matches pipe size, full port ball valves do **not** restrict the flow when fully open.
- A **reduced port** ball valve (also known as a regular port ball valve) has a hole diameter that is smaller than the inner pipe diameter. The reduced diameter partially restricts the flow, causing some pressure drop across the valve.

3.2 Strengths and Limitations

The strengths of ball valves are as follows:

- the flowpath through an open ball valve is smooth. With the smooth flowpath, there is little chance that debris will get trapped when passing through the valve.
- the valve opens/closes quickly because the valve only needs to be rotated a quarter turn
- the valve requires less effort to operate than some other types of valves
- the flowpath through a full port ball valve is completely unobstructed because the diameter of the ball port is identical to the inner pipe diameter. Full port ball valves permit internal piping cleaning/inspection tools (known as pigs or scrapers) to pass through the valve.
- trunnion ball valves can provide double block and bleed isolation as needed to isolate and depressure adjacent piping/equipment for maintenance

NOTE

Because of the low manual effort required to operate the valve and the valve's quick opening/closing ability, ball valves are used as isolation valves where frequent manual operation is required.

Differential Pressure
The difference between the pressure upstream and downstream of a valve.

The limitations of ball valves are as follows:

- ball valves are typically not used to regulate flowrates because the flowpath through the partially open ball valve can erode the ball surfaces and valve seats
- ball valves must not be opened across a differential pressure. Opening the valve across differential pressure results in a high flow velocity through the valve that can damage, erode, or dislodge the valve seats
- quickly closing a ball valve on a liquid line may cause hydraulic hammer damage

Hydraulic Hammer

Hydraulic hammer, also known as water hammer, is the high shock force that results when a moving liquid flow is quickly brought to a stop. The high shock forces can damage or rupture piping. When a valve is suddenly closed, the moving column of liquid stops against the closed valve and high shock forces travel upstream. Downstream of the valve, a vacuum pocket in the flow opens as the fluid moves away from the closed valve. After the fluid stops, it rapidly reverses direction to fill the vacuum gap. As the gap is filled, the fluid comes to a sudden halt against the closed valve, generating high shock forces that travel downstream.

3.3 Typical Applications

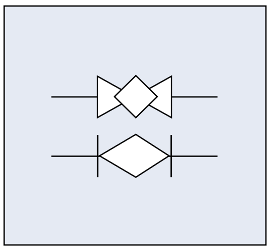
Ball valves are widely used for isolation purposes. For example, ball valves are used:

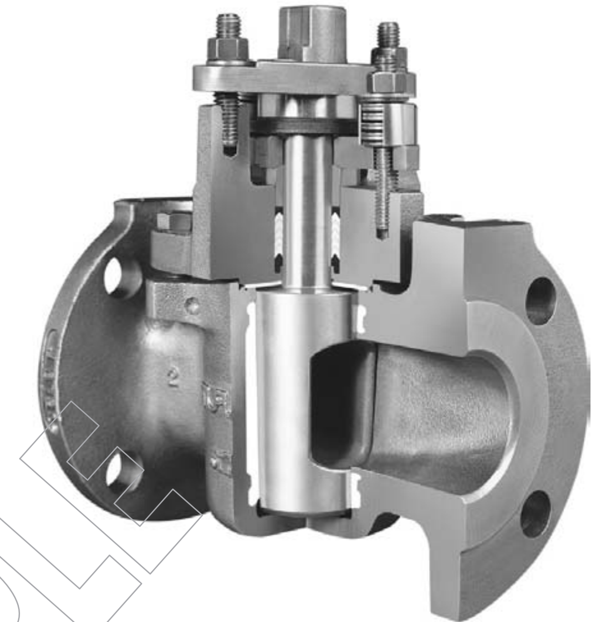
- as the upstream and downstream block valves to isolate control valves
- as pump suction and discharge block valves
- as tank block valves
- as liquid drain valves

Ball valves, in combination with a globe valve, can be used as bypass valves around control valves that experience high pressure drops. Refer to Section 6.3.

4 Plug Valves

Figure 9—
Plug Valve





(Courtesy of Xomox Corporation)

4.1 Operating Principle

A plug valve has a plug-shaped element within the valve body (see Figure 9). The plug has an opening; rotating the plug a quarter turn opens or closes the valve:

- when the valve is open, the opening is in line with the flow to enable fluid to pass through the valve
- when the valve is closed, the opening is at right angles to the flow to prevent fluid from passing through the valve

To prevent leakage across the valve, the plug seals against the large inside surface of the valve body. The sealing surface is either lubricated or non-lubricated and determines the type of plug valve:

- in a lubricated plug valve, injected sealant coats the plug-to-valve body sealing surface. Because sealant is gradually used up during the opening/closing of the valve, the valve has injection fittings to accept makeup lubricant. On a lubricated plug valve, an adjustor screw sets the gap between the plug and the valve body. If the gap is too large, injected sealant is easily expelled from the gap; if the gap is too small, sealant injection is difficult and the valve is at increased risk of seizure.

- in a non-lubricated plug valve, the plug seals against a resilient sleeve in the valve body. (Non-lubricated plug valves are also known as sleeved plug valves.) On a non-lubricated plug valve, an adjustor screw controls the firmness of the plug pushing against the resilient sleeve.

On a plug valve, the size and shape of the opening in relation to the inner pipe flow area is as follows:

- a rectangular port has a rectangular opening that is smaller than the pipe flow area
- a full round port plug valve has a circular opening that matches the inner pipe diameter

On some plug valves, the plug is tapered. Because of the tapered shape, plug valves need internal equalizing passages to prevent the fluid pressure from wedging the valve in position. If not equalized, trapped fluid pressure on the wider end of the plug exerts a greater force than the fluid pressure on the narrower end section of the plug. The unequal forces can seize the valve in position—the seizing is known as pressure locking.

NOTE

Some plug valves have cylindrical plugs; cylindrical plugs are **not** tapered and do **not** pressure lock.

End of Sample

A full licensed copy of this kit includes:

• Training Module and Self-Check
• Knowledge Check and Answer Key
• Blank Answer Sheet
• Performance Check
• Job Aid