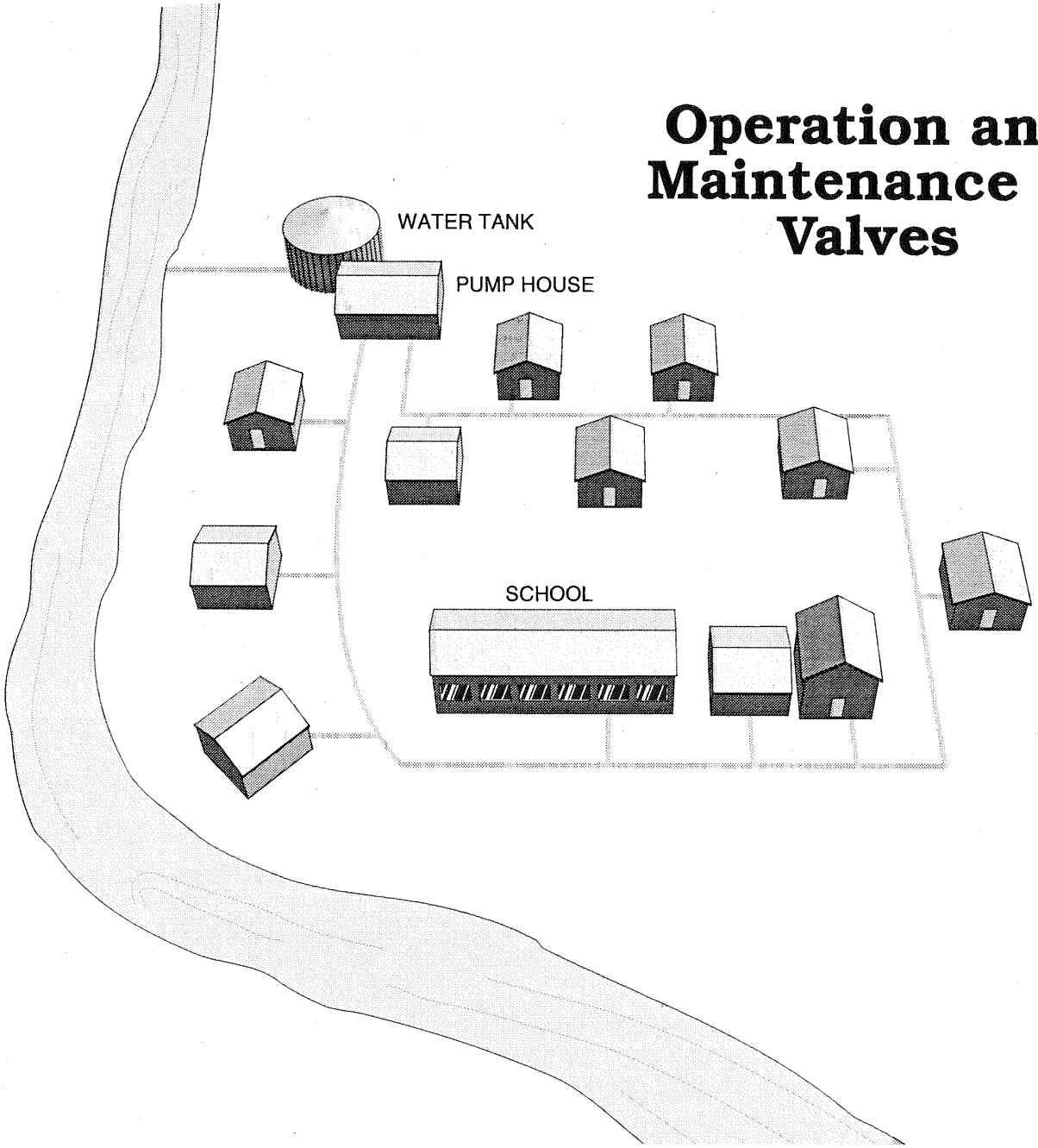
O & M of Small Water Systems



Operation and Maintenance of Valves

Alaska Department of Environmental Conservation
Skeet Arasmith

O & M of Small Water Systems

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O & M OF VALVES

WHAT IS IN THIS MODULE?

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2. The basic components of valves.
3. The nomenclature of the components of gate valves, butterfly valves, globe valves, check valves, air control valves and cross connection control valves.
4. The normal operation of gate valves, butterfly valves, globe valves, check valves, air control valves and cross connection control valves.
5. Routine inspection and maintenance of typical valves in a water system.
6. The terms and sequence used to describe valves.

KEY WORDS

- Air Gap
- Altitude valve
- Atmospheric vacuum breaker
- Backflow
- Backpressure
- Backsiphonage
- Body
- Bonnet
- Cross-Connection
- Double Check Valve Assembly
- Movable closure
- RPZ
- Seal Water
- Stuffing box

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- Headloss

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- Altitude valve
- Check valve
- Foot valve
- Eccentric valve
- Vacuum breaker
- Double check
- RPZ
- Plug valve

O & M OF VALVES

INTRODUCTION

Functions

Valves are found throughout water systems. They serve a wide variety of functions. Among the most common functions are the following:

- On & off or isolation control
- Flow control
- Pressure control
- Reversal of direction control
- Reservoir depth control
- Air and vacuum relief
- Prevention of **backflow**[1] or **backsiphonage**[2] as a result of a **cross-connection**[3]

Content

The following discussion groups valves by function and then type within that function. The discussion includes the nomenclature of the various valve components, how the valve operates and routine maintenance requirements.

Basic Valve Nomenclature

Almost all valves have the following components:

- **Body**[4] - the portion of the valve through which water passes.
- A **movable closure**[5] to allow flow to be controlled.
- Valve seat - the device that the movable closure comes in contact with in order to control flow.
- **Bonnet**[6] - The upper portion of the valve, commonly containing the valve stem.
- Valve stem - The device that is moved in order to adjust the position of the movable closure.
- Operator - The device that is turned, twisted or moved and is attached to the stem. Typical operators, are two inch square nuts and hand wheels.
- Inlet connections.

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[1] **Backflow** - A reverse flow condition, created by a difference in water pressures, which causes nonpotable water to flow into a potable water system.
[2] **Backsiphonage** - A form of backflow caused by a negative or below atmospheric pressure within the water system.
[3] **Cross-connection** - Any physical arrangement whereby a public water supply is connected, directly or indirectly, with a non-potable or unapproved water supply or system.
[4] **Body** - The main portion of a valve. Commonly containing the valve seat(s) and inlet connections.
[5] **Movable Closure** - The portion of a valve that is moved into the flow to either control the flow or stop the flow.
[6] **Bonnet** - The top of a valve, housing the packing box, through which the valve stem must pass.

ON AND OFF OPERATION

Common Types

The most common types of valves used for on and off or isolation operation are:

- Gate
- Butterfly
- Ball
- Plug
- Eccentric
- Globe

GATE VALVES

Types of Gate Valves

There are six different types of gate valves, the single disk, resilient seat, double disk, OS & Y, shear gate and the slide gate.

Advantages of Gate Valves

All gate valves give the advantage of a full flow through the pipe or opening when the valve is open. They offer very little flow restriction resulting in low headloss.

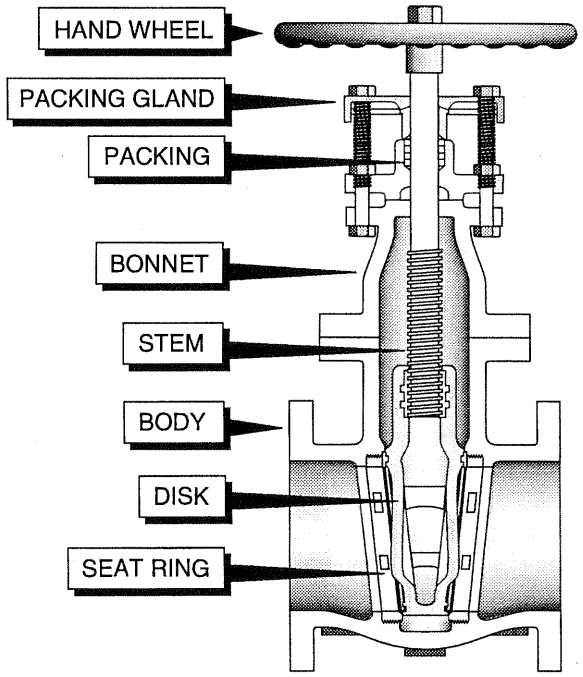
Disadvantage of Gate Valves

The major disadvantage to using gate valves is they are very difficult to open under high pressure conditions. Especially when there is a significant pressure difference across the movable closure.

SINGLE DISK GATE VALVES

Use

Single disk gate valves are commonly used in small sizes, less than 4 inch, and in low pressure conditions. There are very difficult, if not impossible to open under high pressure differential conditions.



Single Disk Gate Valve

Components

The body of a gate valve contains the valve seat and the inlet connections. The upper portion of the valve is called the bonnet and is used to hold the movable closure when the valve is in an open position. The movable closure is a single wedge shaped device. The stem is threaded into the movable closure and when rotated moves the closure up and down. At the top of the stem is the operator, typically a 2 inch square nut or a hand wheel. Hand wheels are popular on smaller sizes and valves used inside of buildings. The square nut is used on valves placed underground. At the top of the bonnet is the packing plate, which holds the packing or "O" rings. On small valves, packing which is compressed by a packing nut is most common. The packing and/or "O" ring is used to control leakage around the stem.

Operation

To close the valve the stem is rotated and the wedge shaped closure is forced into a seat. When the stem is operated in the opposite direction the closure is raised into the bonnet.

Rising and Non-rising Stems

There are two stem types available. The rising and non-rising stem. With the non-rising stem the closure is threaded up and down the shaft as the stem is rotated. With the rising stem there is a threaded collar at the top of the bonnet. The stem moves up and down through this collar.

RESILIENT SEAT

Relatively New

One of the major additions to the gate valve field in recent years is the resilient seat gate valve. The resilient seat gate valve is a single disk gate with a resilient face on the disk.

Use

The resilient seat gate valve can be used in any position where a standard gate valve is used. If offers the advantage of requiring less force than a standard gate valve to open and close.

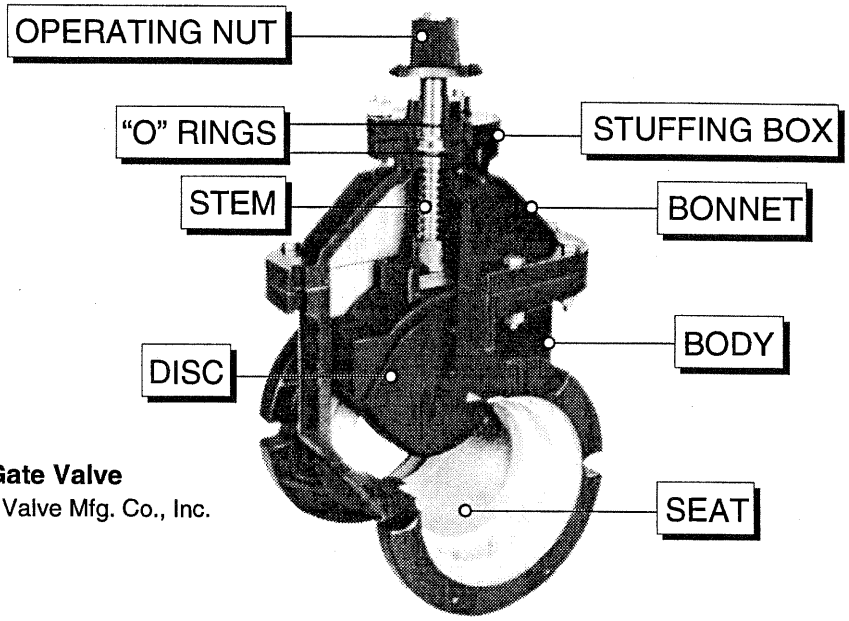
Components

The body is commonly made of cast iron and like other gate valves contains the valve seat and inlet connections. Notice unlike the standard gate valve there is no groove in the bottom of the valve body. Above the body is a standard cast iron bonnet. The movable closure is a single wedge shaped disk with a resilient material on one or both faces. Commonly this disk is flat on one side and wedge shaped on the other with resilient material on the sloped face. A standard stem and operator are used to adjust the position of the closure. The seat is the valve body itself. Leakage around the stem is controlled by one or more "O" rings.

Operation

To close this valve the stem is rotated and the closure is moved downward wedging against the bottom and the seat of the valve body. To open the stem is rotated and the disk moves upward into the bonnet. These

valves are available in rising and non-rising stem configurations.

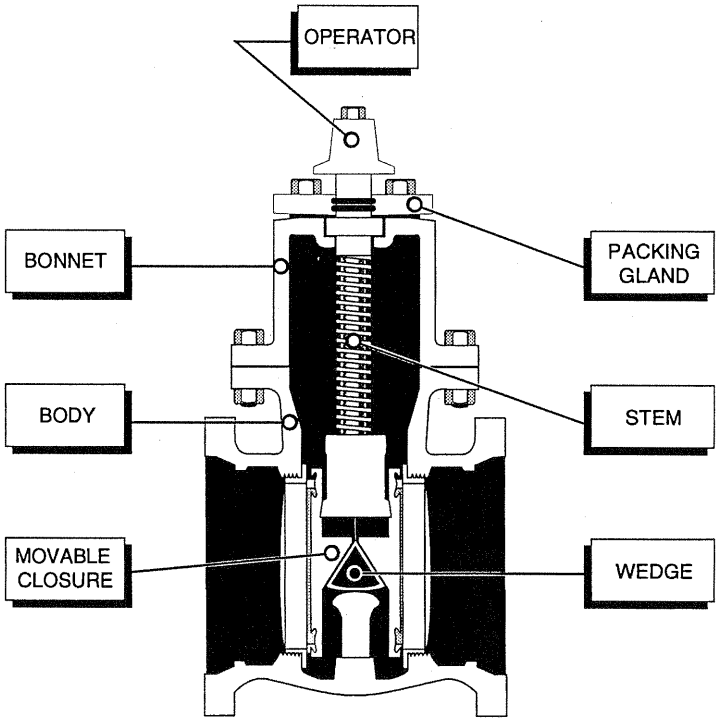


Resilient-Seated Gate Valve
Courtesy of Kennedy Valve Mfg. Co., Inc.

DOUBLE DISK GATE VALVE

Most Common

One of the oldest and most common valves found in water systems is the double disk gate valve. This valve is used under normal on and off control conditions.



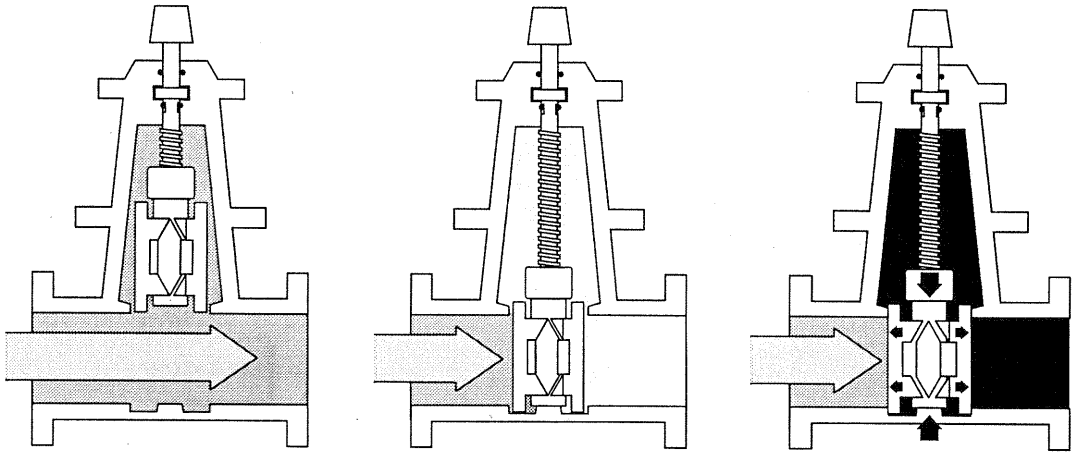
Components

Double disk gate valve bodies are available in PVC, brass and cast iron. In sizes larger than 3 inch cast iron is the most common. The body contains the two brass valve seats set parallel to one another. The uniqueness of this valve is the movable closure. The closure is made of two parallel disks separated by some type of wedging device. A standard brass stem is used to move the closure up and down between the body and the bonnet. Leakage around the stem is control by packing or "O" rings.

Operation

When the valve is in an open position the double disks are completely out of the flow path and stored in the bonnet. As the valve approaches closure a rise in the casting at the bottom of the valve is forced against some type of wedging assembly that is between the two disk. The wedge assembly pushes the two disk against their respective seats. Twisting on the stem places pressure on the top and bottom of the wedge forcing the disk against the seats. The wedge assembly design is unique for each manufacturer.

Operation sequence of double disk gate



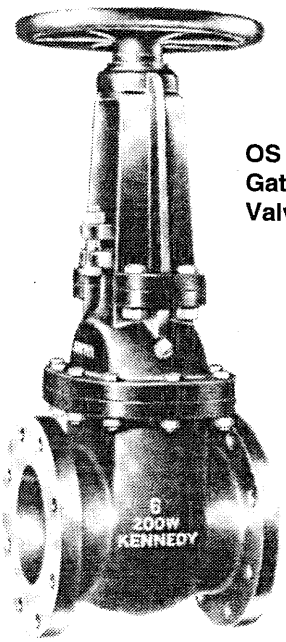
Warning

Notice that at the bottom of the body there is a channel. This channel can fill with silt. When closing the valve, if it does not stop the flow of water, back off on the stem, raise the closure and allow the flow of water under the closure to remove the silt. If after several up and down actions, the silt is not cleared then no further improvement in flow control can be made. Over tightening the stem can bend the disk and cause the leakage to increase.

Two Types

There are two general types of double disk gate valves, rising stem and non-rising stem. The gate previously discussed was a non-rising stem. This type of valve is usually placed underground. In valve pits and pumping stations, rising stem gate valves called, OS & Y (Outside Stem and Yoke) are usually used. This is because it is easy to determine the valve position by

visual observation. With the OS & Y valve the stem is threaded through a collar placed at the top of the yoke.



OS & Y Gate Valve

INLET CONNECTION TO GATE VALVES

Less than 2 inch

In gate valves less than two inch the inlet connections are basically limited to threaded, glued and soldered.

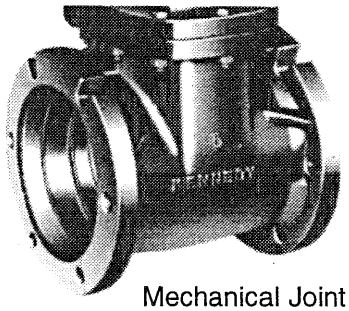
Larger than 2 inch

With valves larger than two inch the inlet connections available include;

- Threaded
- Hub for DCIP, PVC and AC
- Mechanical Joint
- Flanged
- Victaulic
- Dresser connection
- Spigot

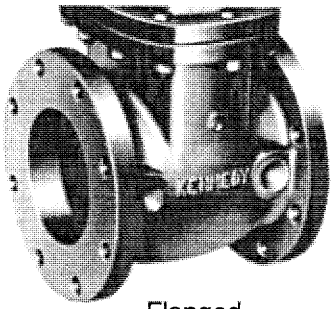
Gate valve are also available in a combination of any of the two common connections. A flange by mechanical joint gate valve is a very common device for connecting a fire hydrant to a flanged tee.

Hub for DCIP

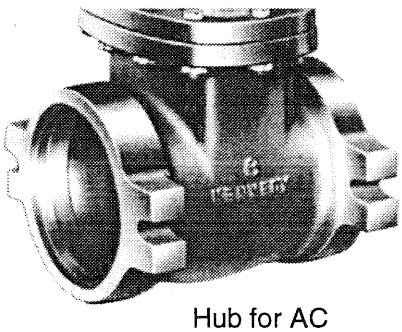


Mechanical Joint

Gate Valve inlet connections



Flanged

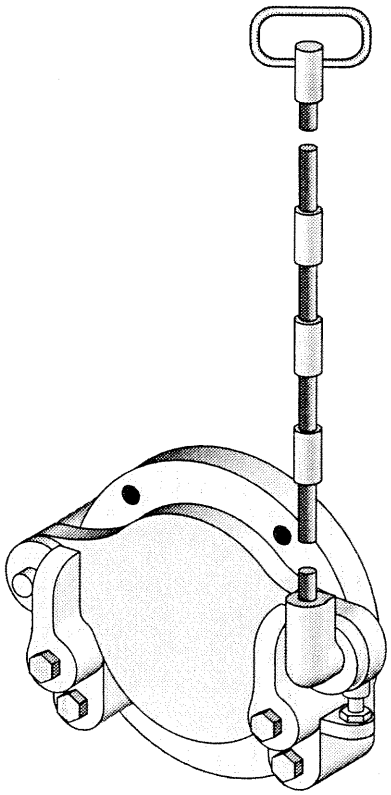


Hub for AC

SHEAR GATES

Use

Shear gates are used to control flow through channels, such as inlet screen boxes or other conditions where being water tight is not a requirement. These devices function best in low pressure conditions.

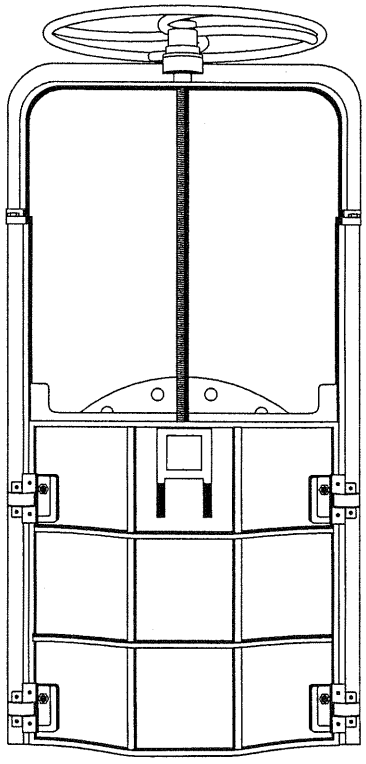


Components

The shear gate valve is a simple device composed of a cast iron body that is attached to a foundation such as concrete screen box. The cast iron closure is hinged on one side to the body. An operator, usually a rod with a handle is connected to the other side of the closure.

Operation

To close the valve the operator has to lower the free side of the closure into a wedge shaped slot. Forcing this arm into the slot on the body closes the valve.



SLIDE GATES

Use

Slide gates are also called sluice gates and are used like the shear gates to control flows where a water tight condition is not required. Typical uses are inlets and outlets to screen boxes at surface water intakes.

Components

The shear gate is a simple device composed of a steel or cast iron body that is fastened over an opening on a surface such as a concrete screen box. The movable

closure is usually made of cast iron and can be round or rectangular. The closure is supported on the sides by wheels that run in tracks. A threaded stem extends upward from the body through a threaded collar that is secured in a yoke and then through the operator. The most common operator is a hand wheel. At large plants the hand wheel is replaced with an electrically operated device.

Operation

As the hand wheel is rotated the stem is threaded though the yoke and the wheel. The stem and gate are raised up out of the flow.

Special Consideration

It is important that the threaded collar, stem and track be lubricated with a water resistant grease.

BUTTERFLY VALVES

Two Types

There are two types of butterfly valves: those with a resilient face on the movable closure and those with a resilient face in the valve body.

Advantages

The major advantage to using a butterfly valve is the ease of opening the valve under pressure. It is easier to move and requires far fewer turns than a gate valve.

Disadvantage

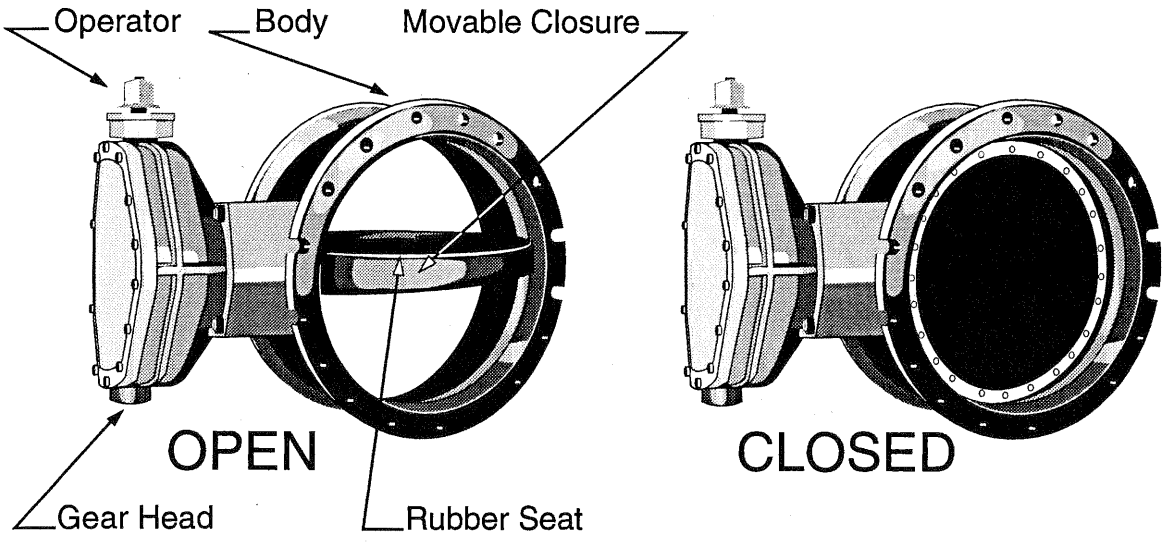
The major disadvantages to using butterfly valves is they provide a restriction of the flow path and thus higher headloss than a gate valve. Under high velocity conditions the movable closure can vibrate causing excessive water hammer.

Uses

Butterfly valves can be used in most conditions calling for on/off control and throttling. The exceptions are they should not be used on the lead to a fire hydrant or the suction side of a end-suction centrifugal pump.

Components

The butterfly valves most commonly used in water systems use a cast iron body and cast iron movable closure. There is a resilient face either on the body or closure. A gear head is used to transfer energy from



the operator to the stem. A one quarter rotation of the stem moves the valve from full open to full close. Typical operators include 2 inch square nuts, hand wheels, electric motors, pneumatic and hydraulic rams.

Operation

The operation of the butterfly valve is relatively simple. A 1/4 turn of the shaft moves the closure from full open to full closed. When the valve is in the full open position the closure is in line with the flow. When closing a butterfly valve they have a tendency to vibrate during the last 1/4 to 1/3 of the travel of the closure.

Flow Control

Other than in the first 1/4 to 1/3 of the travel of the closure the butterfly valve can be used for flow control. This gives it an advantage over the gate valve. The gate valve should never be used for flow control. The movable closure will rattle against the seat and wear a groove in the disk and the seat.

INLET CONNECTIONS ON BUTTERFLY VALVES

Larger than 2 inch

With valves larger than two inch the inlet connections available include:

- Threaded
- Hub for DCIP, PVC and AC
- Mechanical Joint
- Flanged
- Victaulic
- Wafer - a special joint that allows the valve to be placed between two flanges
- Spigot

Butterfly valves are also available in a combination of any of the two common connections.

BALL VALVES

Use

Ball valves are used in small systems and are primarily used on chemical lines, pressure gauges, water service lines and occasionally used as flow and surge control valves on the discharge of a pump.

Advantages

The major advantage offered by the ball valve is the lack of restriction when open. The second advantage is the short on off movement. One quarter turn of the shaft provides complete open or closed action.

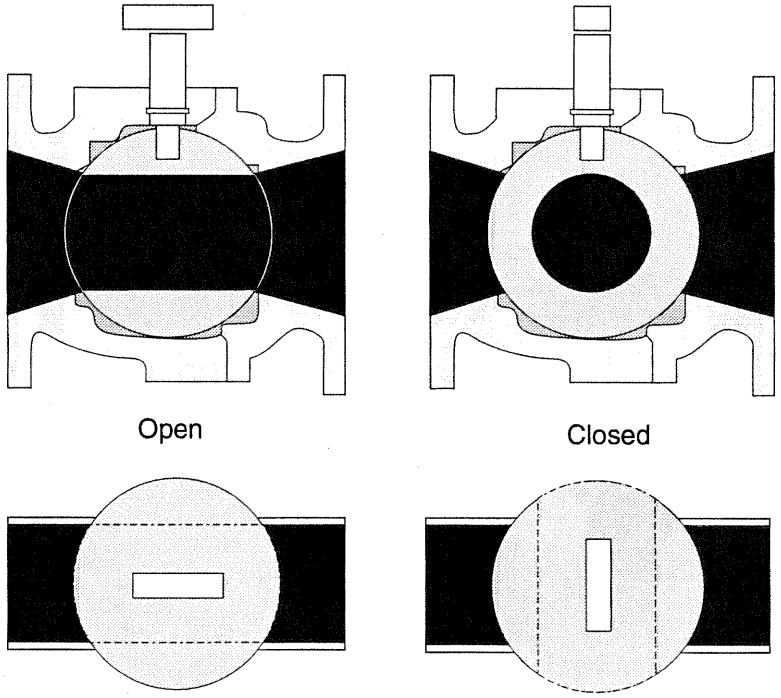
Disadvantage

The major disadvantage to using ball valves is their cost, especially in large (4 inch and up) sizes.

Components

Ball valves are available with PVC and brass bodies. In large diameters cast iron is also available. The movable closure is perfectly round with a hole through the center and is usually made of the same material as the body. With some valves a bearing and/seat arrangement is supplied made of Teflon or some type of resilient material. In smaller valves water tightness is obtained by the tolerance between the closure and the body. The stem is usually made of the same material as the closure. On most valves some type of bonnet is supplied that holds pressure on an "O" ring that is used to control leakage around the shaft. The operator is commonly a straight or "Tee" handle. On larger valves the operator my be electric, pneumatic or hydraulic.

Ball Valve Operating Sequence



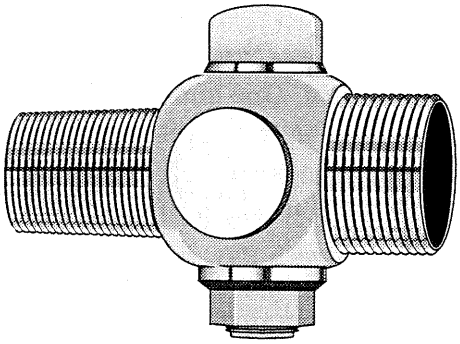
Operation

The operation of a ball valve is simple, a one quarter turn of the stem moves the closure from full open to full closed.

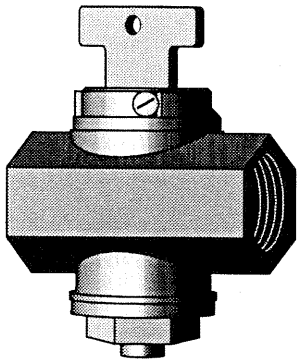
PLUG VALVES

Use

Plug valves used in small water systems are primarily limited to brass curb stops, corporation stops and angle stops.



Corp Stop



Curb Stop

Advantages

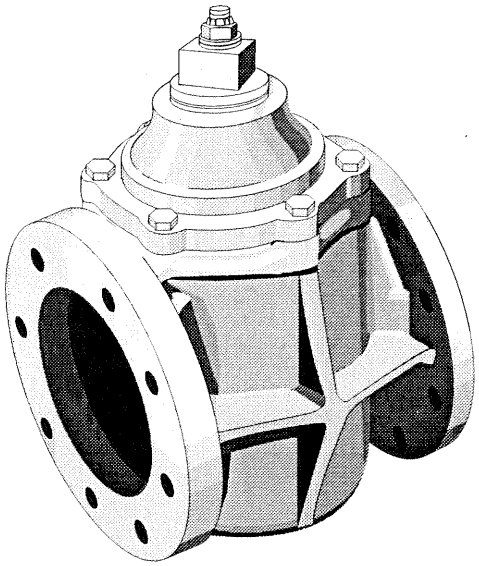
The major advantages to the plug valve are the lack of restriction to flow and the short on off action.

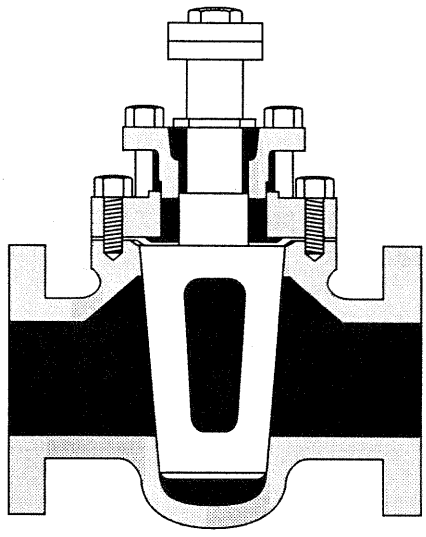
Disadvantages

The disadvantages include high cost in large sizes and difficulty in moving the closure.

Components

While plug valves can be purchased with cast iron bodies, the ones used in water system service lines are made of brass. The closure is made of the same material. Water leakage between the two components is a result of the close fit between them and a wedging like action. In recent years some manufacturers have developed plug valves with "O" ring seals making operating the valve much easier.





Plug valve in closed position

Operation

The plug valve is operated by using the operator to move the closure 1/4 turn from full open to full closed.

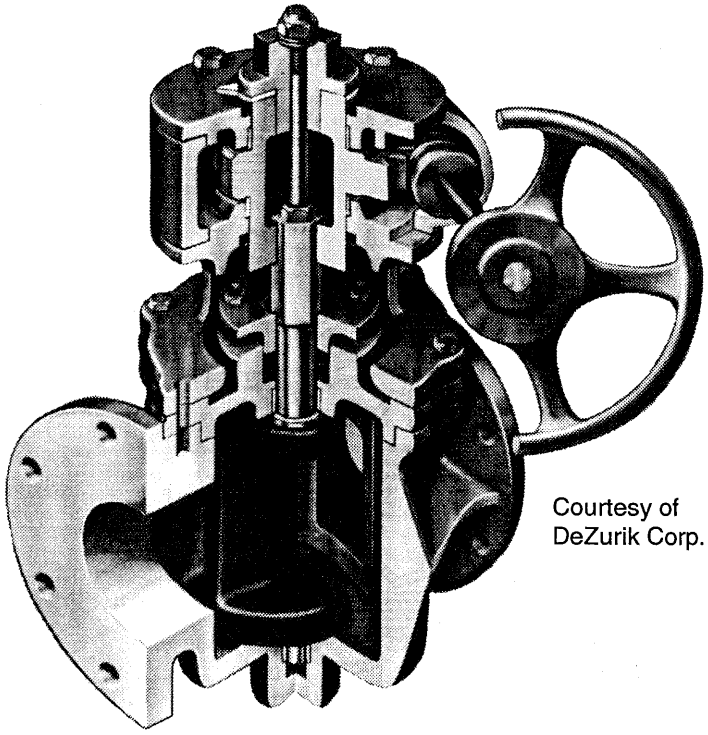
ECCENTRIC VALVES

Use

Eccentric valves are not very common in small water systems and are used to control flow in a single direction.

Components

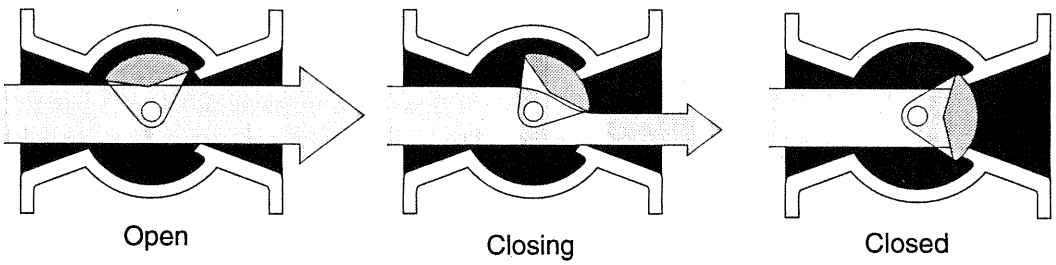
The most common body on eccentric valves is made of cast iron. The movable closure is a single disk also made of cast iron. A **stuffing box**[7] area controls leakage from around the stem. Most eccentric valves use a geared head to reduce the force required to operate the closure.



Courtesy of DeZurik Corp.

Operations

The eccentric valve uses a 1/4 turn on the movable closure shaft to move the closure from full open to full closed. In the closed position, pressure inside the valve body helps seal the disk against the body.



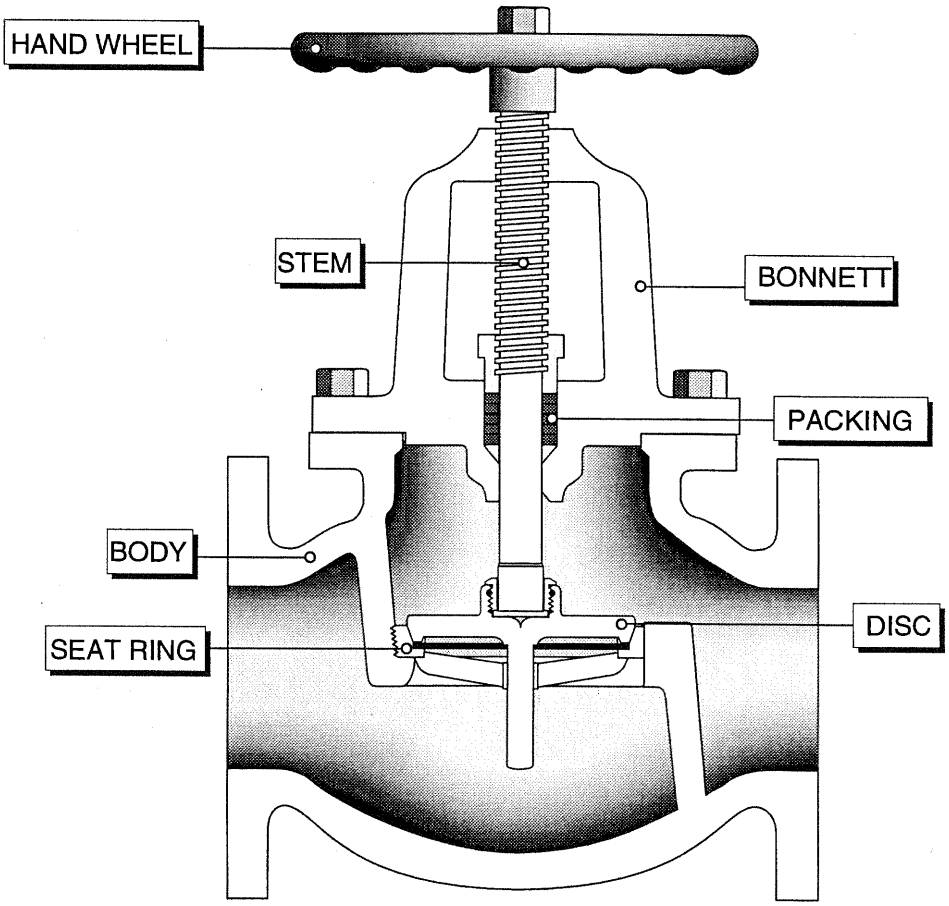
Eccentric Valve Operation

[7] **Stuffing Box** - That portion of a valve which houses the packing or "O" rings used to control leakage around the shaft.

GLOBE VALVES

Use

Globe valves are used for on & off as well as flow and pressure control. A hose bib is a globe valve. They function best when handling flow in one directly only. Their biggest disadvantage is their high headloss.



Flow Control

Their major advantage is their ability to provide precise flow control without damage to the valve.

Components

The most common globe valves used in small water systems have a body made of cast iron or brass. The movable closure is usually brass or stainless steel. In very small globe valves, such as hose bibs the closure is made of a resilient material. The closure seats against a seat commonly made of brass. A stem usually made of high carbon steel or stainless steel is attached to the closure and exits the valve through the bonnet. Leakage is controlled around the stem with packing or Teflon rings. The operator mechanism is commonly a hand wheel on small valves and a hydraulically operated diaphragm on large valves.

Operation

Flow is up through the valve. Rotating the wheel forces the stem and closure toward the seat closing off the flow. This type of valve is a rising stem valve.

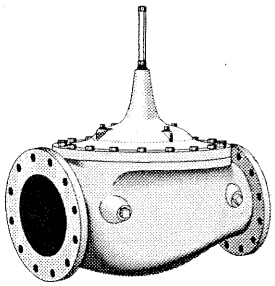
FLOW CONTROL, PRESSURE CONTROL AND SURGE CONTROL

Common Valves

Flow, pressure and surge control is provided using wide body globe valves. In some instances butterfly and ball valves are used for surge and flow control. This portion of the module will be dedicated to the two most common control valves used in rural Alaska, Ross and Cla-val. Both are wide body globe valves. By wide body we mean that the valve body is larger than normal. This is done to reduce headloss and provide more precise control of flow and pressure.

WIDE BODY GLOBE VALVES

Components

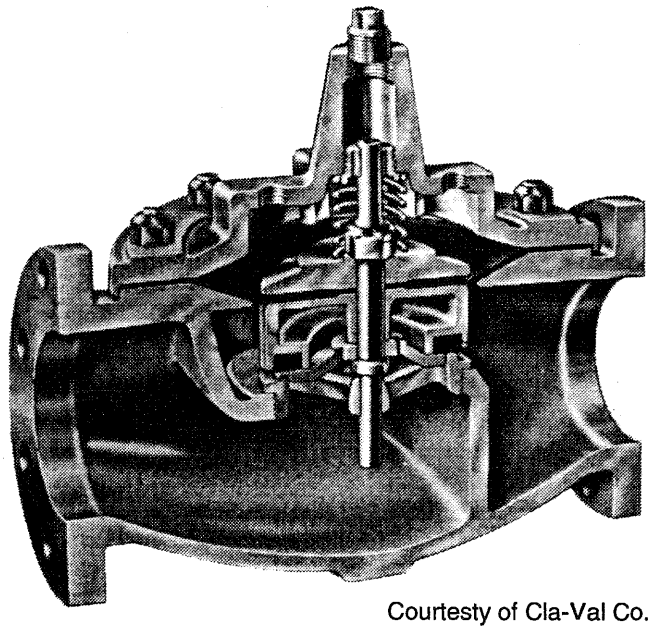


These valves primarily use a cast iron body. The movable closure may contain a resilient face. The seat may be bronze, stainless steel or resilient faced. A stem travels from the movable closure to a diaphragm. A control chamber is designed above the diaphragm and into the bonnet. In some cases an indicator rod extends from the diaphragm, through the bonnet to the outside. Control of leakage around the stem is provided with packing or Teflon "V" rings. In some cases control valves, pilot valves and related piping are used to control the functions of the valve.

PRESSURE REDUCTION

Content

Because the configuration of pilot valves and piping is varied when using a valve for flow or surge control, we have selected pressure reduction as the process to be used to explain the operating function of wide body control valves. This process was selected because it is the most common use of these valves in rural Alaska.



Courtesy of Cla-Val Co.

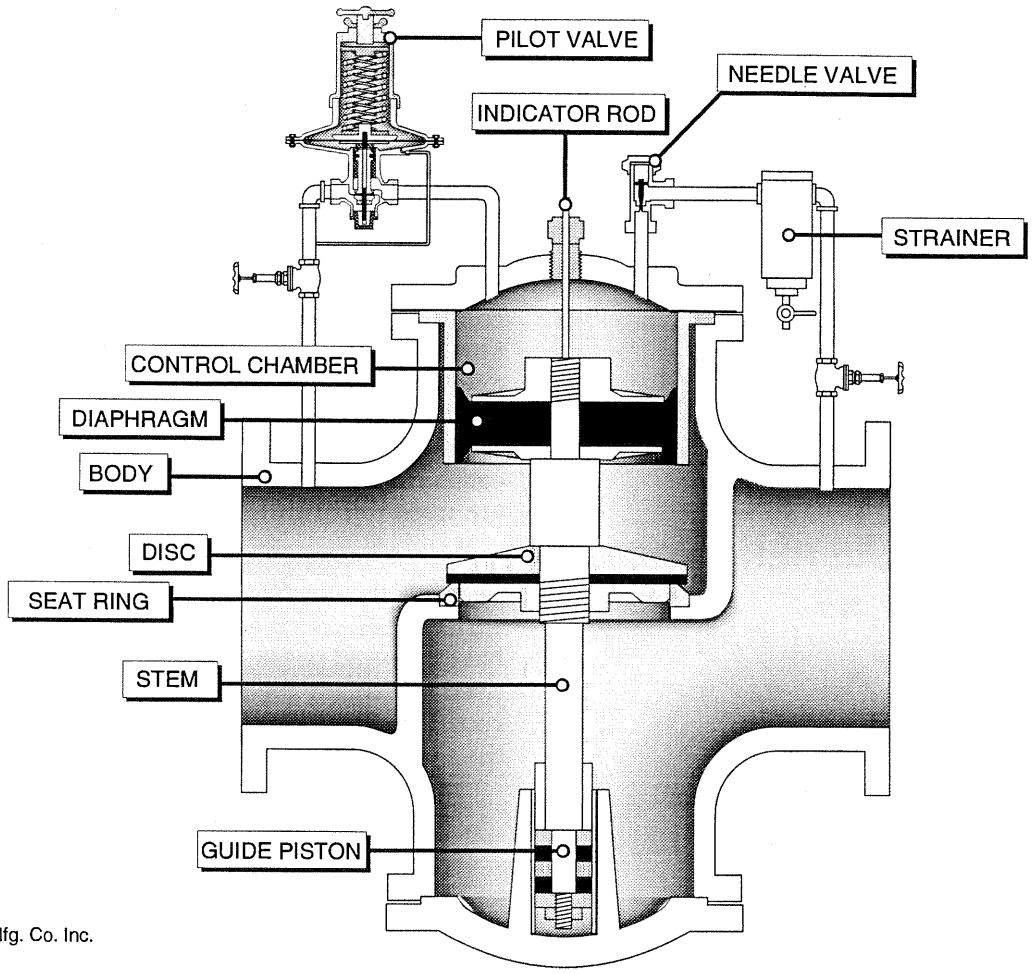
OPERATION OF THE ROSS 40WR

Use

The Ross 40WR is a pilot controlled valve used to control large quantities of water and is available in sizes from 4 inches through 30 inches.

Components

The valve is composed of a movable closure (disc), diaphragm, pilot valve and needle valve.



Ross 40WR
Courtesy of Ross Valve Mfg. Co. Inc.

GENERAL OPERATION

Diaphragm Position

By changing the pressure in the chamber above the diaphragm the position of the closure can be controlled. This position can be varied to provide a set downstream pressure over a wide variety of flows.

Needle valve

The needle valve is used to control rate of change or closure of the valve. The rate of movement of the valve can be increased by turning the needle counterclockwise. The needle valve is also used to restrict the rate of flow into the chamber.

Strainer

A strainer is placed in the needle valve line to protect the needle valve.

Pilot Valve

The pilot valve is used to control downstream pressure.

CONTROL PROCESS

No Control

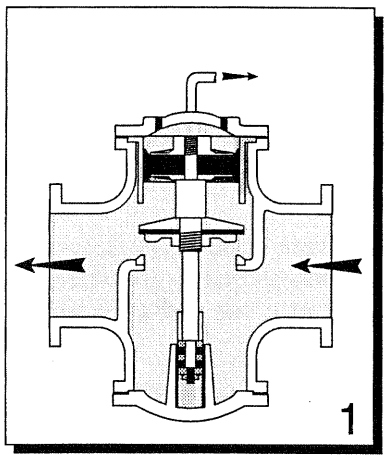
It is easiest to understand the function of this valve by following a theoretical sequence of events. With no pressure applied to the control chamber the upstream water pressure will push the valve open (#1).

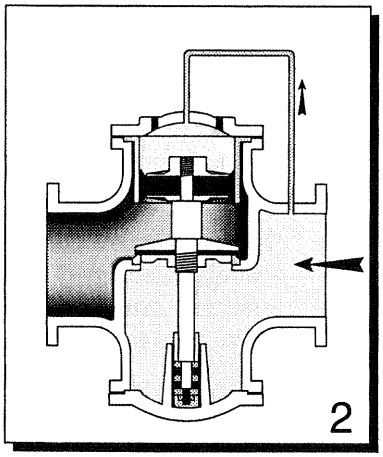
Use Upstream pressure

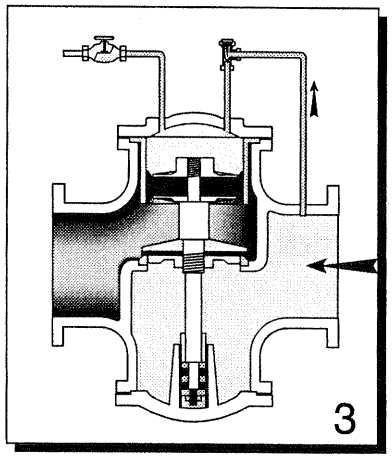
If the pressure upstream of the valve was applied to the chamber above the diaphragm, this pressure would force the diaphragm down and the valve closed (#2).

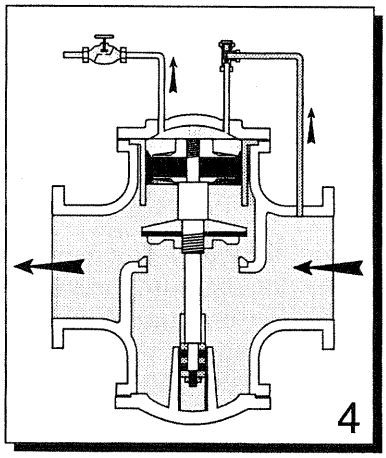
Release Pressure

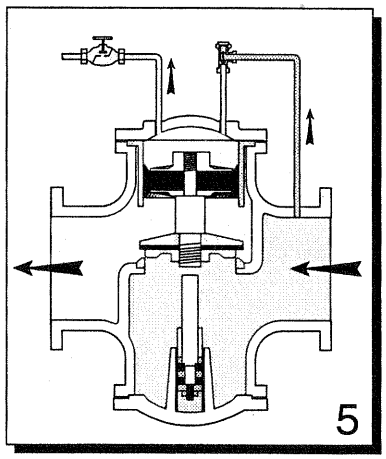
If a flow restrictor were placed in the upstream line an a valve connected to a line in the chamber and vented to waste the position of the valve could be adjusted (#3). To open the valve, the exhaust valve would need to be opened so that the rate of water exiting the chamber exceeded the rate it was entering the chamber (#4). When we wish the valve to close, all that is necessary is to close the exhaust valve. Pressure in the chamber will increase and the valve will close (#5).





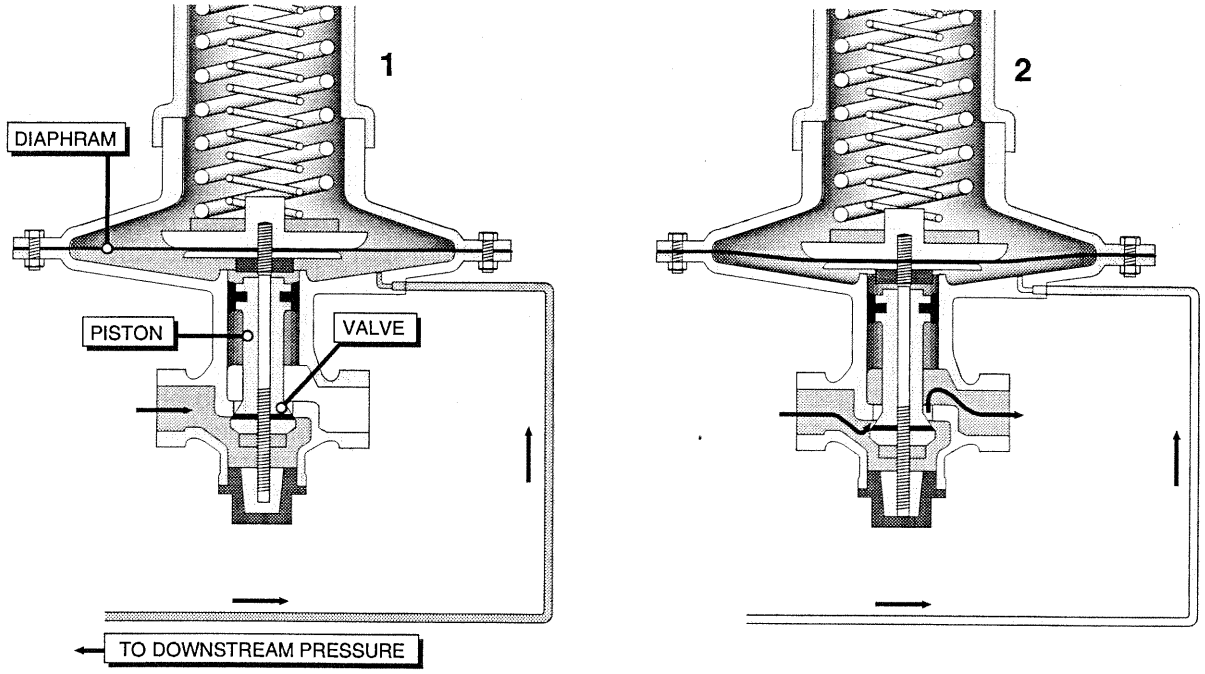






Replace Gate with Pilot

If the valve were replaced with a pilot valve this process could become automatic. The pilot valve is connected to the chamber and the downstream pressure is applied to the bottom of the pilot valve diaphragm.



This is done through the hollow shaft of the valve. The pressure under the diaphragm is counteracted by the spring pressure above the diaphragm. By adjusting the tension on the spring the downstream pressure can be adjusted.

Adjusting Pressure

The pilot valve controls the rate that water flows out of the chamber and thus the downstream pressure. Assume that the valve is set at a set pressure and flow. This is called a set point.

Flow Demand Decreases (1)

If the flow demand downstream is reduced the downstream pressure will increase. This increase in pressure will be applied to the bottom of the pilot valve diaphragm pushing it up. This closes the pilot valve, restricting flow from the pressure chamber of the main valve. The result is an increase in pressure in the pressure chamber causing the valve to move in the closed position. In turn, the downstream flow is restricted and the downstream pressure reduced to the set point.

Flow Demand Increase (2)

As the demand for water downstream of the valve increases, the downstream pressure would drop. This would release pressure under the diaphragm on the control valve. The spring would push the valve down opening the pilot valve. With the pilot valve opened the pressure in the chamber above the diaphragm of the main valve will be reduced allowing the main valve to open, supplying downstream demands and raising the downstream pressure.

Adjusting Downstream Pressure

To increase the downstream pressure turn the pilot valve control counterclockwise.

OPERATION OF THE ROSS 23WR

Use

The Ross 23 WR is a pilot controlled valve used to control small quantities of water and is available in sizes from 1 1/2" inches through 3 inches.

Components

The valve is composed of a movable closure, diaphragm, pilot valve and restriction orifice located in the bottom of the stem of the main valve.

GENERAL OPERATION

Diaphragm Position

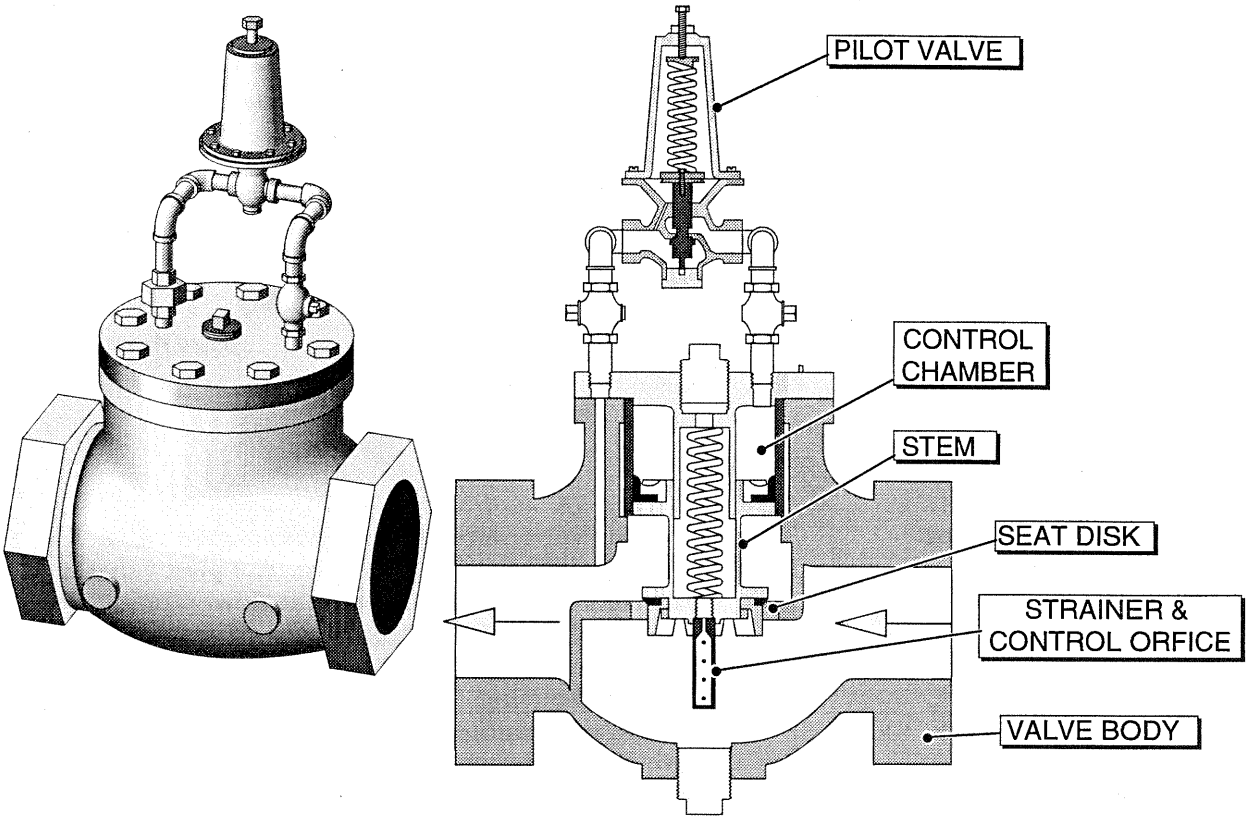
By changing the pressure in the chamber above the main valve diaphragm the position of the closure can be controlled. This position can be varied to provide a set downstream pressure over a wide variety of flows.

Orifice valve

The orifice in the main valve stem is used to restrict the rate of flow into the chamber.

Pilot Valve

The pilot valve is used to control downstream pressure.



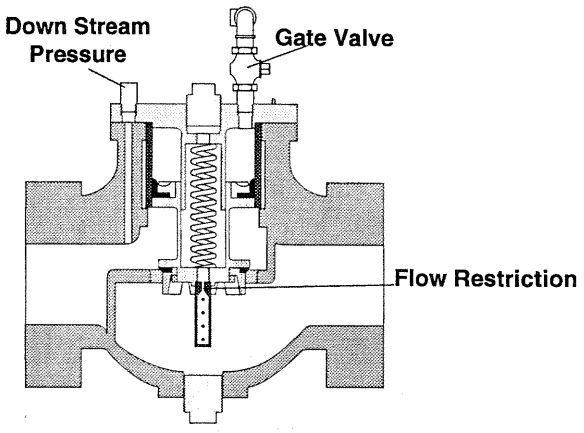
CONTROL PROCESS

Use Upstream pressure

It is easiest to understand the function of this valve by following a theoretical sequence of events. If the pressure upstream of the valve were applied to the chamber above the diaphragm this pressure would force the diaphragm down and the valve closed. This pressure reaches the top of the diaphragm through the hollow shaft of the valve.

Release Pressure

If a flow restrictor were placed in the upstream line (the orifice in the end of the stem) and a valve connected to a line in the chamber and vented to waste the position of the valve could be adjusted. To open the valve the exhaust valve would need to be opened so that the rate water was exiting the chamber exceeded the rate it was entering the chamber. When we wish the valve to close, all that is necessary is to close the exhaust valve. Pressure in the chamber will increase and the valve will close.



Replace Gate with Pilot

If the gate valve were replaced with a pilot valve this process could become automatic. The pilot valve is connected to the chamber and the downstream pressure is applied to the bottom of the pilot valve diaphragm. This is done through the passage in the pilot valve housing. The pressure under the diaphragm is counteracted by the spring pressure above the diaphragm. By adjusting the tension on the spring the downstream pressure can be adjusted.

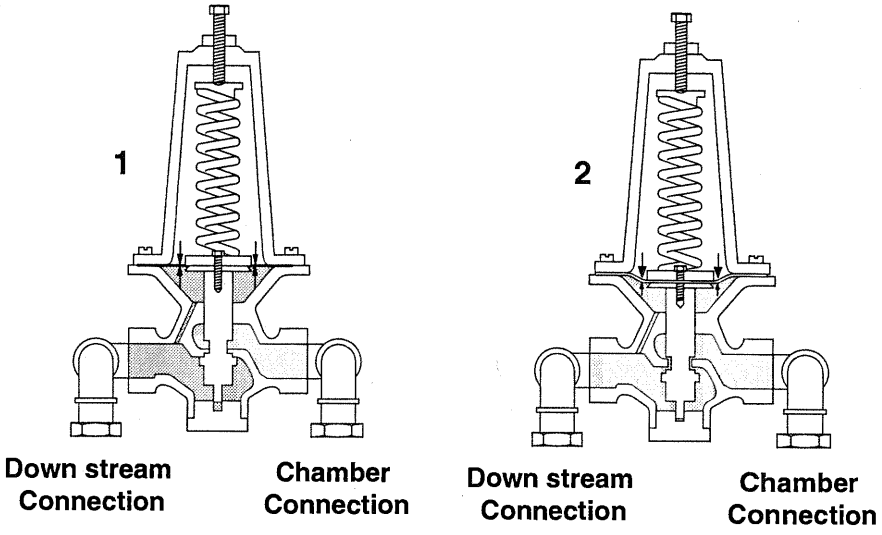
Adjusting Pressure

The pilot valve controls the rate that water flows out of the chamber and thus the downstream pressure. Assume that the valve is set at a set pressure and flow. This is called a set point (#1).

Flow Demand Increase

As the demand for water downstream of the valve increases the downstream pressure would drop (#2). This would release pressure under the diaphragm on the control valve. The spring would push the valve down opening the pilot valve. With the pilot valve opened more pressure in the chamber above the

diaphragm of the main valve will be reduced allowing the main valve to open, supplying downstream demands and raising the downstream pressure.



Flow Demand Decreases

If the flow demand downstream is reduced the downstream pressure will increase. This increase in pressure will be applied to the bottom of the pilot valve diaphragm pushing it up. This closes the pilot valve, restricting flow from the pressure chamber of the main valve. The result is an increase in pressure in the pressure chamber causing the valve to move in the closed position. In turn, the downstream flow is restricted and the downstream pressure reduced to the set point.

Adjusting Downstream Pressure

To increase the downstream pressure turn the pilot valve control counterclockwise.

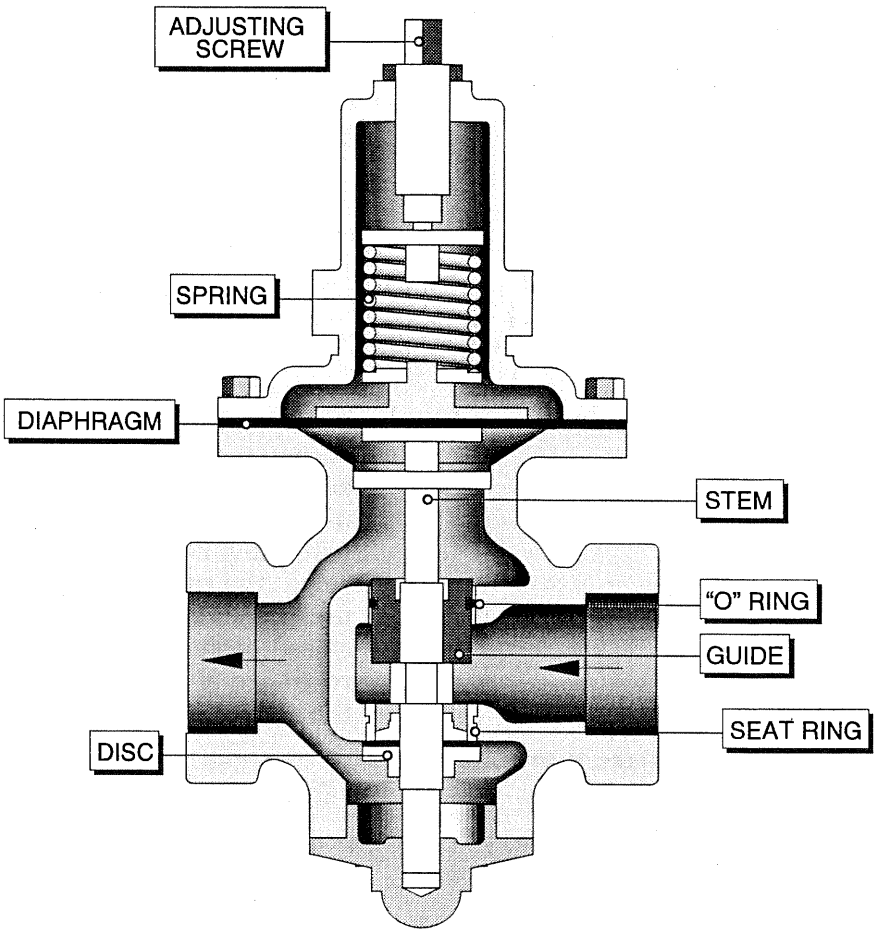
OPERATION OF THE ROSS DIRECT ACTING 82 EP

Use

The Ross 82EP is a direct acting valve used to control small quantities of water and is available in sizes from 2 inches through 3 inches.

Components

The valve is composed of a movable closure, diaphragm and spring.



Normal Operations

The valve position (set point) is held by a balance between the downstream pressure pushing up on the diaphragm and the spring pushing down.

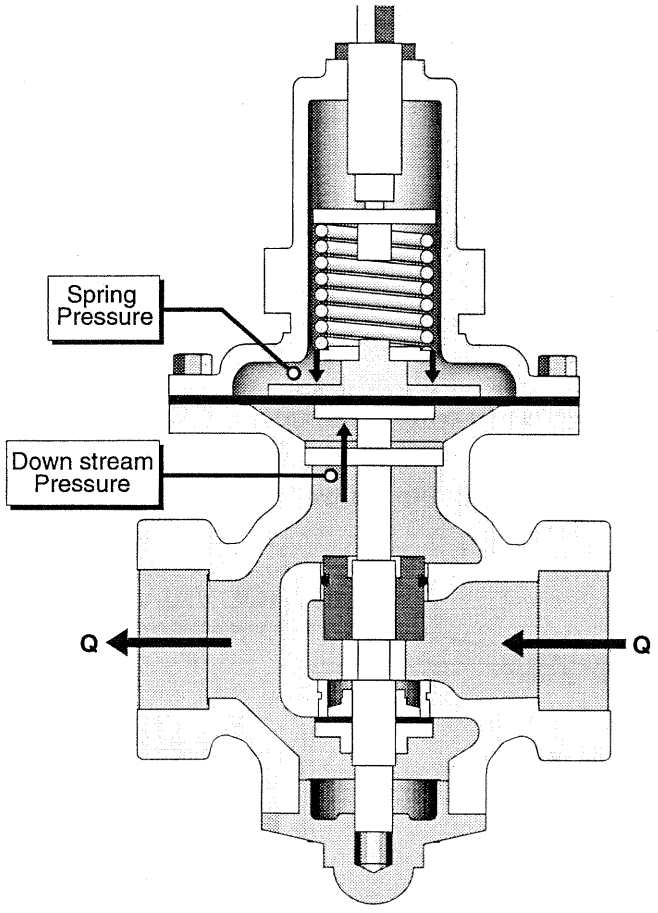
Drop in Pressure

Should the downstream pressure drop as a result of an increase in demand, the pressure under the diaphragm would be reduced. This will allow the spring to push the stem down further opening the main valve and supplying water downstream to meet the demand. The result will be an increase in pressure back to the set point.

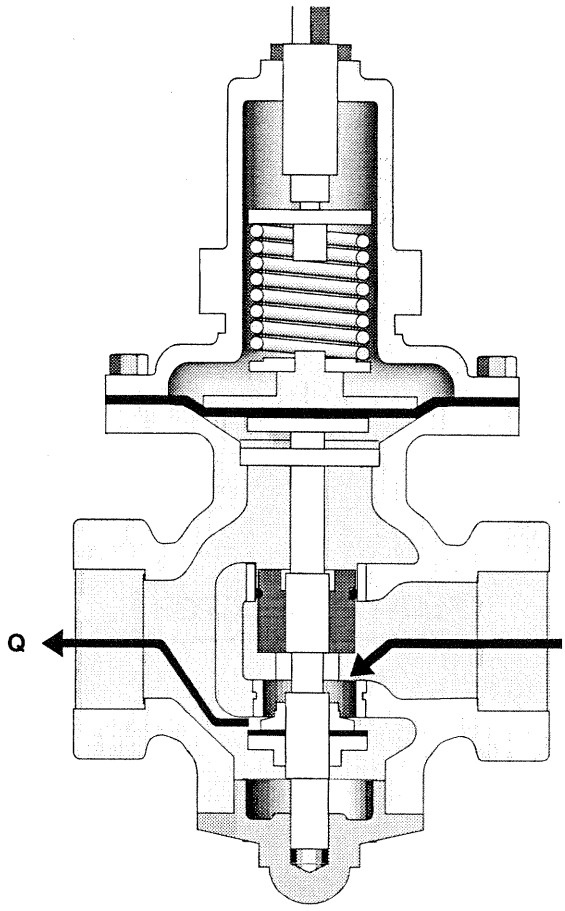
Increase in Pressure

Should the downstream demand drop thus increasing the downstream pressure, this pressure would be applied to the bottom of the diaphragm counteracting the spring. The diaphragm and the stem would be pushed upward. This would further close the valve

and reduce downstream flow and pressure to the set point.



Valve in Closed Position



Valve in Operating Position

CLA-VAL

Use

The cla-val is used to for pressure reduction in sizes from 2 inch through 30 inch.

Components

The major components are the wide body globe valve, the main valve diaphragm, a flow restrictor and pilot valve.

GENERAL OPERATION

Diaphragm Position

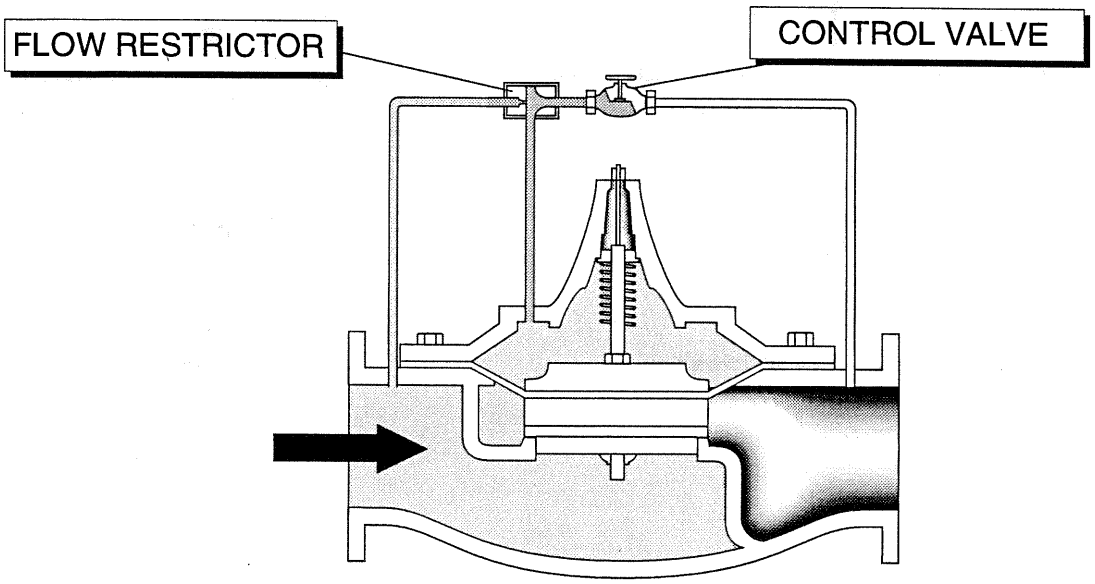
By changing the pressure in the chamber above the main valve diaphragm the position of the closure can be controlled. This position can be varied to provide a set downstream pressure over a wide variety of flows.

Flow Restrictor

A flow restrictor in the line leading between the upstream pressure and the main valve pressure chamber is used to restrict the rate of flow into the chamber.

Pilot Valve

The pilot valve is used to control downstream pressure.



CONTROL PROCESS

Use Upstream pressure

It is easiest to understand the function of this valve by following a theoretical sequence of events. If the pressure upstream of the valve were applied to the chamber above the diaphragm this pressure would force the diaphragm down and the valve closed. This pressure reaches the top of the diaphragm through the hollow shaft of the valve.

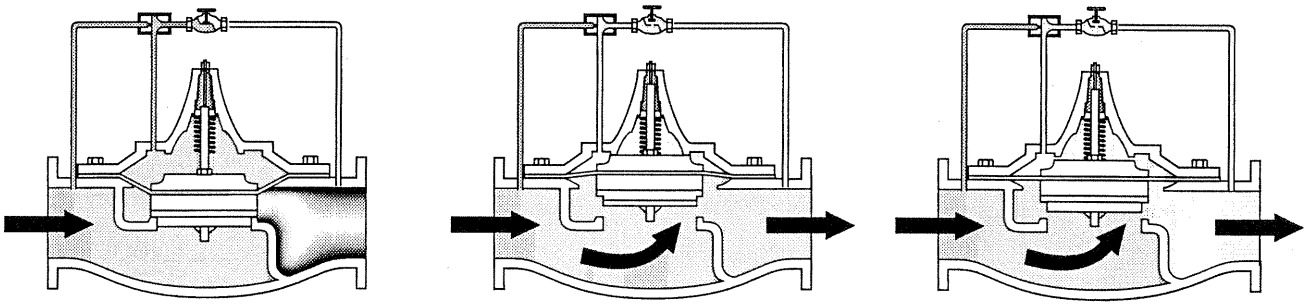
Release Pressure

If a flow restrictor were placed in the upstream line and a valve connected to a line in the chamber and vented to waste the position of the main valve could be adjusted. To open the valve the exhaust valve would need to be opened so that the rate water was exiting the chamber exceeded the rate it was entering the

chamber. When we wish the valve to close, all that is necessary is to close the exhaust valve. Pressure in the chamber will increase and the valve will close.

Replace Gate with Pilot

If the gate valve were replaced with a pilot valve this process could become automatic. One side of the pilot valve is connected to the chamber and the other to the downstream pressure. This downstream pressure is applied to the bottom of the pilot valve diaphragm. The pressure under the diaphragm is counteracted by the spring pressure above the diaphragm. By adjusting the tension on the spring the downstream pressure can be adjusted.



VALVE CLOSED VALVE OPEN VALVE REGULATING PRESSURE

Adjusting Pressure

The pilot valve controls the rate that water flows out of the chamber and thus the downstream pressure. Assume that the valve is set at a set pressure and flow. This is called a set point.

Flow Demand Increase

As the demand for water downstream of the valve increases the downstream pressure would drop. This would release pressure under the diaphragm on the control valve. The spring would push the valve down opening the pilot valve. With the pilot valve opened the pressure in the chamber above the diaphragm of the main valve will be reduced allowing the main valve to open, supplying downstream demands and raising the downstream pressure.

Flow Demand Decreases

If the flow demand downstream is reduced the downstream pressure will increase. This increase in pressure will be applied to the bottom of the pilot valve diaphragm pushing it up. This closes the pilot valve, restricting flow from the pressure chamber of the main valve. The result is an increase in pressure in the pressure chamber causing the valve to move in the closed position. In turn, the downstream flow is restricted and the downstream pressure reduced to the set point.

Adjusting Downstream Pressure

To increase the downstream pressure turn the pilot valve control clockwise.

REVERSAL OF DIRECTION

Common Valves

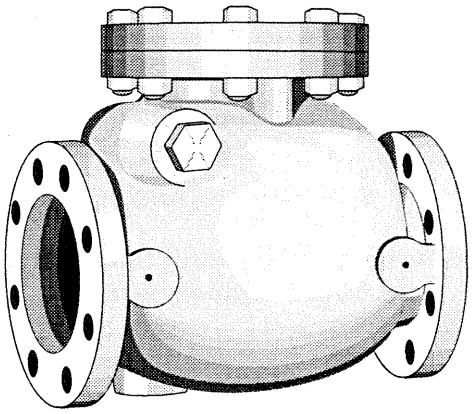
The common valves used to control reversal of direction are foot valves, swing check valves, wafer check valves and silent check valves.

Simple Design

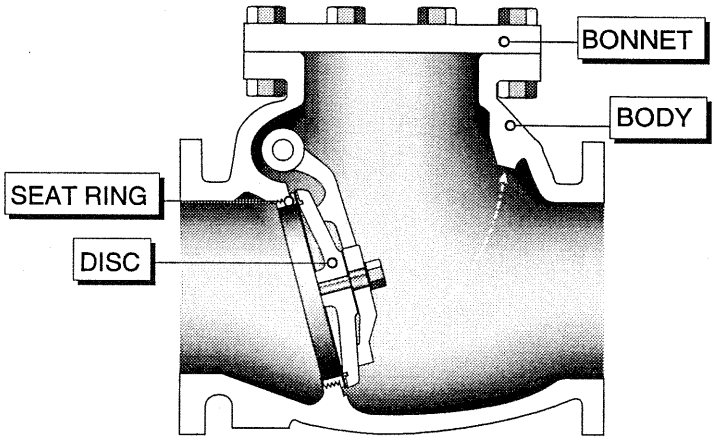
Each of these valves is rather simple in design. They all have a movable closure that is controlled by flow. When there is a reversal of flow the water itself forces the valve closed.

Swing Check

When flow is stopped with a swing check, the movable closure swings toward the seat. The long travel distance allows it to hit with considerable force. This coupled with the metal to metal contact can produce significant water hammer.

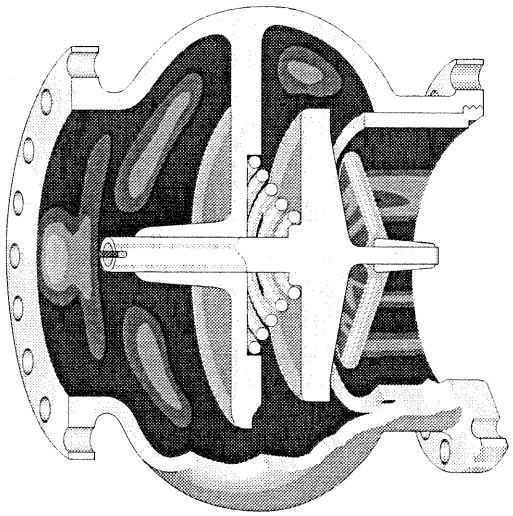


Swing Check



Silent Checks

Silent checks are not really silent but are quieter than standard swing checks. The silent check has less distance for the closure to travel and the resilient seat produce less water hammer than would be produced with a swing check.



STORAGE RESERVOIR DEPTHS

Introduction

The depth of water in a storage reservoir can be controlled by electrodes, pressure sensing devices, float switches, float valves and control valves. When a control valve is used to control the level of water in a reservoir the valve is called an **altitude valve**[8].

Valve Types

There are two general types of valves used to control storage reservoir water level; 1) the angle globe valve with a float for control and 2) a wide body globe valve placed in the inlet or outlet of the reservoir called a altitude valve.

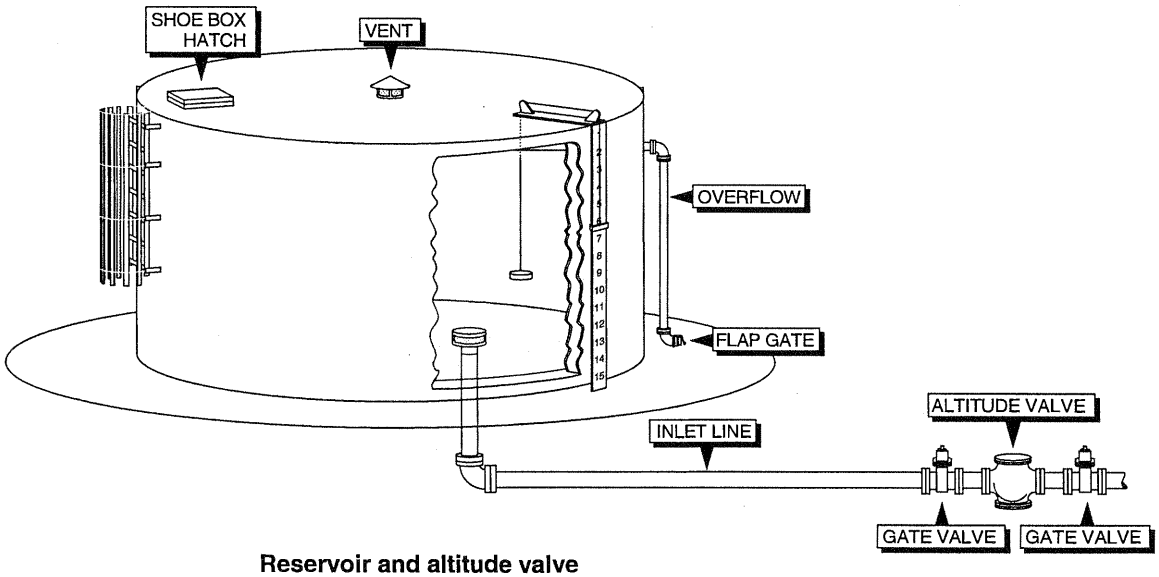
Valve Configurations

The piping and pilot valve configurations used on altitude valves vary greatly based on the reservoir piping system and the water system needs. One manufacturer has four different valve configurations with various alterations to each, making 12 different combinations. Some valves are designed to allow water to only flow in one direction, others in both directions, some for high pressures and some have an additional electric interface.

ALTITUDE VALVES

Content

For our discussion here we will be looking at the simplest and most common of the systems - the single acting altitude valve. This valve is designed to allow water into the reservoir. When the reservoir level drops the valve opens and allows water in. When the reservoir reaches a set level the valve closes. Water is withdrawn from the reservoir through a separate check valve.



Reservoir and altitude valve

[8] **Altitude Valve** - A valve that automatically opens and closes to maintain the level of water in a reservoir. Most commonly a wide body globe valve.

Valve

The valve we have chosen for our discussion is the single acting Ross model 30 AWR.

Components

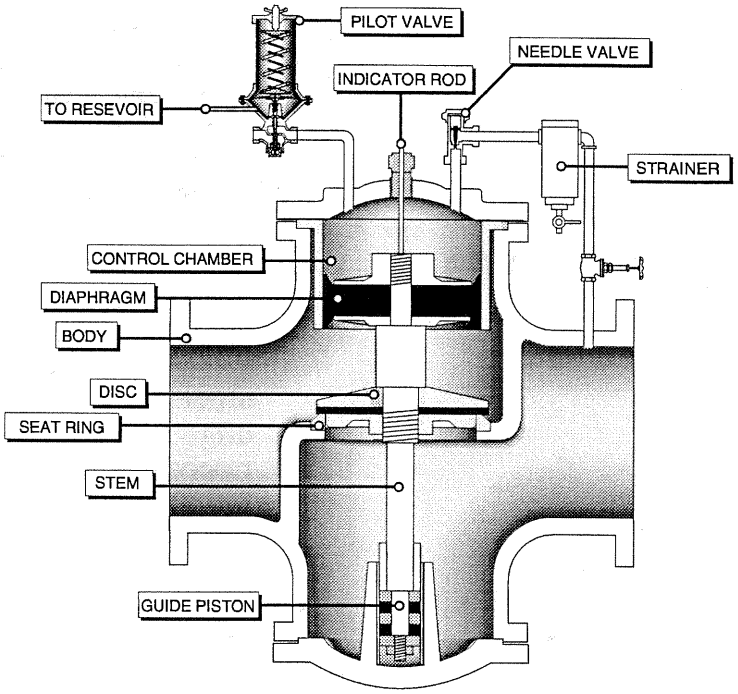
This altitude valve is composed of a diaphragm operated globe valve, needle valve and pilot valve.

Needle Valve

A needle valve is placed in the line leading between the pressure chamber of the main valve and the pilot valve. The needle valve is used to control the rate of opening and closing of the valve.

Piping

The reservoir pressure is piped directly to the underside of the diaphragm of the pilot valve. The main valve pressure chamber is piped through the needle



valve and into the pilot valve. The pilot valve has an opening to waste.

Operation

The valve is not a modulating valve. That is, it is either open or closed. Assume that the valve is open and the reservoir is filling.

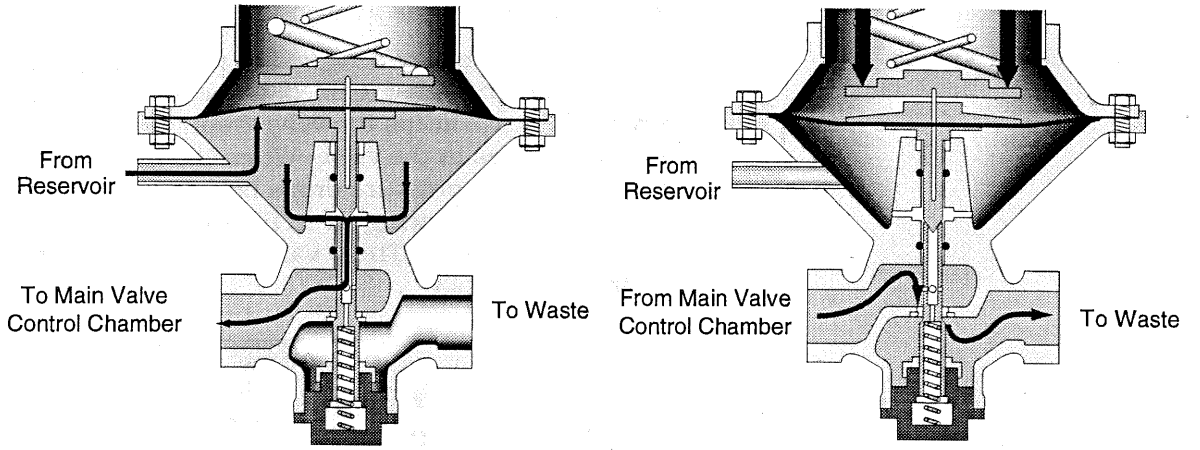
Reservoir Full

When the reservoir has reached its full height the pressure under the pilot valve diaphragm will exceed the spring pressure and force the diaphragm up. This will open the seat between the upper and lower stems of the pilot valve allowing water, under the pressure of the reservoir, to enter the pressure chamber of the main valve pushing the valve in a closed position.

Reservoir Level Falls

When the reservoir level drops to a preset level the pressure under the diaphragm of the pilot valve is no longer able to counteract the spring. This closes the seat between the two pilot valve stems. Water is now channeled from the main valve pressure chamber,

through the hollow stem of the pilot valve and to waste. This releases the pressure in the valve chamber, allowing line pressure to push the main valve open and fill the reservoir.



Reservoir Full - Pressure applied to main valve chamber closing main valve

Reservoir Level Falls - Pressure released from main valve chamber

Operation of pilot valve

FLOAT VALVES

Use

This type of valve is used to control reservoir levels when the inlet pressure is relatively low and a precise level is not required.

Types

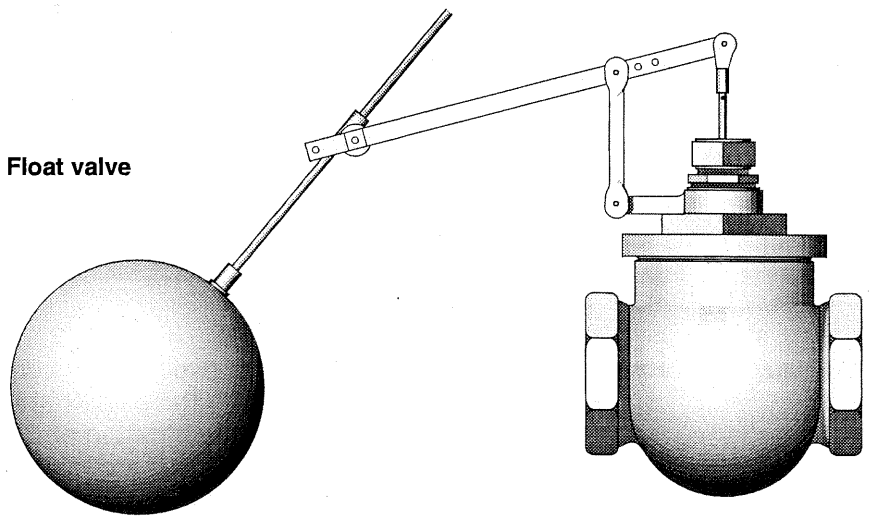
There are two common types of float valves, the wide body globe type previously discussed and the angle globe.

Components

The angle globe valve is composed of a cast iron or bronze body, with a movable closure connected to a stem that exits the bonnet through a stuffing box. The operator is a float attached to a hinge.

Operation

As water level in the reservoir rises the float rises, pushing the valve in the closed position.



Float valve

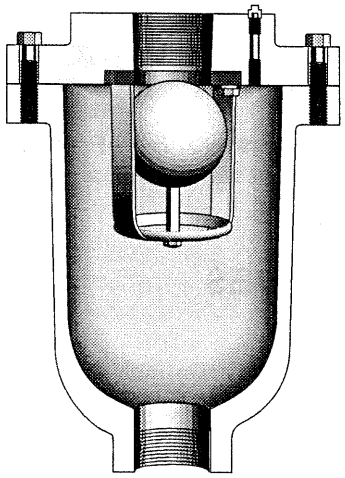
AIR AND VACUUM RELIEF VALVES

Three Types of Valves

There are three common air valves used in a distribution system: air vacuum, air release and combination valves. Each valve has its own unique function.

Air and Vacuum Valves

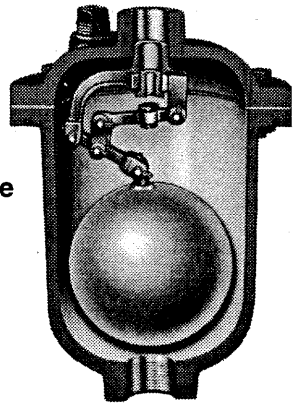
Air vacuum valves are designed to allow the escape of air while the line is being filled. Once filled the pressure in the valve keeps the valve from opening even if air accumulates in the valve. When the line is drained and the internal pressure drops below atmospheric the valve opens allowing air in thus preventing the pipe from collapsing. These valves are also referred to as air relief valves.



Air Vacuum valve

Air Release Valves

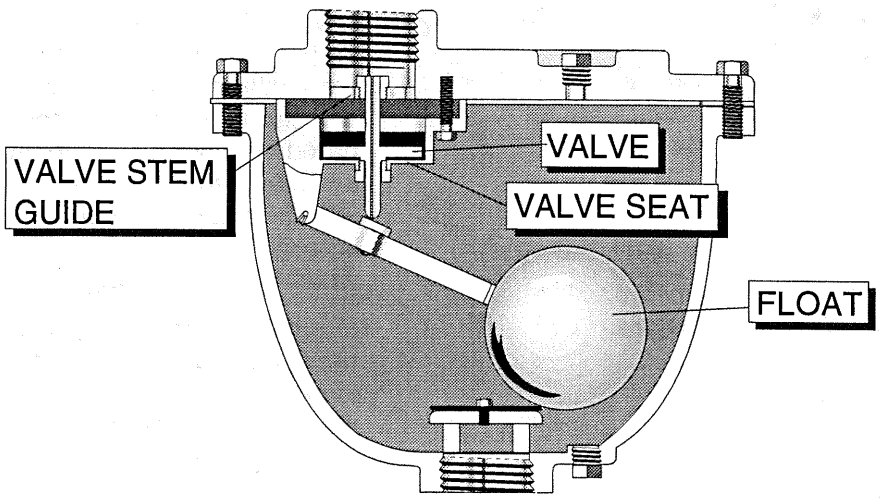
Air release valves are commonly installed at high points in a system and are designed to collect and release air that accumulates in the system. An accumulation of air in a pipe will reduce its flow capacity.



Air Release valve
Courtesy of APCO

Combination Valves

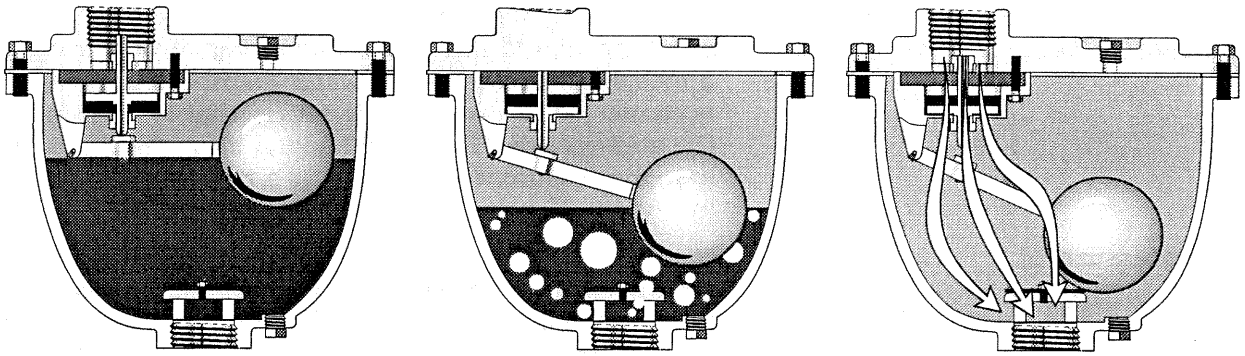
There are two types of combination valves, the most common is the combination of air release and vacuum relief, a combination of the two valves described above and in the diagram to the right. This type of valve is often referred to simply as an air vac valve.



The second combination valve is one designed with two orifices, one for high air flow and one for low air flow. This is a combination air release valve.

Function of Air Valves

Combination air vac valves are installed at high points in the line to allow air in and out of the line. Allowing air out of the line reduces problems with slowing of flows due to a blockage by air. Allowing air into the line during times when the line may be being emptied prevents the low internal pressure from drawing a joint gasket into the pipe and thus causing a leak.



Location

These valves are installed on top of the line usually through a corp stop with a gate valve placed between the corp stop and the air relief valve. The entire setup is normally placed in a valve pit. The discharge from the air valve must extend 18 inches above the ground with a double 90° bend and #24 mesh stainless steel screen over the end.

CROSS-CONNECTION CONTROL

Health Risk

The plumbing at schools, water treatment plants, wastewater plants and other public and private facilities can be so complicated as to allow water contaminated with sewage or chemicals to flow backward into a water system. If this happens a health risk is created. There are hundreds of incidents each year in water systems where contaminated material enters into the water system, through cross-connections.

Small Communities

In small communities possible sources of contamination that could flow into the water system are associated with swimming pools, chemicals such as chlorine, fluoride, water at the harbor, boiler chemicals and wastewater treatment plants.

Cross Connection

A health risk would exist if the drinking water system were connected directly or indirectly to contaminated sources. This could happen when you are mixing a chemical and you place the hose in the vat or connect the drinking water system to the **seal water**[9] supply on a sewage pump. This direct or indirect connection is called a cross connection.

Backflow

The cross-connection can only cause a problem if there is a reversal of flow in the system. This reversal of flow is called backflow. Backflow exists anytime water moves backward through the system.

Backsiphonage

There are two ways that backflow can occur, Backsiphonage and **backpressure**[10]. Backsiphonage occurs when the pressure in the system drops below atmospheric press and the water distribution system is connected to a nonpotable source that is open to the atmosphere. This could happen if the distribution system pressure were lowered as a result of a break or heavy use, like during a fire.

Backpressure

Backpressure exists any time the pressure in the contaminated source exceeds the pressure in the distribution system. Backpressure could happen as a result of a booster pump in a heating system or excessive pressures in a boiler that is improperly connected to the potable water supply, exceeding the pressure of the distribution system.

Prevention

The regulations in each state indicate that a known cross-connection cannot be allowed to exist. Because inspection of facilities is difficult, time-consuming and not always possible, the water works industry has taken a preventive approach to cross-connection control. Under this approach, facilities that have a high potential of cross-connection or handle highly haz-

9 **Seal Water** - The water supplied to the stuffing box to lubricate and flush packing or the mechanical seal.
10 **Backpressure** - A condition in which a pump, elevated tank, boiler, or other means produces a pressure on the customers' side of the services that is greater than the supply pressure.

ardous materials are required to protect the water system. This is accomplished by installing special devices in the facility and on the water service connection where it enters the facility.

Devices

The devices used to prevent backflow from a potential cross-connection are:

- **Air gaps**[11]
- Atmospheric vacuum breakers
- Pressure vacuum breakers
- **Double check valve assemblies**[12]
- Reduced pressure backflow prevention device assemblies

Selection of Devices

Only approved devices may be installed in a water system. In order for a device to be approved it must undergo extensive testing by a private testing laboratory. DEC maintains a listing of approved devices. Contact the regional DEC representative for a listing of these devices.

Degree of Hazard

A high hazard facility would include a sewage treatment plant or lift station. A low level of hazard would be a situation where the odor and taste of the water might be fouled but there is no health risk.

Approved Devices

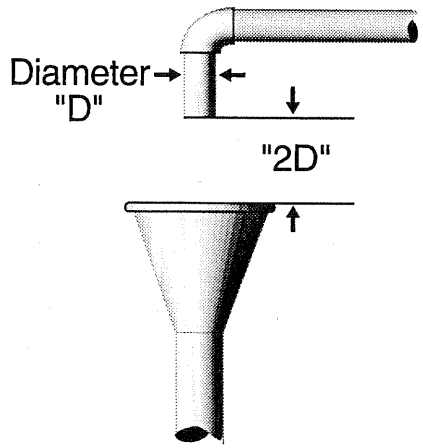
Only approved devices are allow to be used for cross-connection control. ADEC maintains a list of approved devices.

DEVICES

AIR GAP

High Hazard Device

The most protective of the devices is the air gap. The air gap is easy to observe and inspect. The air gap is a positive way to protect the water supply from a chemical vat. The requirements are that the air gap between the two water sources be twice the diameter of the outlet of the supply line or a minimum of 1 inch from the rim of the tank. Air gaps can be used on high hazard conditions.



[11] **Air Gap** - A positive means of preventing a cross-connection. An air gap should be twice the diameter of the discharge pipe or a minimum of 1 inch above the rim of the tank.

[12] **Double Check Valve Assembly** - An assembly of two independently acting check valves with shut-off valves on each side of the check valves and test ports for checking the water tightness of each check valve.

ATMOSPHERIC VACUUM BREAKER

Low Hazard Device

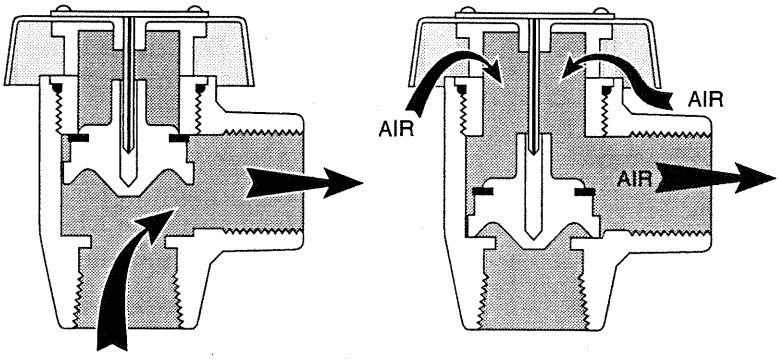
Atmospheric vacuum breakers are used on low degree hazard conditions such as janitor sinks, lawn sprinkler systems, and supply lines on low concentration chemical vats, such as chlorine and fluoride solutions.

No Downstream Valve

A downstream valve can not be installed on an atmospheric vacuum breaker, they prevent the device from working.

Operation

Positive pressure inside of the vacuum breaker keeps the movable closure in a closed position. When the pressure inside the vacuum breaker drops to atmospheric or below the closure drops down allowing air to enter from under the bonnet. The air breaks the siphon and a backsiphonage is prevented. This type of device will not work under a backpressure condition.



Flow condition

Non flow condtions

PRESSURE VACUUM BREAKERS

Low Hazard

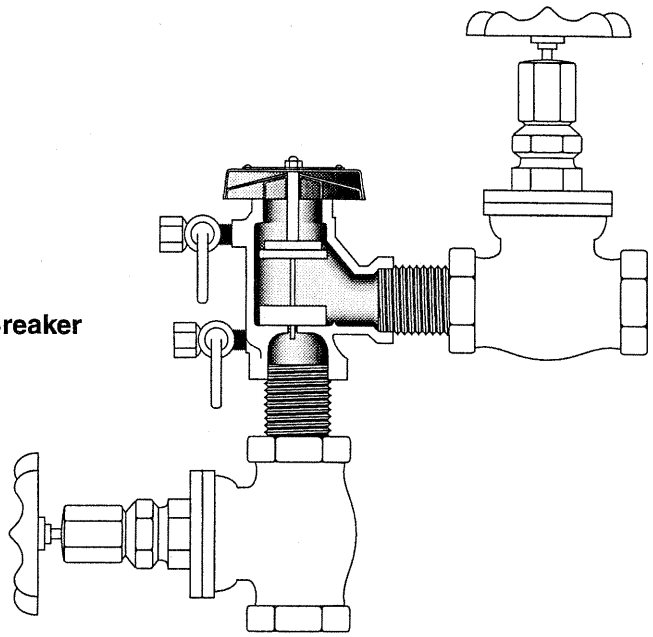
Pressure vacuum breakers are used for the same functions as atmospheric vacuum breakers. There are only three differences. The pressure vacuum breaker has an internal spring that helps it to open, there are valves to allow the device to be tested, and a valve can be placed in the downstream line.

Components

The major components of a pressure vacuum breaker are brass body, movable closure or diaphragm, guide stem, canopy and internal spring. The valve is equipped with test ports and is purchased and installed as an assembly which includes isolation valves.

Operation

A spring holds the movable closure closed against a seat. When there is pressure in the system, the pressure overpowers the spring and opens the valve allowing flow. A reduction of pressure inside of the valve to near atmospheric would allow the spring to push the closure in a closed position and air would enter the valve from under the canopy.



Pressure Vacuum Breaker

DOUBLE CHECK VALVE ASSEMBLIES

Low Hazard

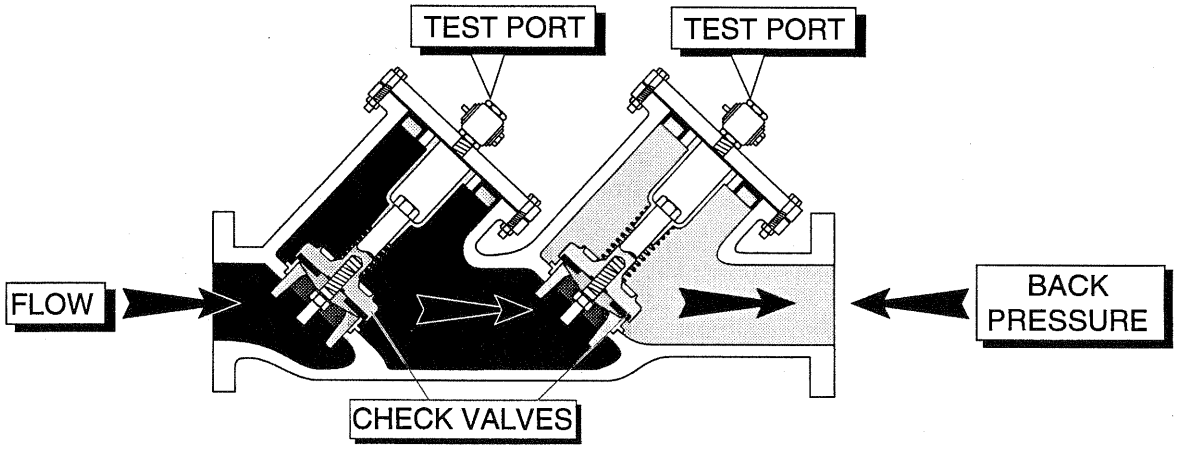
A double check valve assembly (DCVA) will protect against backpressure or backsiphonage on low hazard conditions or nuisance conditions. These are conditions where the water that might enter the system as a result of backflow contains no material that is toxic or pathogenic. These conditions would include clothes washers, steam generators and booster pumps.

Components

The DCVA is composed of two independent internally weighted (springs) check valves, isolation valves on each side of the assembly and test ports on the assembly that allow a tester to determine that the check valves are watertight.

Operation

When the inlet pressure drops below the downstream pressure or if the downstream pressure raises above the inlet pressure the springs in the valve will close both check valves. Backflow can only occur if both valves fail.



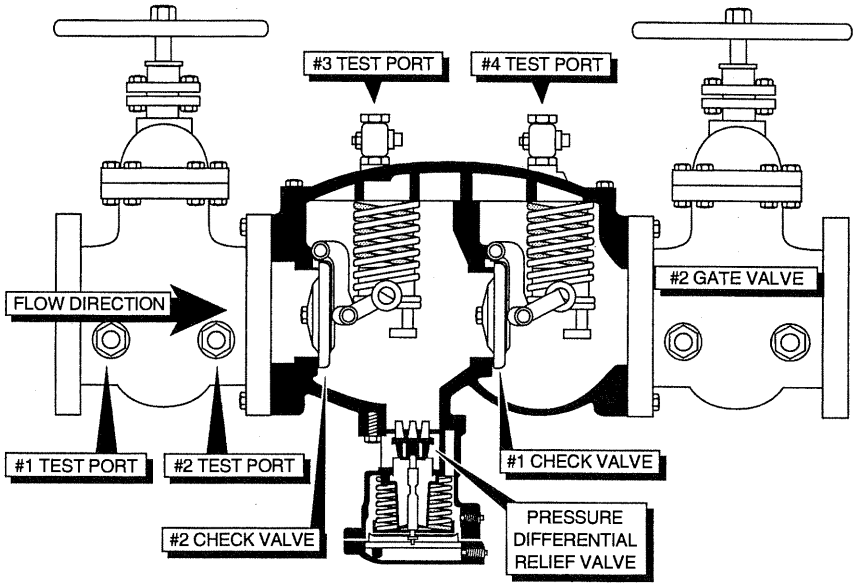
REDUCED PRESSURE DEVICE

High Hazard

High hazard conditions require an air gap or a reduced pressure zone backflow prevention device (**RPZ**[13]).

Components

The RPZ is composed of two independent, internally weighted check valves separated by a reduced pressure zone which is valved to the atmosphere. The assembly also has an isolation valve on each end as well as test ports to determine the proper operation of the assembly.



Rockwell Model 701

Operation - General

There are three valves. The two check valves and a relief valve. The relief valve is connected to the zone between the two check valves, called the reduced pressure zone. The valve is designed so that the pressure in the reduced pressure zone is always maintained at least 2 psi lower than the inlet pressure. The outlet pressure will normally be about 1 psi lower than the reduced pressure zone.

Operation - Backsiphonage

Should the inlet pressure drop to below the downstream pressure the two check valves will be forced closed. If the inlet pressure drops to within 2 psi of the reduced pressure zone pressure, the relief valve will open lowering the pressure in the reduced pressure zone. This process will continue until the pressure in the reduced pressure zone reaches zero. At this point the relief valve is completely open. If a vacuum exists in the supply line and the inlet valves fail, air will be "pulled" into to satisfy the vacuum and prevent contamination.

[13] **RPZ** - Reduced Pressure Backflow Zone Prevention Device - A backflow prevention assembly containing two check valves, a differential relief valve located between the two check valves, shut-off valves on each end of the assembly and test ports for checking the water tightness of the check valves and the operation of the relief valve.

Operation - Backpressure

Under a backpressure condition the downstream check valve will be forced closed. Should the downstream check valve fail the pressure in the reduced pressure zone will be increased. When it is within 2 psi of the supply pressure the relief valve will open and release the pressure.

Unofficial - Selection Guide

The following is a brief selection guide that can be used to provide insight into the proper selection of cross-connection control devices.

Hazard	**VB**	**DC**	**AG**	**RPZ**
Sewage Plant			X	X
Lift Station			*X*	
Washeteria		X		
Janitorial Sink	*X*			
Harbor Water			X	
Low pressure boiler water only		*X*		
Low pressure boiler - glycol			X	X
Clinic			*X*	*X*
Power Plant			X	X
Fish Processing plant			*X*	*X*
Ice Plant		X		

Testing Device

The devices must be tested once each year by a certified backflow prevention device tester. In order to obtain a certification as a backflow prevention device tester you must attend a school and pass a written and practical exam. In order to maintain your certification some states require an annual refresher course, proof that you have tested devices in the past year and a certificate indicating that your test instruments have been tested in the past year.

VALVE DESCRIPTIONS

Description Sequence

In order to properly describe valves the following sequence should be used:

1. Size

1. Start by giving the valve size.

2. Valve Type

2. Next give the valve type. Either gate or butterfly.

3. Body Material

3. The body material is next. Valves are made from plastic, bronze, gray cast iron and ductile cast iron.

4. Connection Type

4. Now identify the type of connections. Valves can be purchased with a wide variety of inlet connections. The most common connections are flange, various hub and mechanical joint. These valves may also be purchased with a combination of connections.

5. Operator Type

5. The description of the operator needs to indicate type and shape. Common operators are the two inch square nut, hand wheels and electric.

6. Pressure

6. Operating pressure is an important part of the description. Valves are manufactured for pressures from 125 psi to 3000 psi.

7. Special Considerations

7. One of the most important areas of the description is the special considerations section. This section covers the number of discs, and the type of valve seats. It describes if the stem is rising or non-rising and if the type of packing is conventional or "O" rings. It also covers the direction of rotation of the shaft to open the valve and gives special information on valves that are to be mounted horizontally rather than vertically.

ROUTINE INSPECTION

Normal Conditions

Under normal conditions all valves should be identified, inspected and exercised at least once each year. Distribution system line valves should be located on the distribution system map. A valve record should be maintained on all valves.

Wye Strainers

The wye strainers on all valves should be cleaned once each month.

Valve Record

A sample valve record card is provided below.

Valve Record

Brand_____ Type _____ Manf. Date _____ No. _____

Location_____ Use _____

Size_____ Type of Connections_____ NO or NC Open - L - R No. of Turns _____

In ground valves Valve box type _____ Depth _____

Date	Located	Exercised	Repaired	Remarks

ROUTINE MAINTENANCE

GENERAL

Normal Conditions

Under normal conditions, valves with packing should have the packing replaced once each year, or change the packing to Teflon. Teflon packing will not have to be replaced for several years. Valves with "O" rings need to have the "O" rings replaced only when they leak.

Globe Valves

Globe valves should be disassembled once each year. The interior, valve seat, movable closure and diaphragm should be inspected. Any damaged or worn parts should be replaced. New gaskets should be installed each time the valve is disassembled.

Pilot Valves

Pilot valves used on control valves require specific annual maintenance. Once each year the spring, valve faces, valve seats and diaphragms must be replaced.

CLAY VALVES

General

If wide body globe valves such as Clay™ valves are used for control valves, they should be disassembled once each year. The valve seat, movable closure and diaphragm should be inspected. If damaged or worn they should be replaced.

Clay Valves - Stem Rise

To determine the maximum stem rise on a Clay valve multiply 0.28 X valve size. For instance a six inch valve 0.28 X 6" = 1.68 inches.

Clay Valves - Cavitation

Most wide body globe valves will cavitate in the lower 15% of their stroke. The style of Clay valves used at Craig has a history of seldom experiencing cavitation even in the lower 15% of the stroke. However during the annual inspection the downstream area of the valve should be inspected for cavitation.

Clay Valve - PM

Replace PRV pilot valve diaphragms and disks annually.

If a pilot valve is used with the globe valves, the pilot valve seat, spring and diaphragm should be replaced once each year.

Wye Strainers on Clay Valves

There are various Clay valve piping and pilot combinations. The two piping set-ups below are the most common. These procedures can be used to properly remove and clean the wye strainer, without changing the downstream pressure.

Frequency

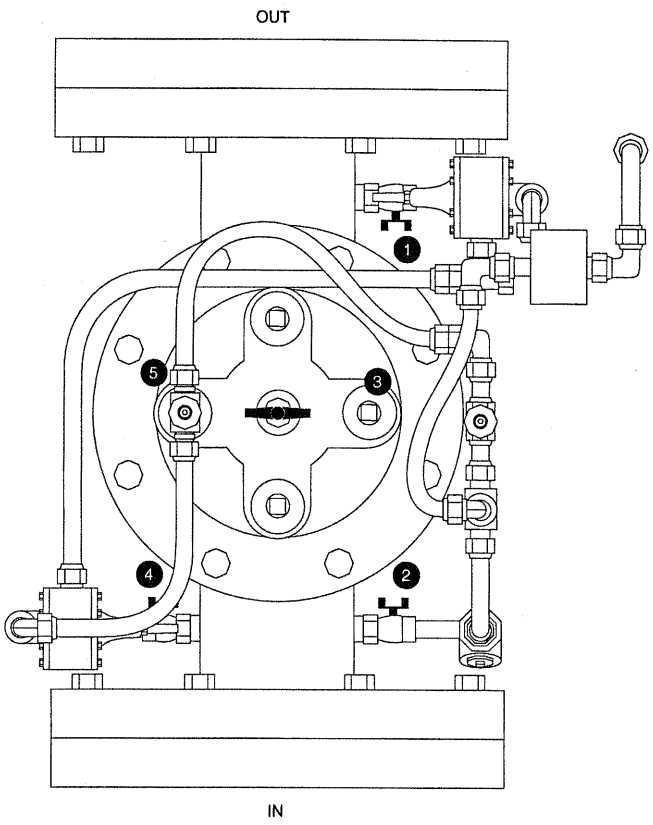
The Wye strainers on each of the PRV's should be cleaned weekly. Should the Wye strainers become clogged the PRV's will have a tendency to modulate.

Valve Sequence

The wye strainers can be cleaned without shutting down the plant flow if you follow the valve closing sequence described below. This sequence will lock the

valve diaphragm in position. Cleaning should be done promptly and the valves returned to normal operation as quickly as possible.

SOLENOID OPERATED, DUEL PILOT



Shut off Sequence

Shut off the valves in the following order as shown on the drawing above.

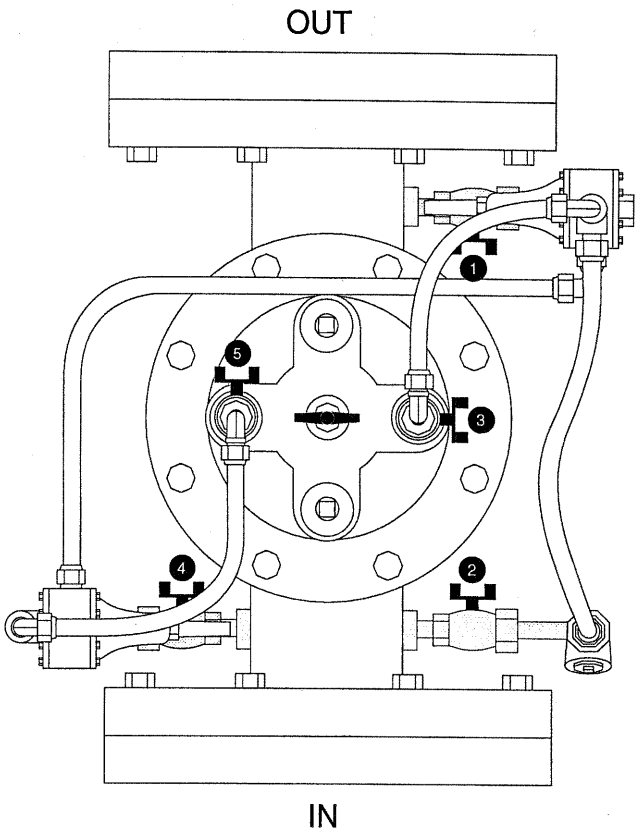
- Close valve 1 slowly
- Close valve 2
- Close valve 4
- Close valve 5

Open Sequence

Open the valves using the following sequence as shown on the drawing above.

- Open valve 2
- Bleed air from cover
- Open valve 1 slowly
- Open valve 5
- Open valve 4

HYDRAULIC OPERATED, DUAL PILOT



Shut off Sequence

Shut off the valves in the following order as shown on the drawing above.

- Close valve 1 slowly
- Close valve 3
- Close valve 2
- Close valve 4
- Close valve 5

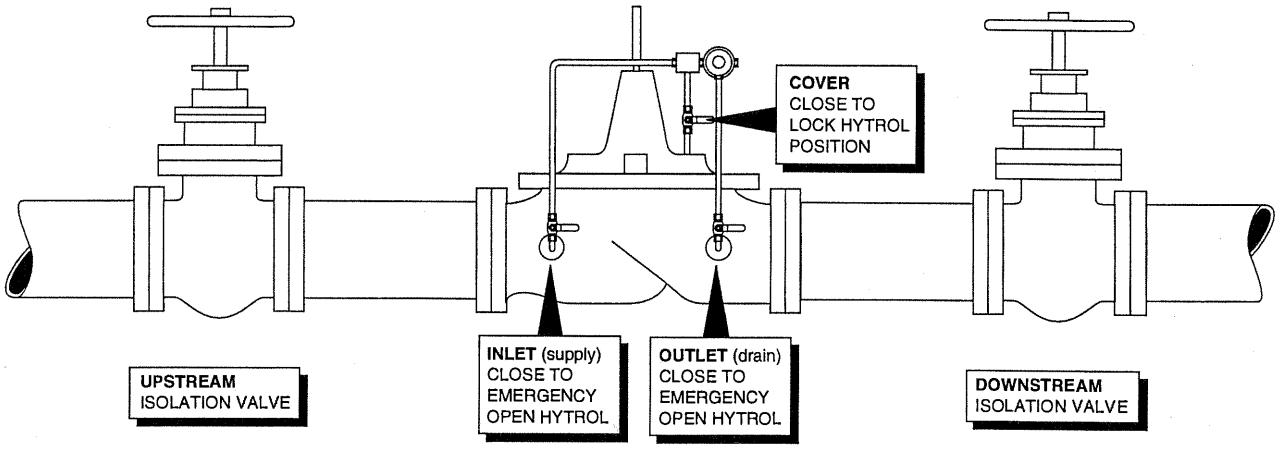
Open Sequence

Open the valves using the following sequence as shown on the drawing above.

- Open valve 2
- Open valve 3
- Bleed air from cover
- Open valve 1 slowly
- Open valve 5
- Open valve 4

LOCKED POSITION

At various times it is desirable to manually open or close a control valve or lock it in a single position. The following information can be used on Cla-Val's with single pilot controls.



O & M OF VALVES

WORKSHEET

1. Identify the valves below.

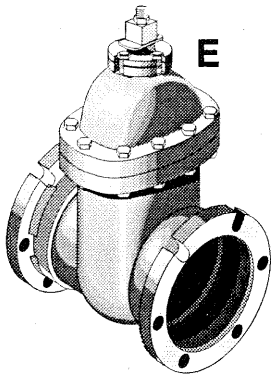
_____ Gate valve

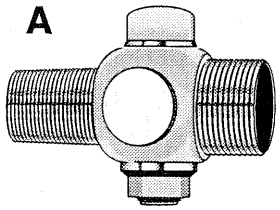
_____ Butterfly valve

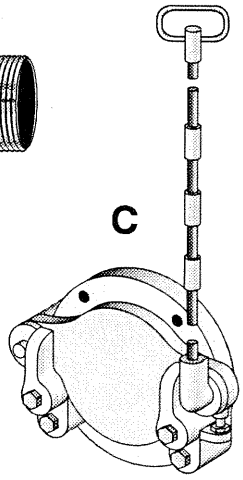
_____ Globe valve

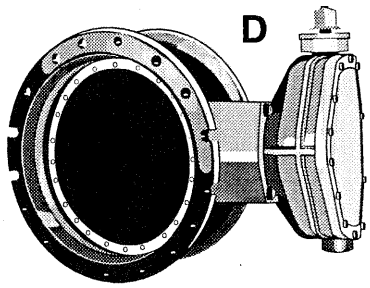
_____ Corp stop

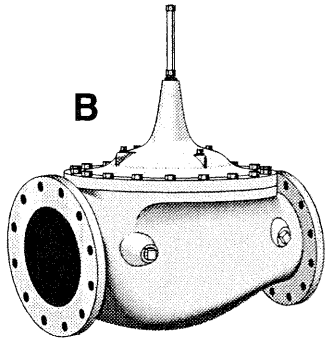
_____ Shear gate











2. Identify the components indicated.

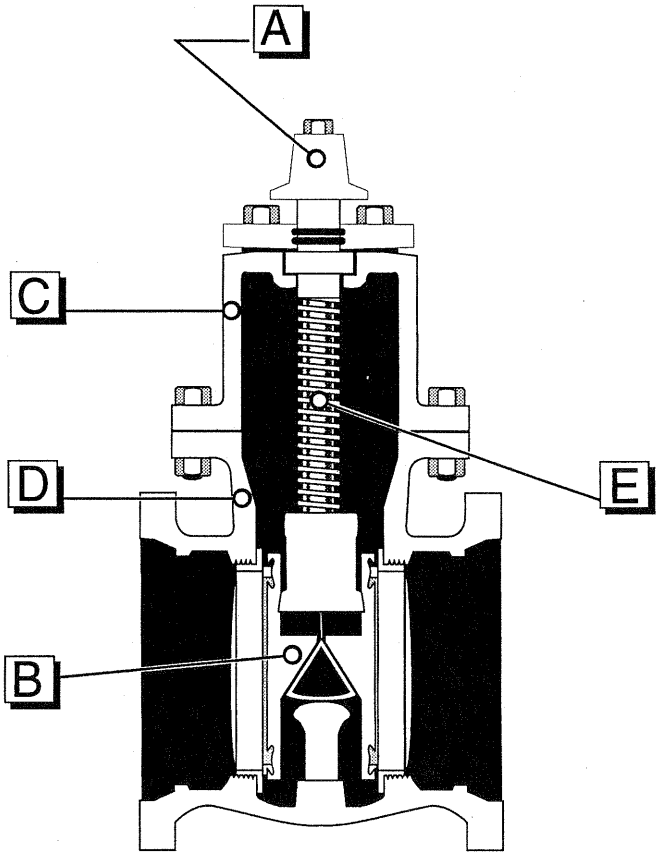
_____ Body

_____ Operator

_____ Bonnet

_____ Movable Closure

_____ Stem



3. Identify the components indicated.

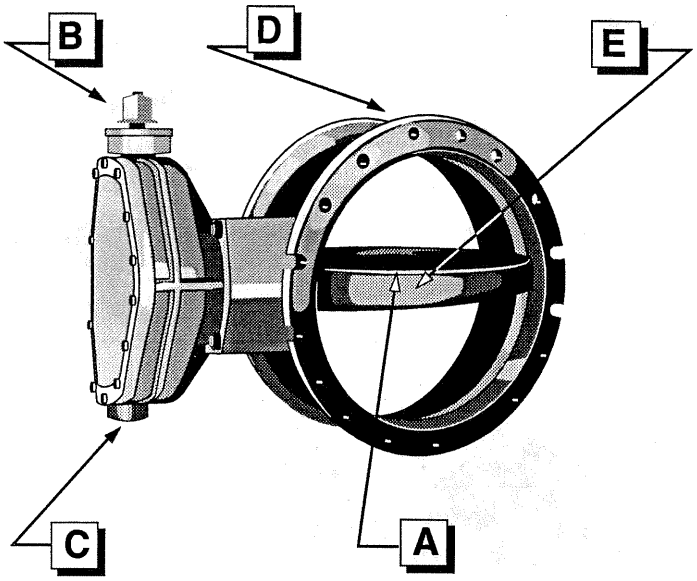
_____ Operator

_____ Movable Closure

_____ Body

_____ Gear Head

_____ Resilient Seat



4. Identify the components indicated.

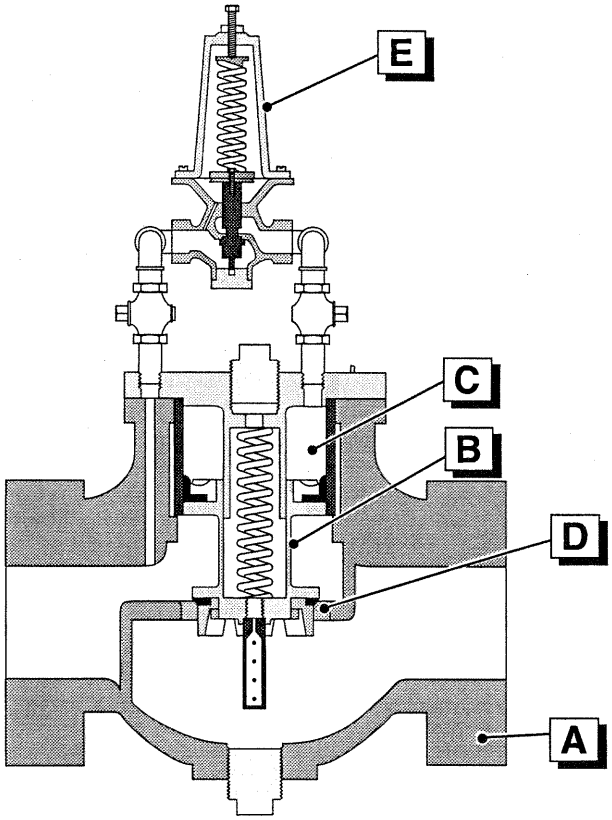
_____ Body

_____ Control Chamber

_____ Pilot Valve

_____ Stem

_____ Valve Seat



5. Which of the following are **not** common functions of valves in a water distribution system?

_____ a. Flow control

_____ b. Pressure control

_____ c. Pumping surge control

_____ d. Reversal of direction control

_____ e. Reservoir depth control

6. If a gate valve will not stop the flow of water when it is closed you should...

_____ a. Retighten the valve

_____ b. Allow it to leak

_____ c. Open the valve 1/2 way and then retighten

_____ d. Open the valve just enough to allow water to pass freely and reclose

_____ e. Open and close 4 to 6 times

7. A double disk would be found in what type of valve?

_____ a. Butterfly

_____ b. Globe

_____ c. Gate

_____ d. Plug

_____ e. Ball

8. A n O S & Y valve would be what type of valve?

_____ a. Butterfly

_____ b. Globe

_____ c. Gate

_____ d. Plug

_____ e. Shear gate

9. Which of the valves listed below require only 1/4 turn from open to close?

_____ a. Butterfly

_____ b. Globe

_____ c. Gate

X _____ d. Plug

_____ e. Shear gate

10. Which type of valve would be used on a screen box intake?

_____ a. Butterfly

_____ b. Globe

_____ c. Gate

_____ d. Plug

_____ e. Shear gate

11. The rate of opening and closing on a Ross globe valve is controlled by...

_____ a. Pilot valve

_____ b. Needle valve

_____ c. Wye strainer

_____ d. Differential pressure between the pilot and the pressure chamber

_____ e. The pressure on the underside of the pilot valve diaphragm

12. The discharge line from an air release valve should extend above the ground _____ inches.

_____ a. 6

_____ b. 12

_____ c. 18

_____ d. 24

_____ e. 30

13. The reversal of flow as a result of a broken main line in the distribution system is what type of back-flow?

_____ a. Backsiphonage

_____ b. Backpressure

14. The reversal of flow as a result of a boiler at the school is called what type of backflow?

_____ a. Backsiphonage

_____ b. Backpressure

15. The proper protection from a cross-connection at the clinic would require what type of device?

_____ a. Vacuum breaker

_____ b. Pressure vacuum breaker

_____ c. Double check valve

_____ d. Barometric loop

_____ e. RPZ

16. The proper protection from a cross-connection at the harbor would require what type of device?

_____ a. Vacuum breaker

_____ b. Pressure vacuum breaker

_____ c. Double check valve

_____ d. Barometric loop

_____ e. RPZ

17. Which device would be used on the lowest level of hazard?

_____ a. Vacuum breaker

_____ b. Pressure vacuum breaker

_____ c. Double check valve

_____ d. Barometric loop

_____ e. RPZ

18. The valve most commonly used in a water distribution system is the...

_____ a. Ball valve

_____ b. Diaphragm valve

_____ c. Gate valve

_____ d. Globe valve

_____ e. Eccentric valve

19. Which is the correct type of valve for controlling water levels in a distribution system's elevated tank?

_____ a. Altitude valve

_____ b. Check valve

_____ c. Pressure regulating valve

_____ d. Pressure relief valve

_____ e. Storage tank level control valve

20. Rising stem valves are most often used...

_____ a. On blow-offs

_____ b. On hydrants

_____ c. Before and after household metes

_____ d. In pumping stations

_____ e. On main lines

21. A reduced-pressure-zone backflow preventer will...

_____ a. stop backsiphonage but not backpressure

_____ b. stop backpressure but not backsiphonage

_____ c. stop backpressure and backsiphonage

_____ d. stop cross-connections

_____ e. prevent high velocity flows