# Control valves

Control valves are the most common final control element in the processing industry. A final element is a device that receives a control signal and regulates the amount of material or energy in a process. Regulators are self operating control valves. Other types of final elements include variable speed drives, dampers, and electric power controllers.

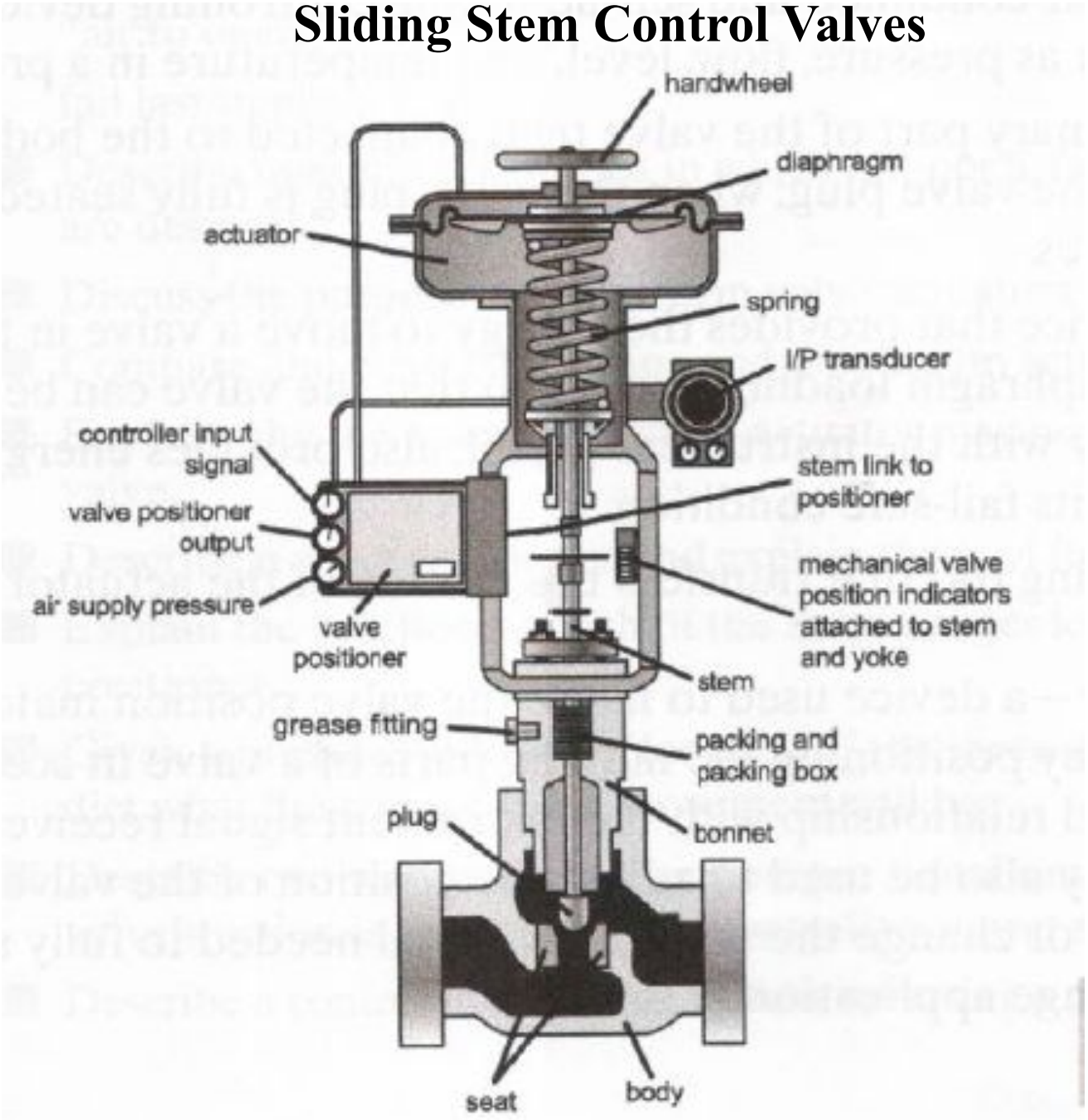
Control valves operate the process by producing a differential pressure drop at least 10 percent of the process pressure in the line. Control valves regulate the flow of materials in the process.

A control valve has actuating device or actuator. The actuator. The actuator changes an instrument signal into a linear or rotary motion. This motion drives the flow controlling mechanism in a valve.

- The valve **bonnet** is the top portion of the valve body and connects the valve body to the actuator and can be removed to allow entry into the valve body cavity.
- The bonnet usually contains the packing box that provides a seal around the sliding stem mechanism that connects the actuator to the valve plug.
- The valve **plug** assembly that includes the valve stem moves to open or close the flow path through the valve. As the plug moves away from the seat, the flow through the valve increases. As the plug nears the seat, flow decreases. Once the plug reaches the seat, a reasonably tight seal is formed stopping the flow through the valve. In other valves, such as the butterfly and ball valve, the plug component is referred to as a **disc** or ball.
- The **actuator** is the device that provides motion to the valve using a spring diaphragm, spring piston, or double-acting piston.
- The **stem** is the pushing and pulling rod that transfers the motion of the actuator to the valve plug.
- The **seat** in a valve is the stationary part of the valve trim connected to the body that comes in contact with the valve plug. When the plug is fully seated, the flow through the valve ceases.
- The **spring** provides the energy to move the valve in the opposite direction of the diaphragm loading motion. This provision is made so that the valve can be opened and closed proportionally with the instrument signal. The spring provides the energy to return the valve back to its fail-safe condition.
- The diaphragm is the flexible member that creates a force to move the stem.

- A **valve positioner** is actually a proportional-only controller. The position of the valve stem is sensed by a mechanical link that is directly connected to the positioner. The position of the valve stem is then compared to the value of the instrument signal and a response is produced to make the position of the valve and the signal equal.
- A **handwheel** is an actuator accessory that is used to manually override the actuator or to limit its motion. The handwheel may be located on the top of the actuator or on its side. Process technicians may manually limit or close a problem valve if it is equipped with a handwheel. Many control valves have associated handwheel inlet, outlet, and bypass valves to permit maintenance activities since these reduce installation costs.
- An **I/P** or **current-to-pneumatic transducer** is a device that converts a milliampere signal into a pneumatic pressure. The most common use for an I/P transducer is to provide the source of energy needed to drive a diaphragm or piston actuator. A current to pneumatic transducer typically receives a 4-20 mA current signal and converts it to a 3-15 psig pneumatic signal.

# Sliding Stem Control Valves



## Sliding Stem Control Valves

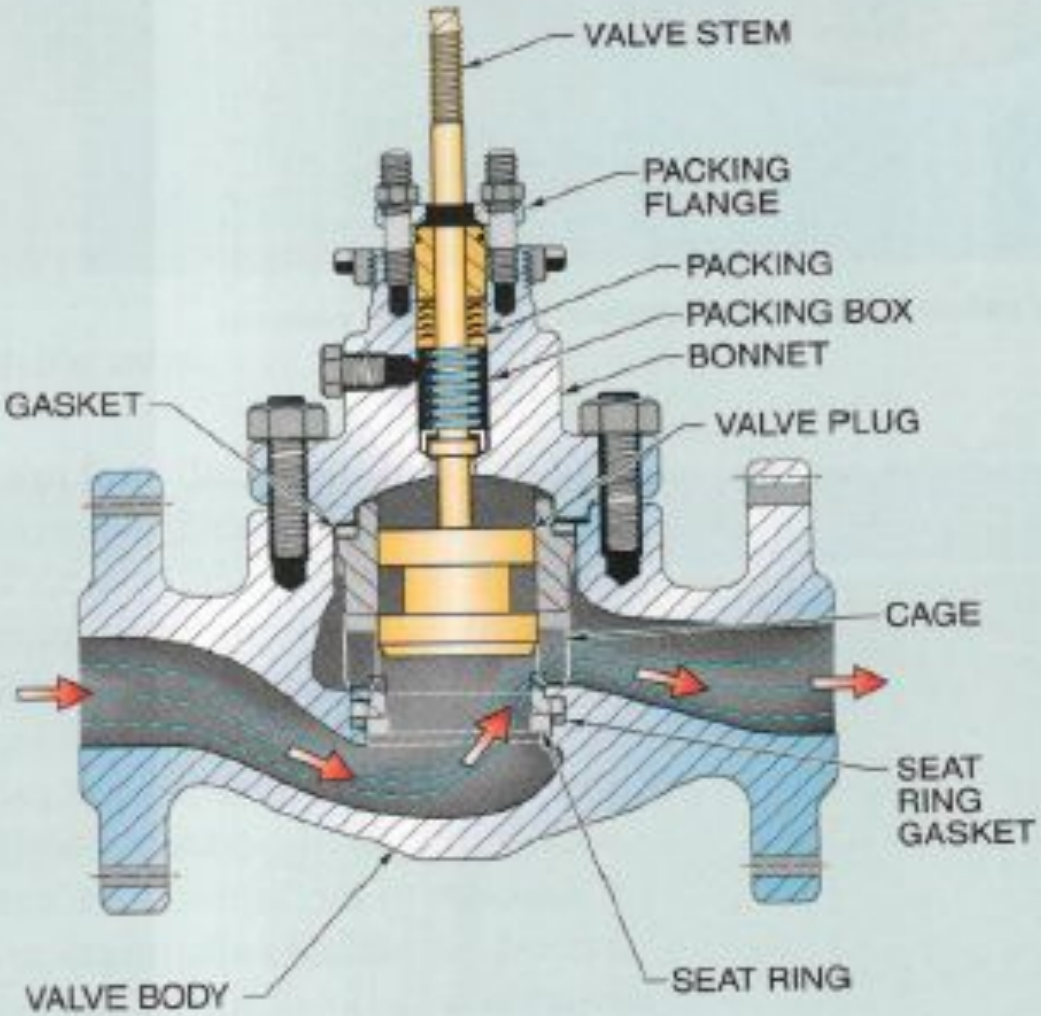



Figure 39-7. A sliding stem control valve uses the linear motion of the stem to open or close the valve.

# Control Valve Failure Conditions

Control valves are ultimately rwesponsible for regulating the movement of fluids in a process. If there is a power or air failure, they should move to a safe position.

Control vslves generally designed fail in open, closed or last position. Actuators without return mechanisms typically fail in last position.

## Fail Closed

When air to open control valve loses its instrument air signal or supply the valve fails closed because a return spring provides more opposing force than the diminishing instrument air applied to the diaphragm and the force applied by the process pressure.


FIGURE 11-2 Fail Conditions–Air-to-Open or Fail Closed

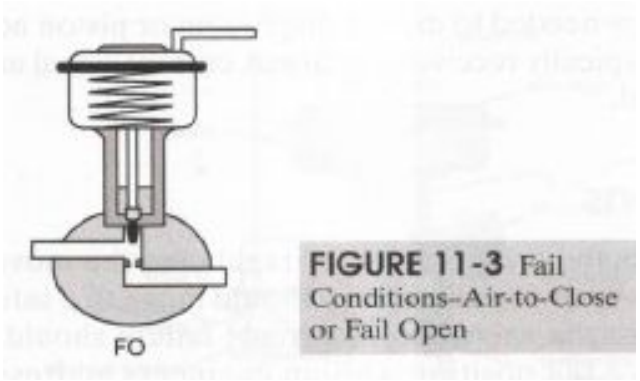



FIGURE 11-3 Fail Conditions–Air-to-Close or Fail Open

## Fail Open

When air to close control valve loses its instrument air signal or supply, the valve fails open because the return spring , once again, provides more opposing force than the diminishing instrument air applied to the diaphragm and the force applied by process if any.

# Fail in Place or Fail Last

Pneumatic actuators with opposing springs naturally fail in the direction of their spring tension, unless it has a lockup relay attached. A lockup relay seals in the existing signal applied to the actuator at the point of power loss. Actuators without a spring or other return mechanism usually fail in their last position just prior to loss of power unless the process pressure is high enough to change the valve position. Electric motor actuators, for example naturally fail in place.

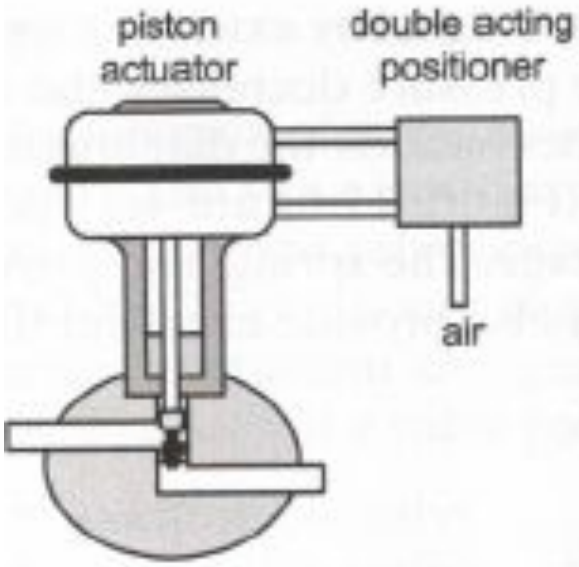
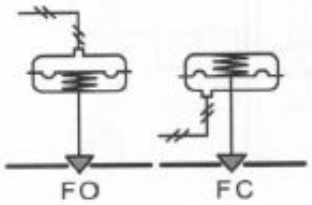



**FIGURE 11-4** Fail Conditions–Fail-in-Place or Fail Last

# Direct and reverse action

- A valve is considered to be direct acting when the valve stem is pushed down to close and reverse acting when the valve stem is pulled.
- ***A direct acting actuator*** is an actuator that extends the shaft when the air is applied to the diaphragm.
- ***A reverse acting actuator*** is an actuator that retracts the shaft when air is applied to the diaphragm.



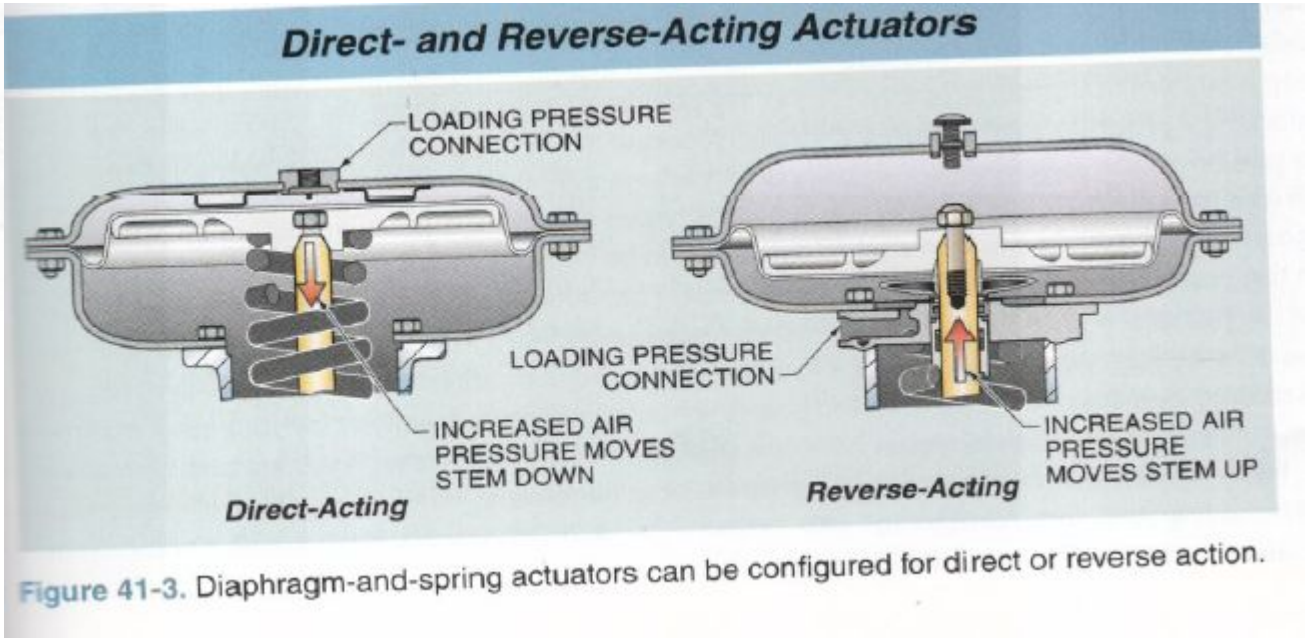




Figure 41-3. Diaphragm-and-spring actuators can be configured for direct or reverse action.

# Pneumatically Drives Actuators

There are two major subcategories of pneumatically drives actuators:

- the spring and diaprhagm
- The piston type actuators

The most common spring and diapraghm actuator g has a single diaphragm supprted by a diaphragm plate connected to a steel rod called stem. A spring is placed on the opposite side of the plate to create an opposing return force.

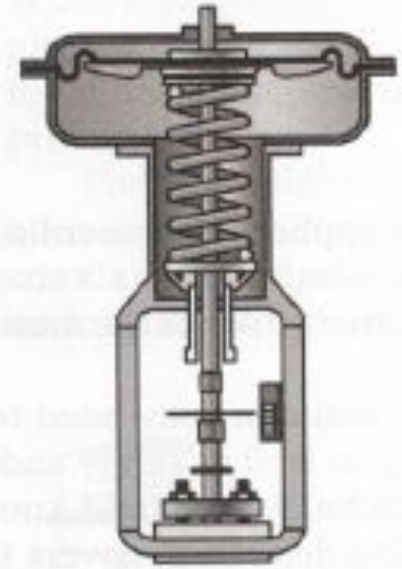


FIGURE 11-6 Spring-and-Diaphragm Actuator

# Piston Type Actuator

- Piston type actuator fall into two major categories: single and double acting.
- In the single acting spring opposed actuator, like the diaphragm type, the piston is opposed by a spring. In the single acting air cushion type, the piston actuator has pressure trapped under the piston and the air compresses as the piston is pushed down.
- In the double acting type, instrument air pressure is routed to both sides of the piston driving the stem to a required position by balancing the pressure on either side of the piston. A double acting positioner is required to do this.

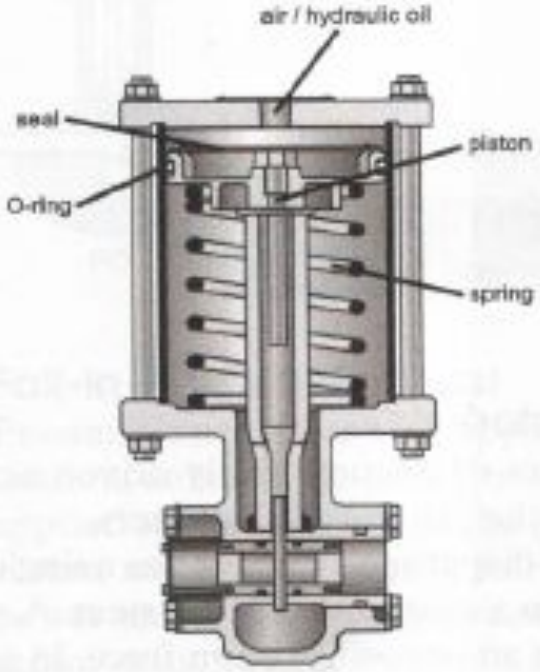



**FIGURE 11-7** Piston-Type Actuator

## Pneumatic Sliding Stem Piston Actuators

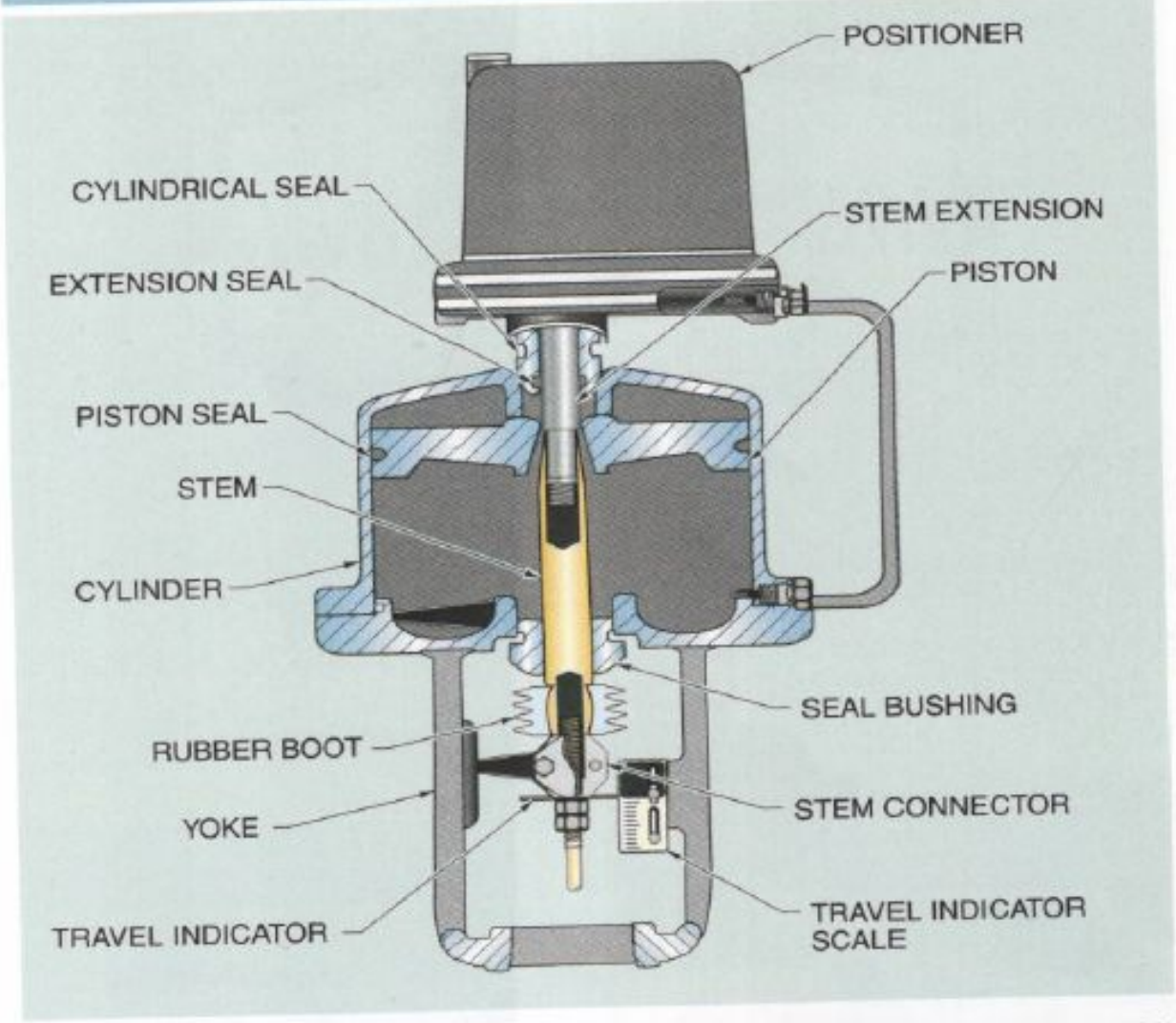



**Figure 41-4.** A pneumatic sliding stem piston actuator uses a piston with balancing air pressures to move a valve stem. High air pressures can be used to overcome large forces on the valve plug.

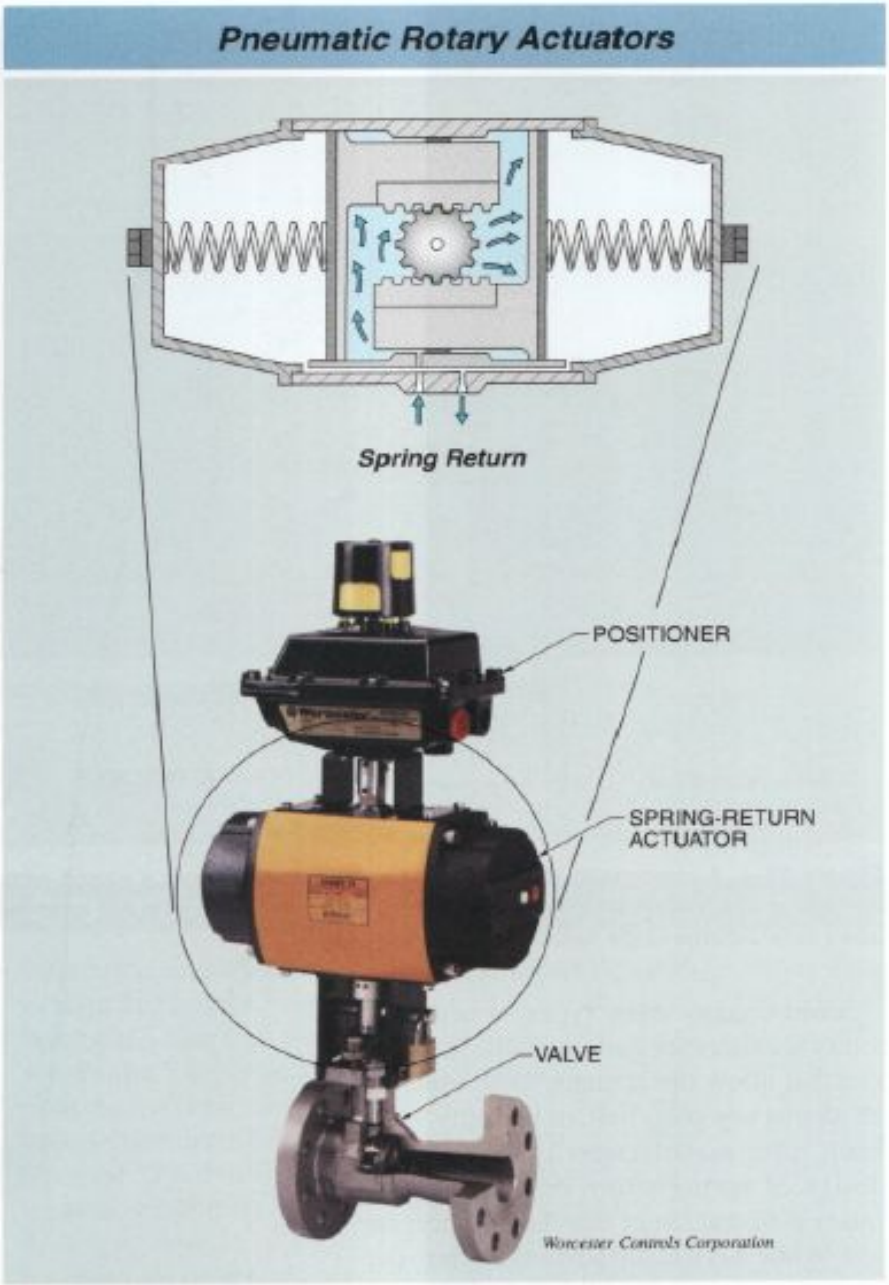



Figure 41-5. Pneumatic rotary piston actuators are primarily designed for ON/OFF action.

# Valve Positioner

- The function of a positioner is to make the valve position match the controller output signal. The valve positioner positions the moving parts of a valve in accordance to a predetermined relationship with the instrument signal received from the loop controller. The postioner can be used to modify the relationship between the input and output instrument air signal.

The uses of  a valve positioner are to:

- Position  of the valve
- Reverse action
- Mimic a valve trim type
- Provide split range control

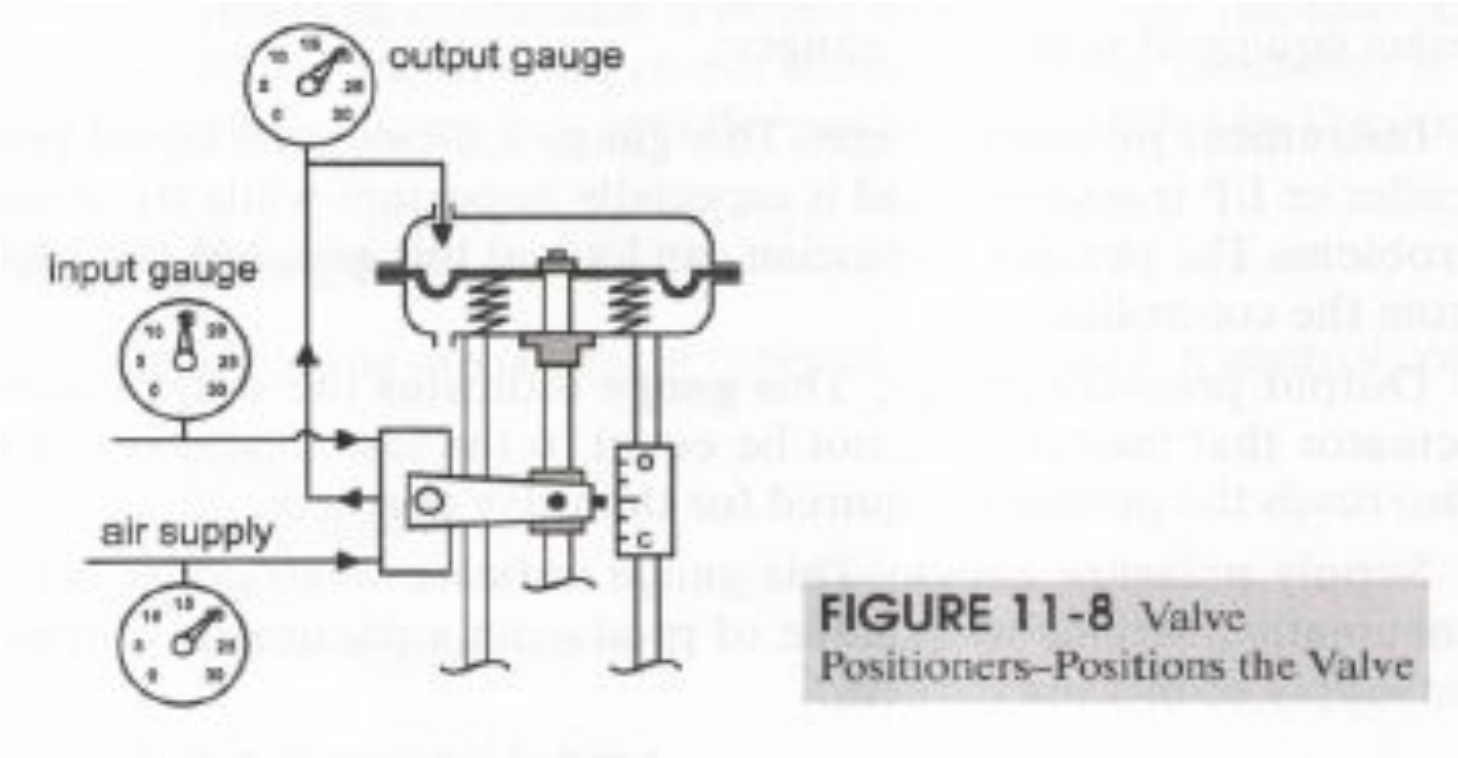



**FIGURE 11-8** Valve Positioners–Positions the Valve

A valve positoner may be used to adjust the position of the valve according to specific needs or to change the amount of signal needed to fully stroke the valve. A split range application would be an example.

A split range operation is a control configuration where a single control signal 4 mA to 20 mA or 3 psig to 15 psig, can be directed to two throttling control valves or dampers equipped with electrpneumatic positioners

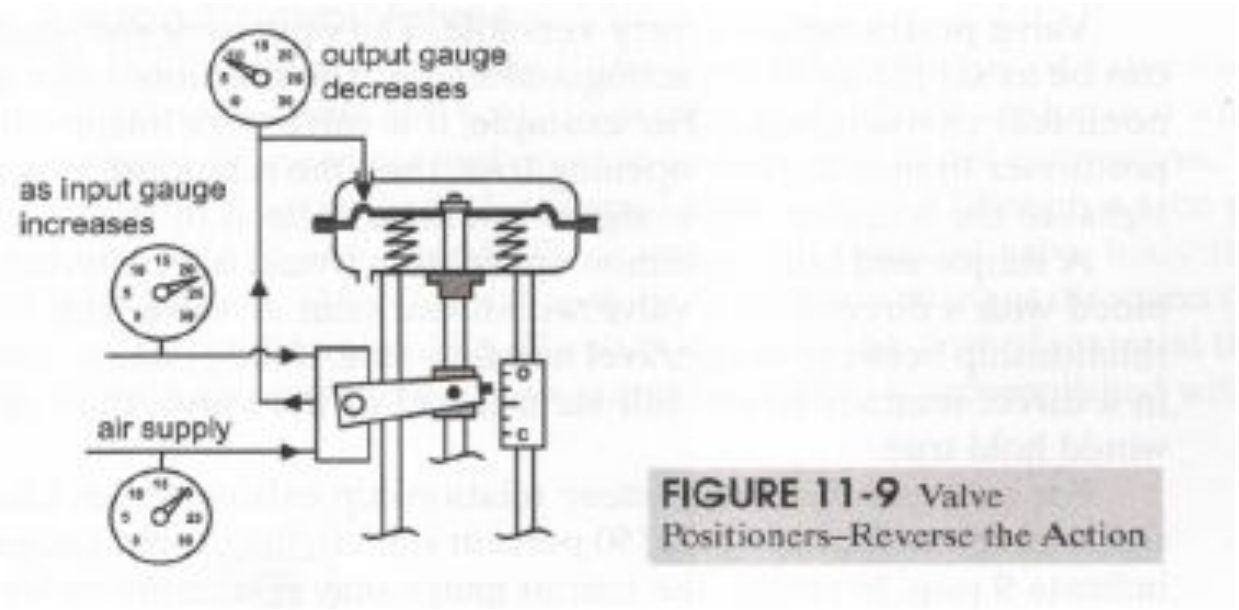



**FIGURE 11-9** Valve Positioners–Reverse the Action

The controller output action, direct or reverse, is determined by what is necessary for proper feedback control, but the desired valve failure position on loss of air supply may require the reverse action. An example, is a controller signal 4 mA to 20 mA and a  positioner output 15 psig to 3 psig. This arrangement does reduce the safety of the loop since a loss of the control signal, while the air supply is maintained, causes the valve to go to a potential unsafe position

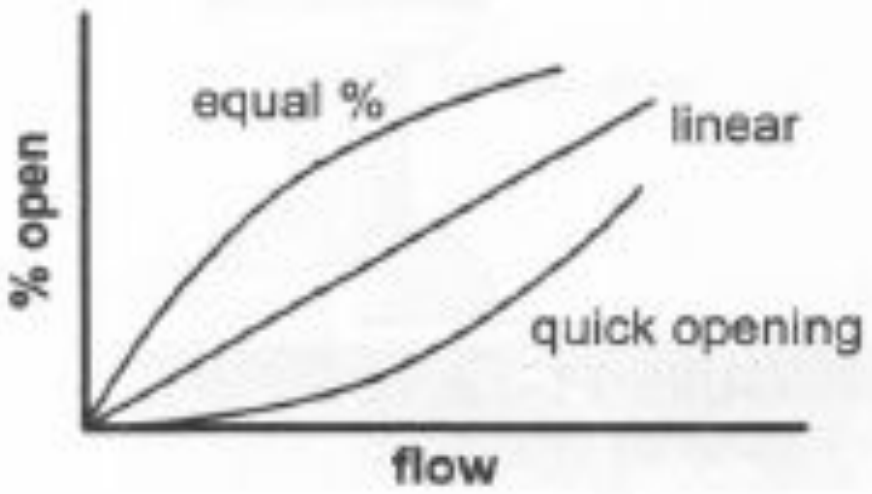



**FIGURE 11-10** Valve Positioners–Trim Characteristics Curves

A valve positioner may also be selected to mimic the characteristics of different valve trim types such as quick opening, linear, and equal percentage

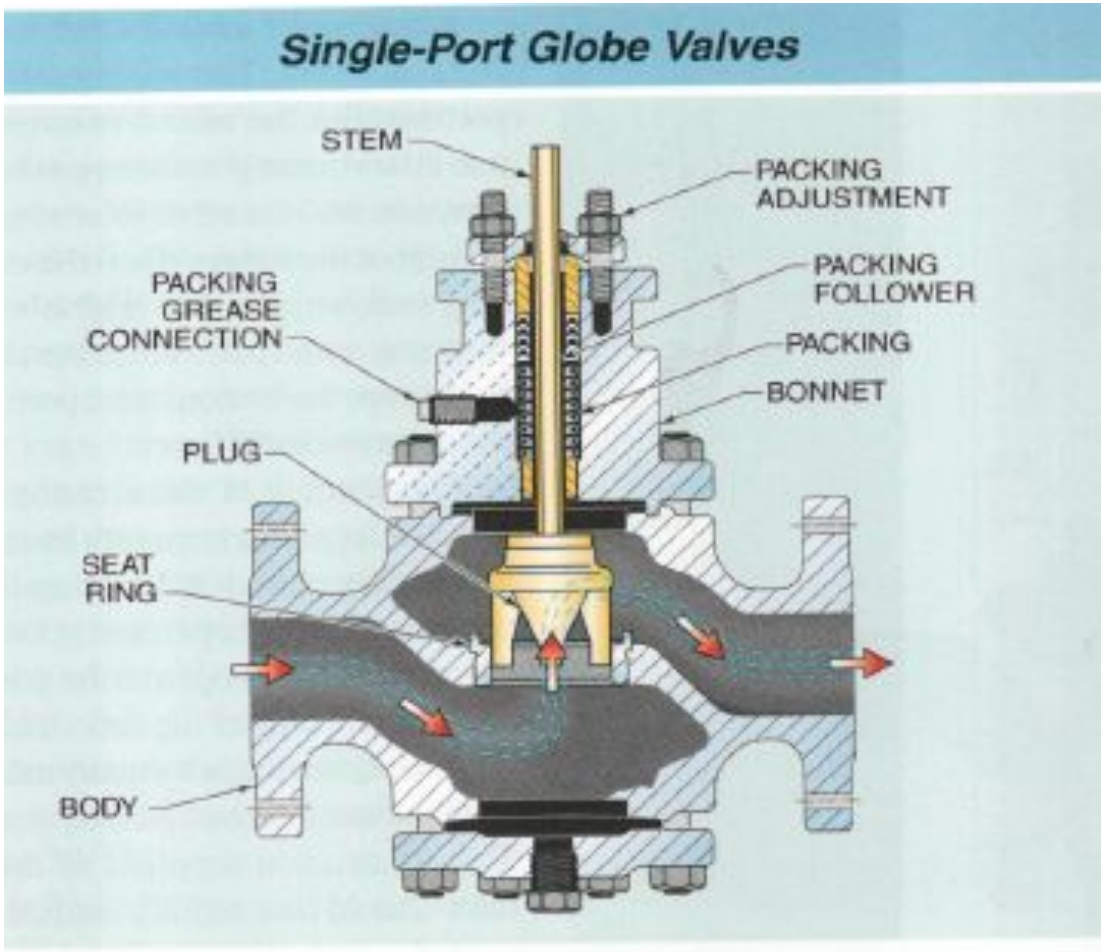
# Types of control valves

The following are the main types of valves used in control confihurations:

- Globe
- Three way
- Butterfly
- Ball or segmented ball

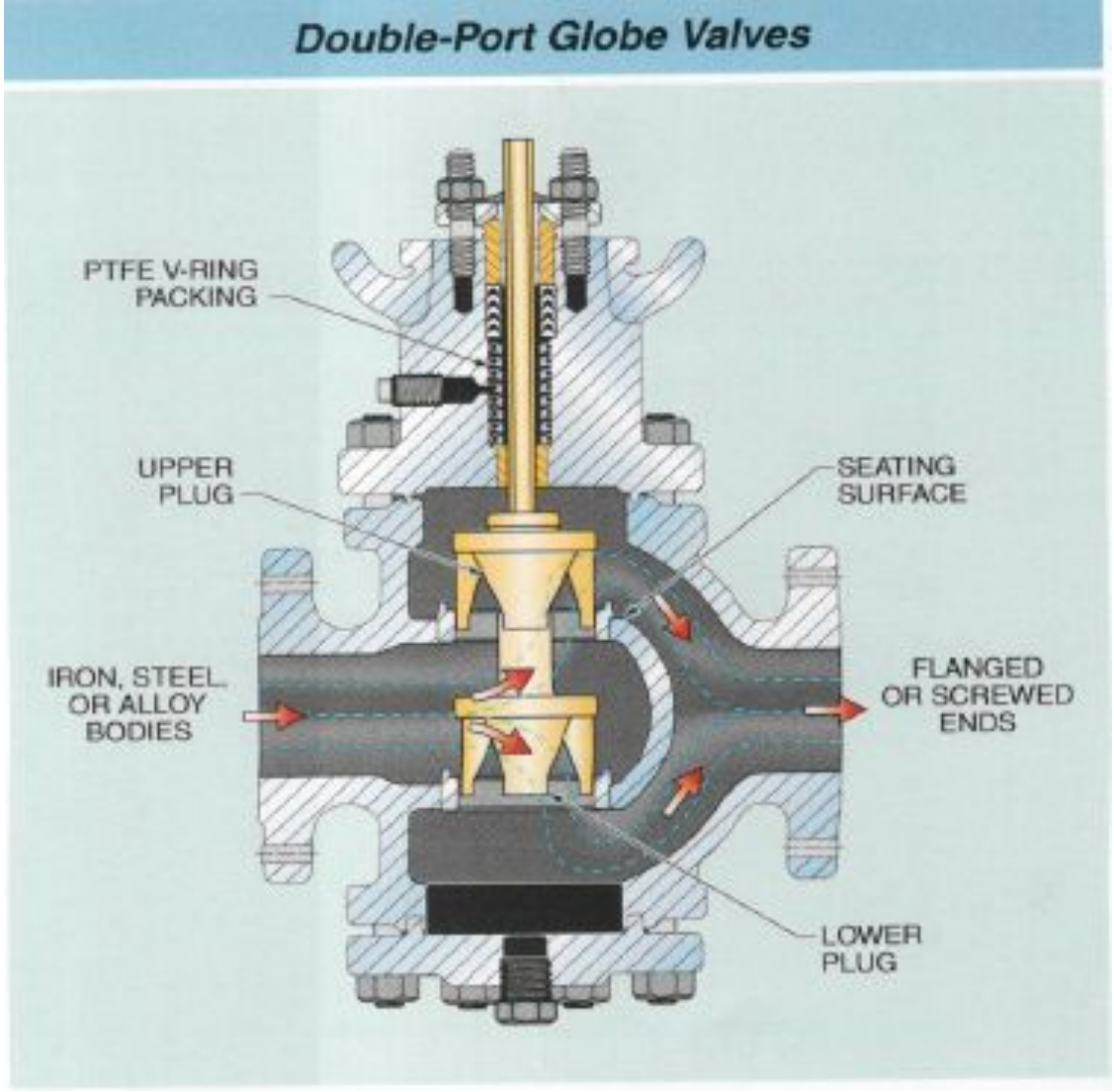
**Globe control valves**

The globe –style body is the most common type of valve used in the processing . The plug and seat often called valve trim are located within the inner cavity or body of the valve and provide an inlet and outlet connection. The glove valve like all valves controls the flow of material through the inner cavity with its plug and set components. The body of the globe valve is a single casting with one or two integral ports plus an opening for the bonnet.




8. A single-port globe valve has one path through the valve.

A single port globe valve is a globe that consists of single valve plug and seat ring through which a fluid flows.

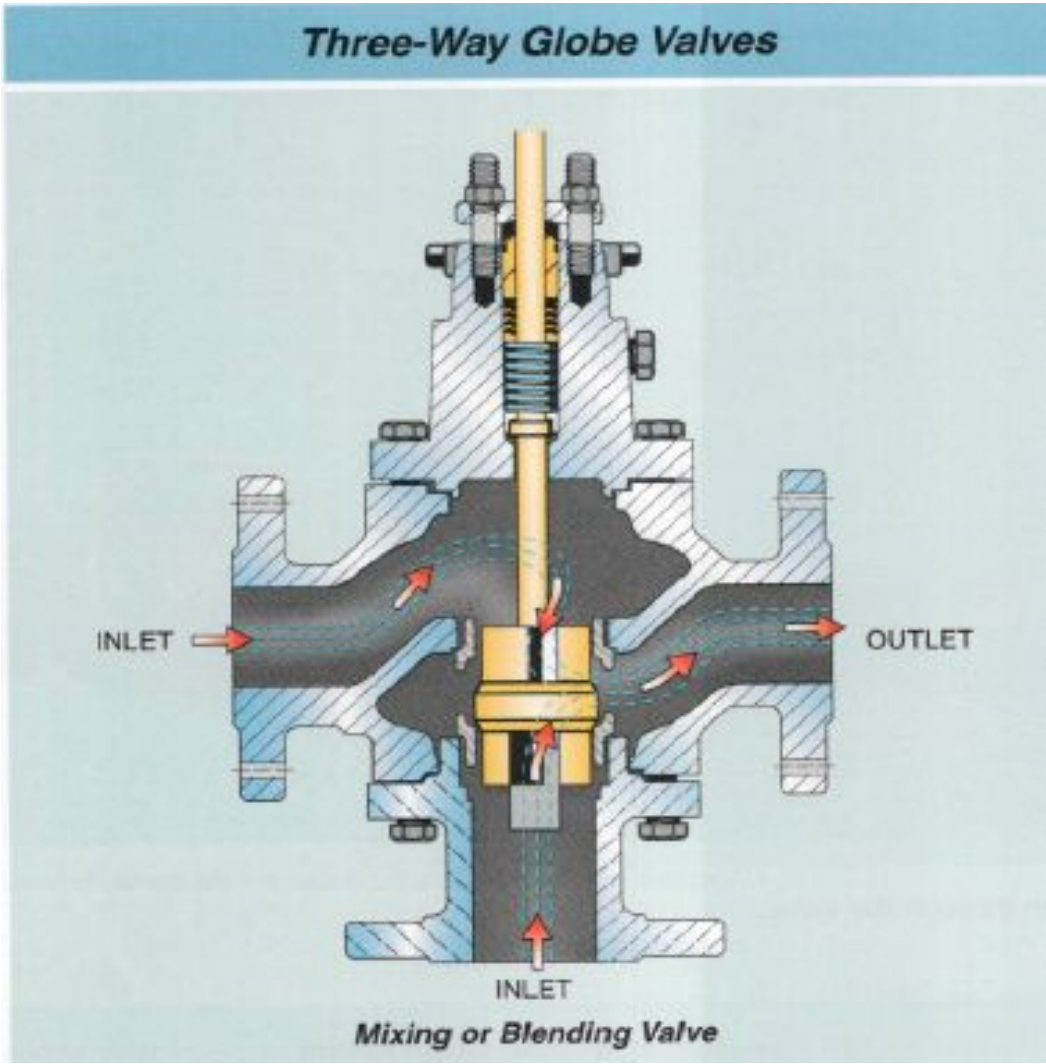



In a double port valve, there is a division of the flow through the two ports. The division of flow reduces the imbalance of the forces acting upon the plugs. The reduced force imbalance makes it possible to use a smaller actuator than the a single port actuator.

# Three way control valves

•They are designed to either mix two flowing streams together or divert one flowing stream between two outputs.

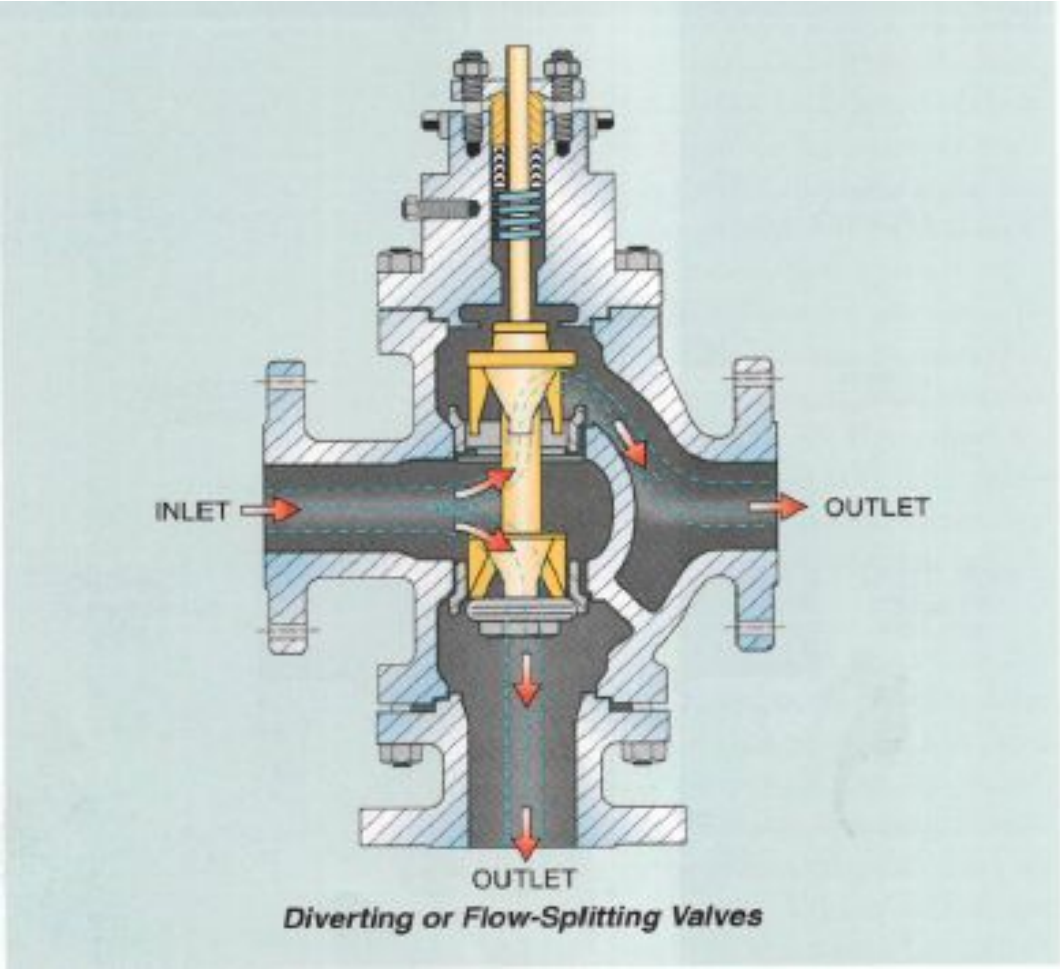
•A three way mixing valve has two inlets and one outlet. The mixing three-way valve could be used for blending two separate into one , producing a proportioned mixture of the two. When control valve plug is down, the side inlet is routed to the common outlet port. When the control valve plug is up, the bottom inlet port is routed to the common outlet port.



A divertin valve is a three way valve that has one inlet and two outlets. The diverting valve could be used as a switching valve diverting a flowing stream from one vessel to another.

A common application is to use a diverting valve to send a water stream through or around  a heater.

Diverting valves arev often used in applications that require ON/OFF flow.



# Butterfly valves

- A butterfly valve is valve with a disc that is rotated perpendicular to the valve body. Standard butterfly valves are made in diameters from 2 inch up to 24 inches. Butterfly valves are usually supplied with water-style bodies. Water style bodies are those without their own flanges and are inserted between flange pairs and secured by through bolts.

A conventional butterfly valve has an effective Operational range for throttling services of $20^{\circ}$ to $60^{\circ}$ to open. Butterfly valves shouldn't be Allowed to throttle at less than $20^{\circ}$ open

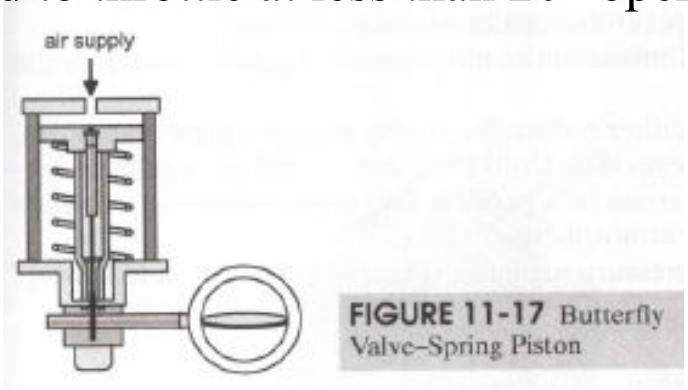
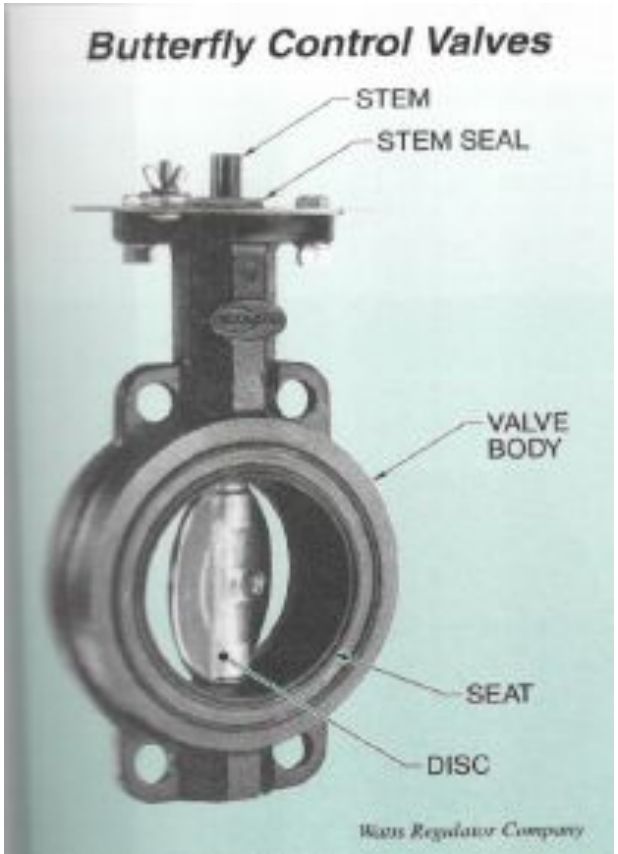



FIGURE 11-17 Butterfly Valve–Spring Piston



# Ball or Segmented Ball Control Valves

- The full ball control valve is a rotery valve that contains a spherical plug. The control valve actuators rotates the plug to control the flow of fluid through the valve body. By comparison,  a segmentd ball valve has one edge either contoured or havin V-shaped edge to yield  a desire flow charachteristic.
- Ball control valves may be used a tight shut-off or as a modulating valve offering high flow capacity because there are no internal obstructions when the valve is fully open.
- The spherical plug of the ball control valve is adaptable to function in the three way service

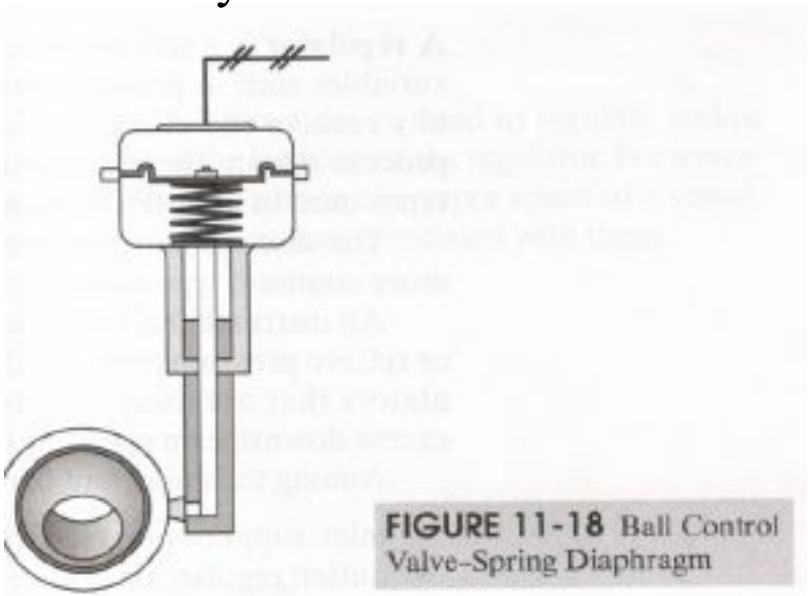


FIGURE 11-18 Ball Control Valve–Spring Diaphragm

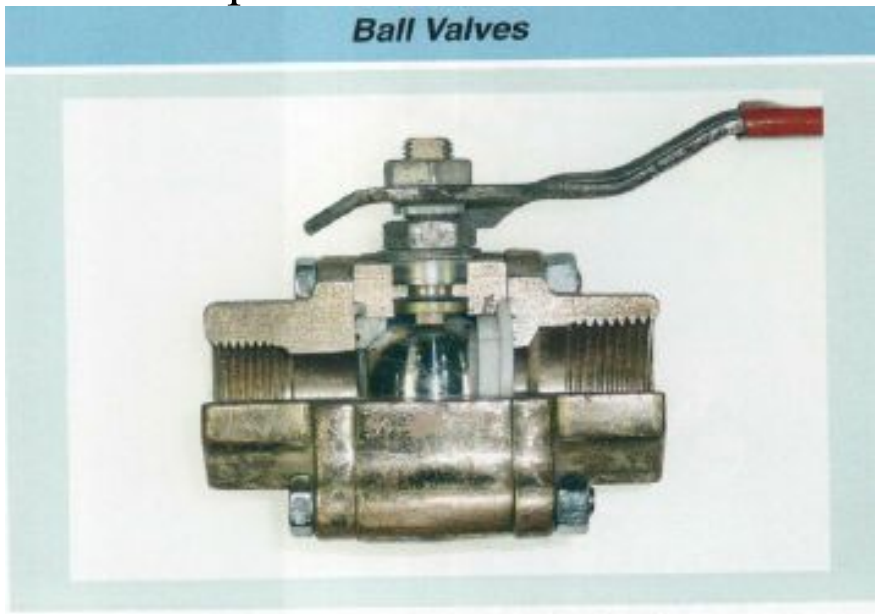



Figure 39-15. A ball valve works best for ON/OFF service.