2013

FATIMA FERTILIZER COMPANY LIMITED

INTERNSHIP REPORT

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University of Management Technologies Lahore

CONTENTS:

Acknowledgments:

I am thankful to

Allah Almighty,

For His boundless blessings and bounties,

And for keeping me sound and successful;

My parents and friends,

For all their support and trust in me and my aims;

My teachers and guides,

For teaching me things I knew not,

And last but not the least

Management and Employees of Fatima Fertilizer Company limited

Especially my mentors **Mr.Rafaqat** (Engineer 1) **and Mr. M.Junaid** (G.T.E)

Unit Manager (Instruments):**Mr. Asghar Ali Rana**

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Mr.Shafqat (Technician)

All the board men and area operators at different plants (NA, Urea, Ammonia)

For their utmost help, guidance and time

This made me make most of my internship at plant site.

INTRODUCTION:

"**The only source of knowledge is experience**" (Albert Einstein)

Industrial internships are an incomparable experience for an undergraduate student. With Fertilizers Industry holding the maximum learning potential for an electrical engineer, ***FATIMA FERTILIZERS*** leaves an impact of its own. The four weeks internship experience was unique in every sense of the word. The learning opportunities and Industrial exposure at ***FATIMAH*** not only related the book knowledge and to field application but also developed a thorough understanding of industrial practices and operating concepts.

During the course of my internship I visited various plants (e.g. Urea, Nitric-Acid, substations etc.)But the project assigned to me was regarding ***CONTROL VALVES***.

INTRODUCTION TO CONTROL VALVES:

One of the most common final control elements in industrial control system is *control valve.* A *control valve* works to restrict the flow of fluid through a pipe at the command of an automated signal from a loop controller or logic device (such as PLC). Some control valve designs are intended for discrete (on/off) control of a fluid flow, while others are designed to *throttle* fluid flow somewhere between fully open and fully closed. The electrical equivalent of an on/off valve is switch, while the electrical equivalent of a throttling valve is variable resistor.

Control valves are comprised of two major parts, the *valve body* which contains all the mechanical components necessary to influence fluid flow and the *valve actuator,* which provides the mechanical power necessary to move the components with in the valve body. The major difference between an on/off control valve and throttling control valve is the type of actuator applied to the valve: on/off actuators need only position a valve mechanism to one of two extreme positions (fully open/fully closed). Throttling actuators must be able to accurately position a valve mechanism anywhere between those extremes.

TYPES OF CONTROL VAVES:

1. *SLIDING STEM VALVES:*

   A *sliding-stem valve* is one that actuates with a linear motion. Some examples of sliding stem valve body designs are listed below:

   - *Single-ported globe valve*
   - *Double-ported globe valve*
   - *Gate valve*
   - *Diaphragm valve*

Single-ported globe valve: Single-ported globe control valves type Z (for gases) is used in automatic and remote control systems to control flow of gases and liquids. Wide range of material and design versions make the valves widely sought-after in chemical industry, heat and power generation industry, paper industry, food industry, metallurgy and coal mining.

YD100S/ YD100E/ YD101S

Globe valves:

Globe valves restrict the flow of fluid by altering the distance between a movable plug and a stationary seat (in some cases, a pair of plugs and matching seats). Fluid flows through a hole in the center of the seat, and is more or less restricted by how close the plug is to that hole. The globe valve design is one of the most popular sliding-stem valve designs used in throttling service. A photograph of a small globe valve body appears here:

A set of three photographs showing a cut-away *Masoneilan model* 21000 globe valve body illustrates just how the moving plug and stationary seat work together to throttle flow in a direct-acting globe valve. The left-hand photo shows the valve body in the fully closed position, while the middle photo shows the valve half-open, and the right-hand photo shows the valve fully open:

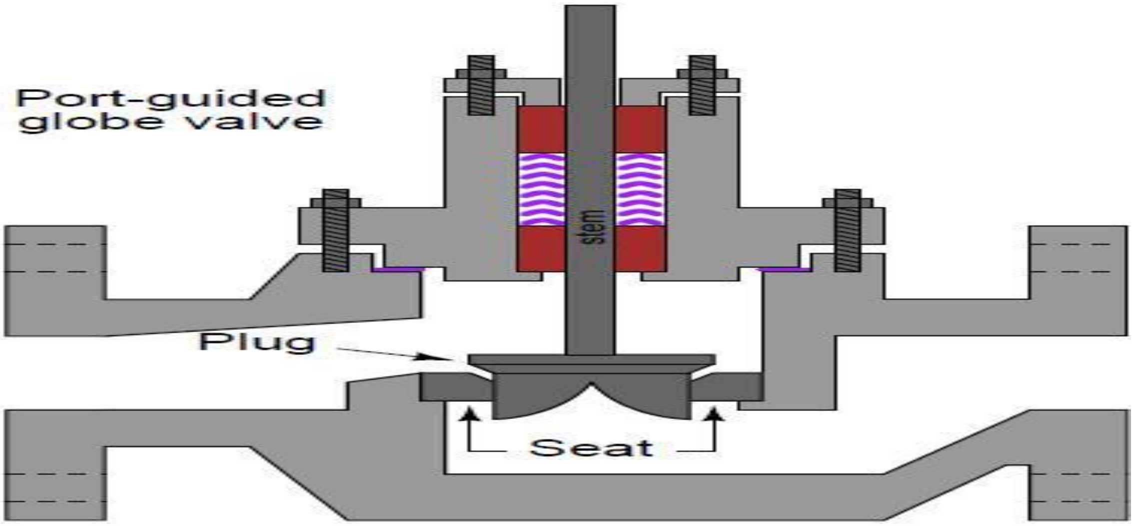


It can be seen from these photographs that the valve plug is guided by the stem so it always lines up with the centerline of the seat. For this reason, this particular style of globe valve is called a *stem-guided globe valve.*

A variation on the stem-guided globe valve design is the needle valve, where the plug is extremely small in diameter and usually fits well into the seat hole rather than merely sitting on top of it. Needle valves are very common as manually-actuated valves used to control low flow rates of air or oil. A set of three photographs shows a needle valve in the fully-closed, mid-open, and fully-open positions (left-to-right):

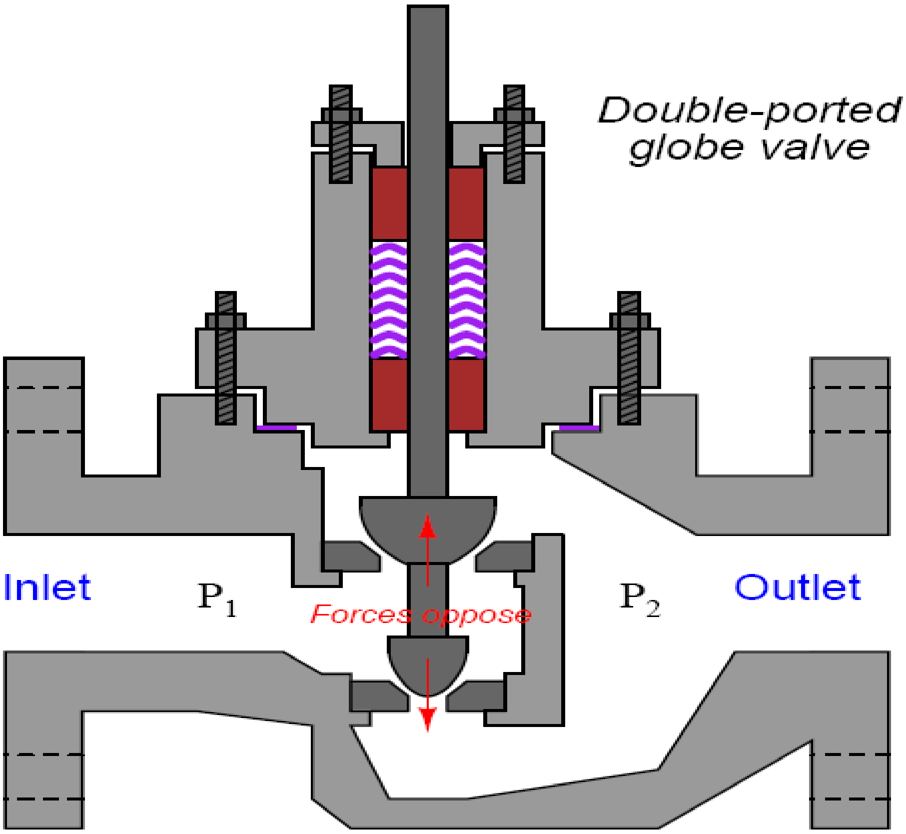


Yet another variation on the globe valve is the port-guided valve, where the plug has an unusual shape that projects into the seat. Thus, the seat ring acts as a guide for the plug to keep the centerlines of the plug and seat always aligned, minimizing guiding stresses that would otherwise be placed on the stem. This means that the stem may be made smaller in diameter than if the valve trim were stem-guided, minimizing sliding friction and improving control behavior.



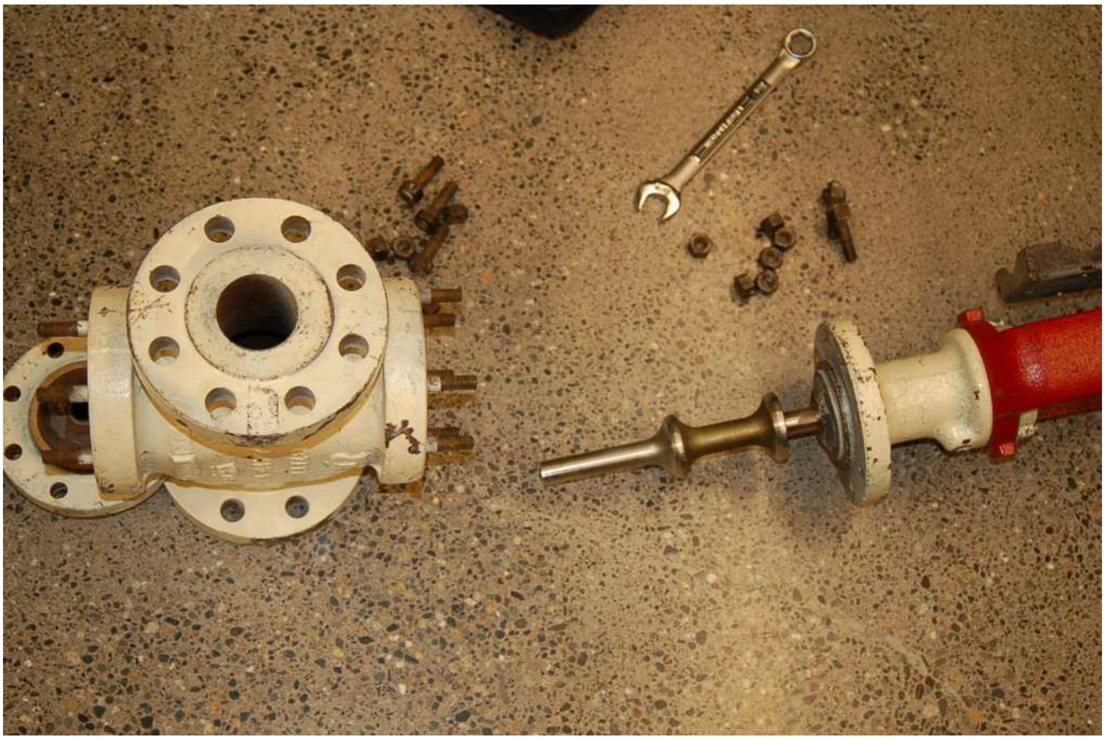
Double-ported globe valves:

These valves with pressure balanced plug are used as final flow control valves (units) for automatic and remote control systems. They can be applied to adjust flow of fluids in various industries, such as chemical plants, steelworks, shipyards, etc. The purpose of double-ported control valve is to minimize the force applied to the stem by the process fluid pressure across the plugs.



Differential pressure of the process fluid (P1 − P2) across a valve plug will generate a force parallel to the stem as described by the formula F = PA, with A being the plug's effective area presented for the pressure to act upon. In a single-ported globe valve, there will only be one force generated by the process pressure. In a double-ported globe valve, there will be two opposed force vectors, one generated at the upper plug and another generated at the lower plug. If the plug areas are approximately equal, then the forces will likewise be approximately equal and therefore nearly cancel. This makes for a control valve that is easier to actuate (i.e. the stem position is less affected by process fluid pressures).

The following photograph shows a disassembled Fisher "A-body" double-ported globe valve, with the double plug plainly visible on the right:



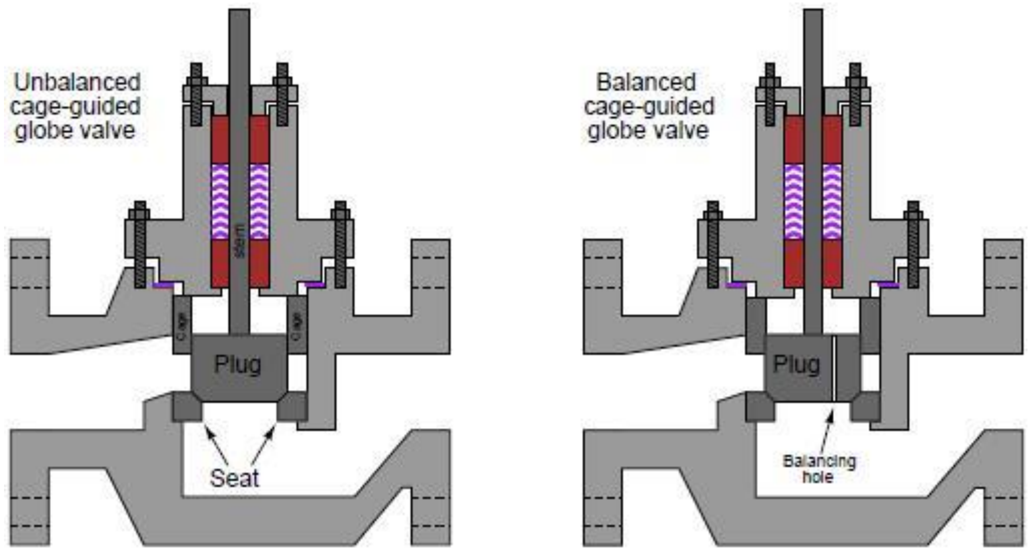
While double-ported globe valves certainly enjoy the advantage of easier actuation compared to their single-ported cousins, they also suffer from a distinct disadvantage: the near impossibility of tight shut-off. With two plugs needing to come to simultaneous rest on two seats to achieve a fluid-tight seal, there is precious little room for error or dimensional instability. Even if a double-ported valve is prepared in a shop for the best shut-off possible, it may not completely shut off when installed due to dimensional changes caused by process fluid heating or cooling the valve stem and body. This is especially problematic when the stem is made of a different material than the body.

Globe valve stems are commonly manufactured from stainless steel bar stock, while globe valve bodies are commonly cast of iron.

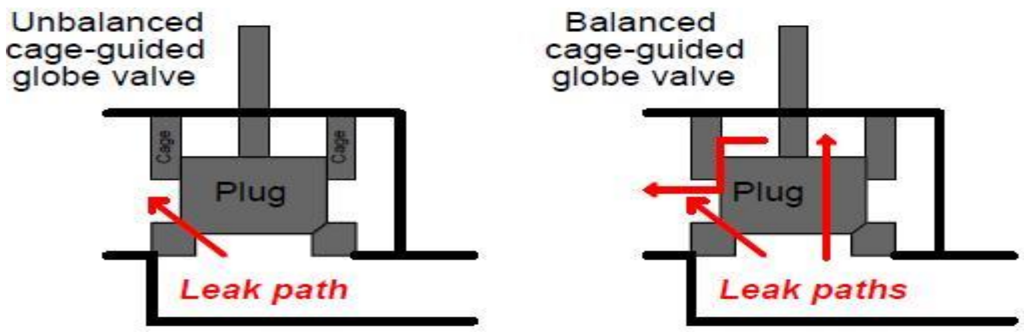
A more modern version of the globe valve design uses a piston-shaped plug inside a surrounding cage with ports cast or machined into it. These cage-guided globe valves throttle flow by uncovering more or less of the port area in the surrounding cage as the plug moves up and down. The cage also serves to guide the plug so the stem need not be subjected to lateral forces as in a stem-guided valve design. A photograph of a cut-away control valve shows the appearance of the cage (in this case, with the plug in the fully closed position). Note the "T"-shaped ports in the cage, through which fluid flows as the plug moves up and out of the way:

An advantage of the cage-guided design is that the valve's flowing characteristics may be easily altered just by replacing the cage with another having different size or shape of holes. Many different cage styles are available for certain plug (piston) sizes, which mean the plug need not be replaced while changing the cage. This is decidedly more convenient than the plug change necessary for changing characteristics of stem-guided or port-guided globe valve designs.

Cage-guided globe valves are available with both balanced and unbalanced plugs. A balanced plug has one or more ports drilled from top to bottom, allowing fluid pressure to equalize on both sides of the plug. This helps minimize the forces acting on the plug which must be overcome by the actuator:



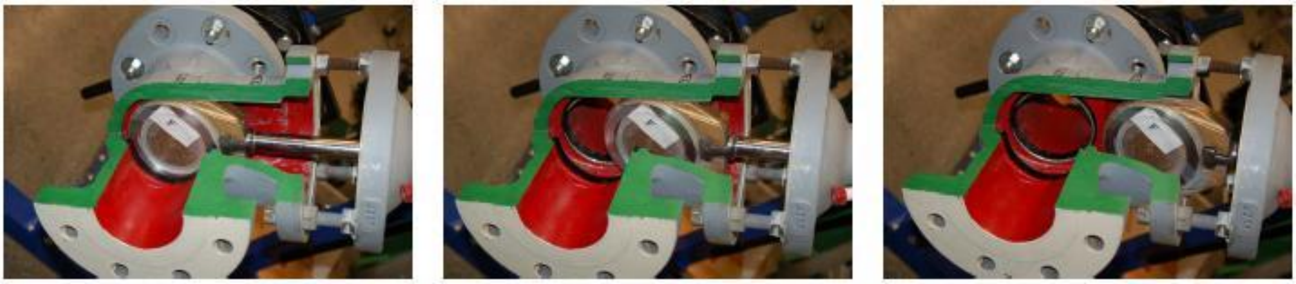
Unbalanced plugs generate a force equal to the product of the differential pressure across the plug and the plug's area (F = PA), which may be quite substantial in some applications. *Balanced plugs* do not generate this same force because they equalize the pressure on both sides of the plug, however, they exhibit the disadvantage of one more leak path when the valve is in the fully closed position (through the balancing ports, past the piston ring, and out the cage ports):

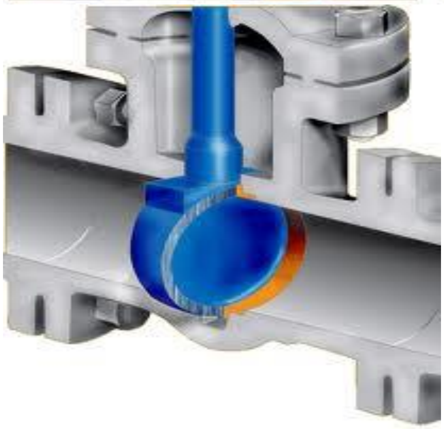


Gate valves:

Gate valves work by inserting a dam ("gate") into the path of the flow to restrict it, in a manner similar to the action of a sliding door. Gate valves are more often used for on/off control than for throttling.

The following set of photographs shows a hand-operated gate valve (cut away and painted for use as an instructional tool) in three different positions, from full closed to full open (left to right):





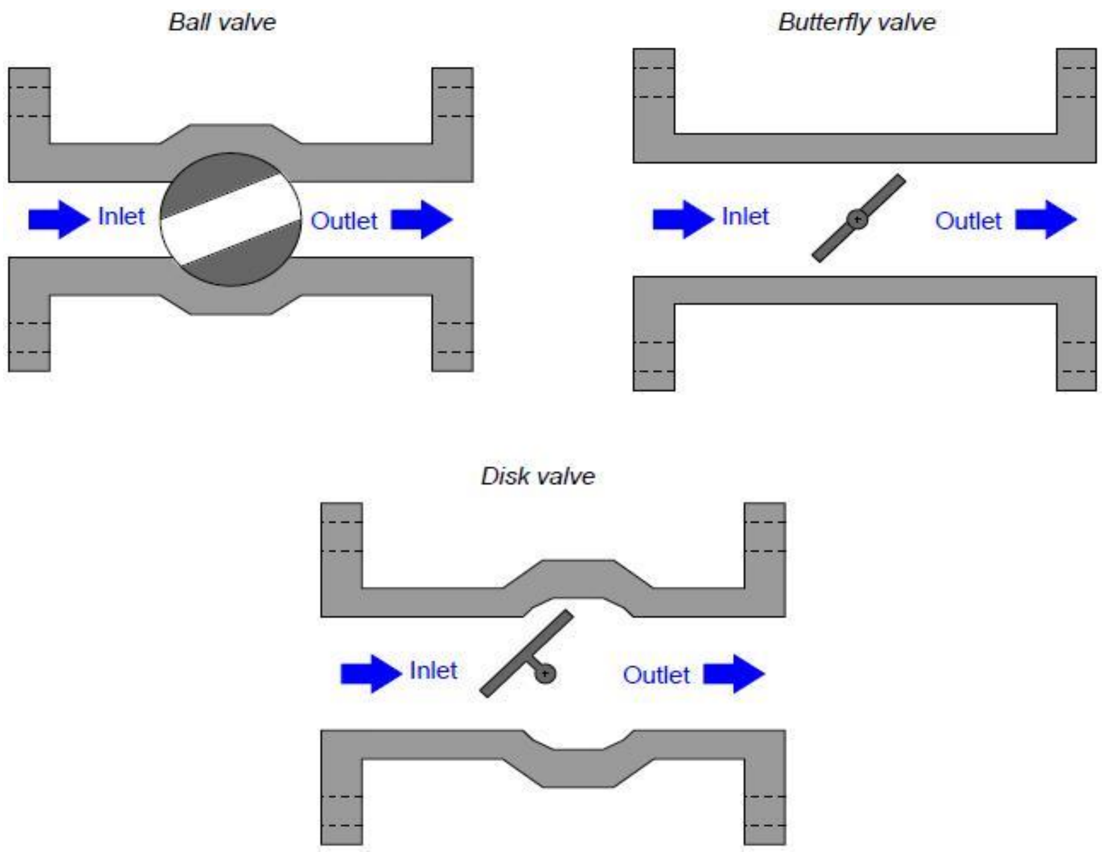
Diaphragm valves:

Diaphragm valves use a flexible sheet pressed close to the edge of a solid dam to narrow the flow path for fluid. These valves are well suited for flows containing solid particulate matter such as slurries, although precise throttling may be difficult to achieve due to the elasticity of the diaphragm. The next photograph shows a diaphragm valve actuated by an electric motor, used to control the flow of treated sewage:

The standard preparatory technique is called *lapping.* To "lap" a valve plug and seat assembly, an abrasive paste known as lapping compound is applied to the valve plug(s) and seat(s) at the areas of mutual contact when the valve is disassembled. The valve mechanism is reassembled, and the stem is then rotated in a cyclic motion such that the plug(s) grind into the seat(s), creating a matched fit. The precision of this fit may be checked by disassembling the valve, cleaning off all remaining lapping compound, applying a metal-staining compound such as Prussian blue, then reassembling. The stem is rotated once more such that the plug(s) will rub against the seat(s), wearing through the applied stain. Upon disassembly, the worn stain may be inspected to reveal the extend of metal-to-metal contact between the plug(s) and the seat(s). If the contact area is deemed insufficient, the lapping process may be repeated.

2. *Rotary-stem valves:*

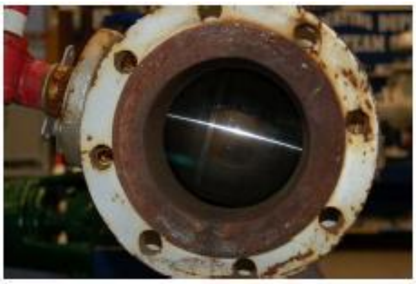
A different strategy for controlling the flow of fluid is to insert a rotary element into the flow path. Instead of sliding a stem into and out of the valve body to actuate a throttling mechanism, rotary valves rely on the rotation of a shaft to actuate the trim. An important advantage of rotary control valves over sliding-stem designs such as the globe valve and diaphragm valve is a virtually obstructionless path for fluid when the valve is wide-open.



Ball valves:

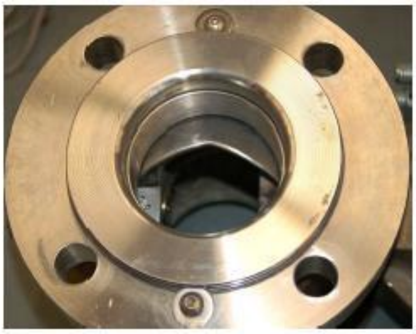
In the *ball valve* design, a spherical ball with a passageway cut through the center rotates to allow fluid more or less access to the passageway. When the passageway is parallel to the direction of fluid motion, the valve is wide open; when the passageway is aligned perpendicular to the direction of fluid motion, the valve is fully shut (closed).

The following set of photographs shows a hand-operated ball valve in three different positions, from nearly full closed to nearly full open (left to right):



Simple ball valves with full-sized bores in the *rotating ball* are generally better suited for on/off service than for throttling (partially-open) service. A better design of ball valve for throttling service is the characterized or segmented ball valve, shown in various stages of opening in the following set of photographs:





The V-shaped notch cut into the opening lip of the ball provides a narrower area for fluid flow at low opening angles, providing more precise flow control than a plain-bore ball valve.

Butterfly valve:

Butterfly valves are quite simple to understand: the “butterfly” element is a disk that rotates perpendicular to the path of fluid flow. When parallel to the axis of flow, the disk presents minimal obstruction; when perpendicular to the axis, the disk completely blocks any flow. Fluid-tight shutoff is difficult to obtain in the classic butterfly design unless the seating area is lined with a soft (elastic) material.

Disk valves:

Disk valves (often referred to as eccentric disk valves or as high-performance butterfly valves) are a variation on the butterfly design intended to improve seat shut-off. The disk's center is offset from the shaft centerline, causing it to approach the seat with a "cam" action that results in high seating pressure. Thus, tight shut-off of flow is possible even when using metal seats and disks.

The following photograph shows the body of a Fisher E-plug control valve, with the disk in a partially-open position:

Of course, gate valves also offer obstructionless flow when wide-open, but their poor throttling characteristics give most rotary valve designs the overall advantage.

Valve Actuators:

Valve actuators provide force to move control valve trim. For precise positioning of a control valve, there must be a calibrated relationship between applied force and valve position. Most pneumatic actuators exploit Hooke's Law to translate applied air pressure to valve stem position.

$$F = kx$$

Where,

F = Force applied to spring in newton's (metric) or pounds (British)

k = Constant of elasticity, or "spring constant" in newton's per meter (metric) or pounds per foot (British)

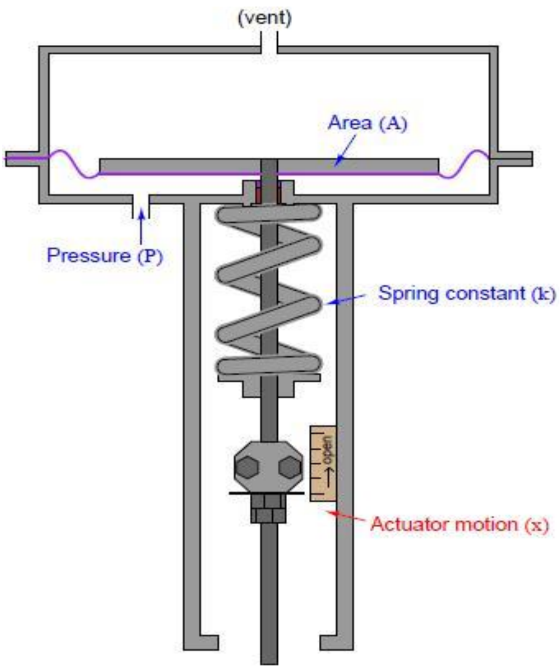
x = Displacement of spring in meters (metric) or feet (British)

Hooke's Law is a linear function, which means that spring motion will be linearly related to applied force from the actuator element (piston or diaphragm). Since the working area of a piston or diaphragm is constant, the relationship between actuating fluid pressure and force will be a simple proportion (F = PA). By algebraic substitution, we may alter Hooke's Law to include pressure and area:

$$F = kx$$

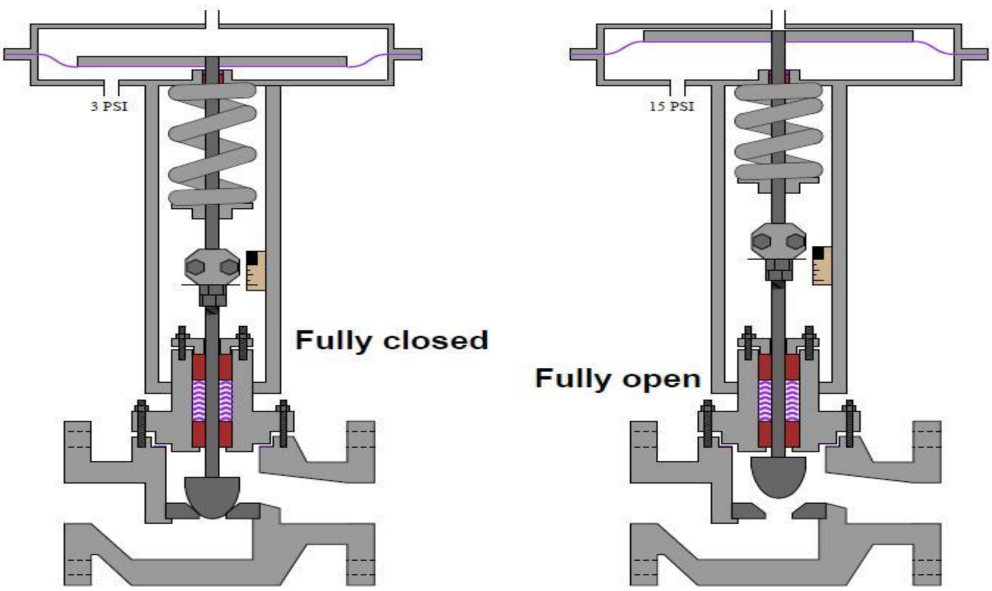
$$PA = kx$$

Solving for spring compression as a function of pressure, area, and spring constant:



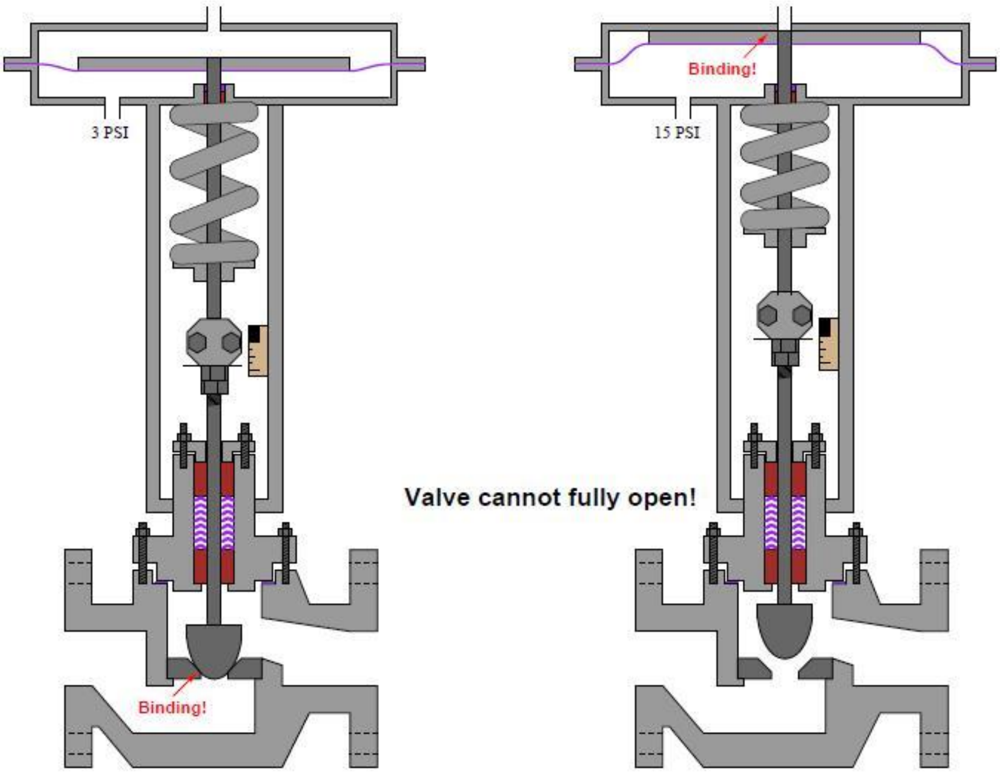
When a control valve is assembled from an actuator and a valve body, the two mechanisms must be coupled together in such a way that the valve moves between its fully closed and fully open positions with an expected range of air pressures. A common standard for pneumatic control valve actuators is 3 t015PSI.

There are really only two mechanical adjustments that need to be made when coupling a pneumatic diaphragm actuator to a sliding-stem valve: the stem connector and the spring adjuster. The stem connector mechanically joins the sliding stems of both actuator and valve body so they move together as one stem. This connector must be adjusted so neither the actuator nor the valve trim prevents full travel of the valve trim:



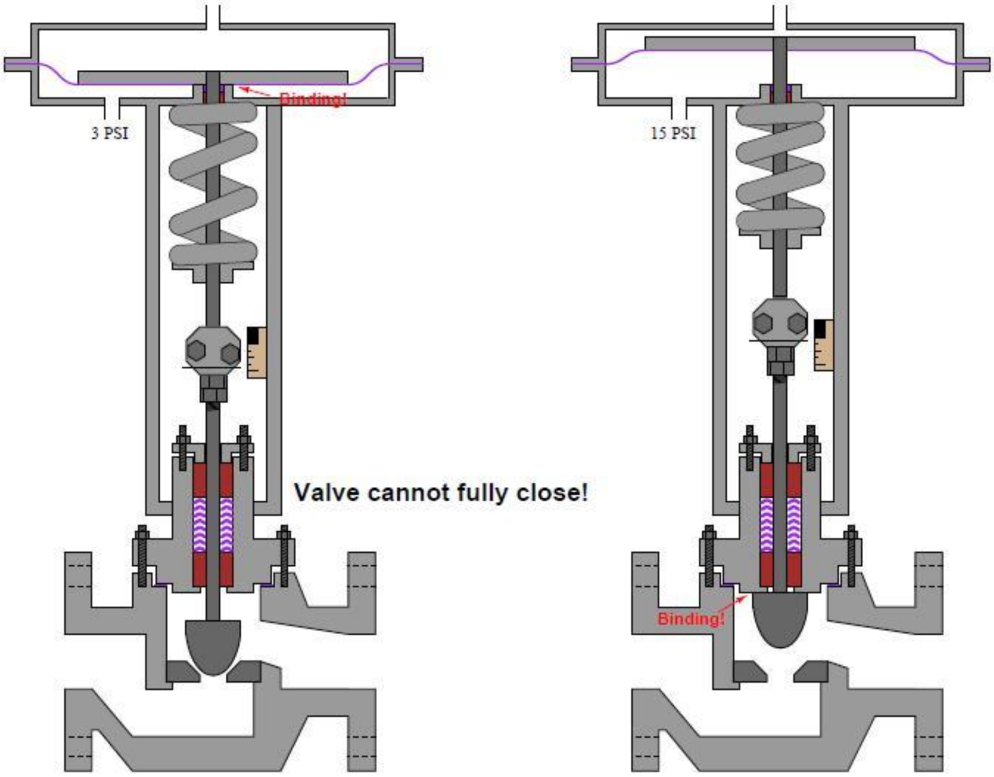
Note how the plug is fully against the seat when the valve is closed, and how the travel indicator indicates fully open at the point where the actuator diaphragm nears its fully upward travel limit. This is how things should be when the stem connector is properly adjusted.

If the stem connector is set with the actuator and valve stems spaced too far apart (i.e. the total stem length is too long), the actuator diaphragm will bind travel at the upper end and the valve plug will bind travel at the lower end. The result is a valve that cannot ever fully open:



A control valve improperly adjusted in this manner will never achieve full-flow capacity, which may have an adverse impact on control system performance.

If the stem connector is set with the actuator and valve stems too closely coupled (i.e. the total stem length is too short), the actuator diaphragm will bind travel at the lower end and the valve plug will bind travel at the upper end. The result is a valve that cannot ever fully close:



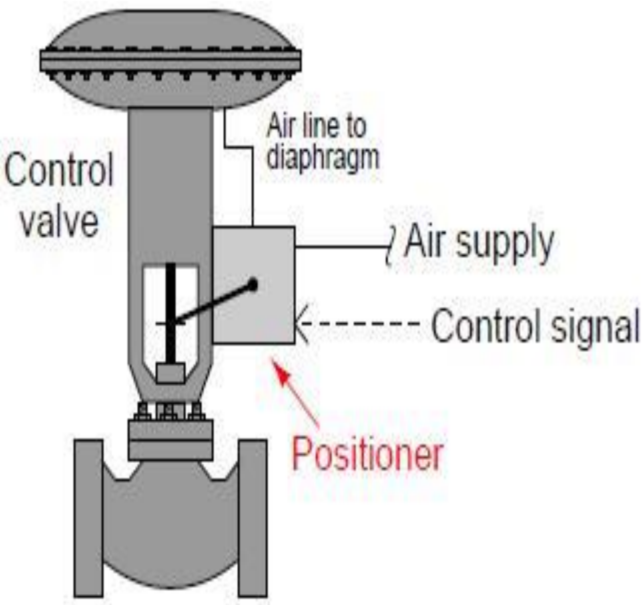
This is a very dangerous condition: a control valve that lacks the ability to fully shut off. The process in which this valve is installed may be placed in jeopardy if the valve lacks the ability to stop the flow of fluid through it!

Once the stem length has been properly set by adjusting the stem connector, the spring adjuster must be set for the proper bench set pressure. This is the pneumatic signal pressure required to lift the plug off the seat. For an air-to-open control valve with a 3 to 15 PSI signal range, the “bench set” pressure would be 3 PSI.

Bench set (actuator) is a very important parameter for a control valve because it establishes the *seating pressure* of the plug when the valve is fully closed. Proper seating pressure is critical for tight shut-off, which carries safety implications in some process services. Consult the manufacturer’s instructions when adjusting the bench set pressure for any sliding-stem control valve. These instructions will typically guide you through both the stem connector and the spring adjuster procedures, to ensure both parameters are correctly set.

Valve Positioners:

A positioner is a motion-control device designed to actively compare stem position against the control signal, adjusting pressure to the actuator diaphragm or piston until the correct stem position is reached:



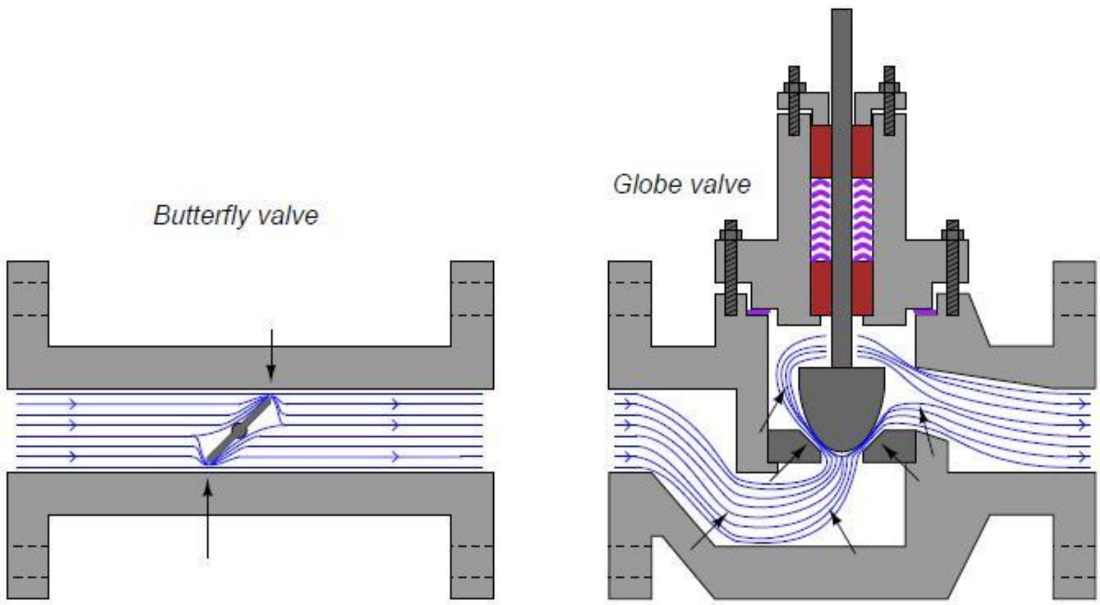
Positioners essentially act as control systems within themselves: the valve's stem position is the process variable (PV), the command signal to the positioner is the set point (SP), and the positioner's signal to the valve actuator is the manipulated variable (MV) or output. Thus, when a process controller sends a command signal to a valve equipped with a positioner, the positioned receives that command signal and does its best to ensure the valve stem position follows along.

The *positioner* is the grey-colored box with three pressure gauges on the right-hand side:

Control valve sizing:

When control valves operate between fully open and fully shut, they serve much the same purpose in process systems as resistors do in electric circuits: to dissipate energy. Like resistors, the form that this dissipated energy takes is mostly heat, although some of the dissipated energy manifests in the form of vibration and noise.

In most control valves, the dominant mechanism of energy dissipation comes as a result of turbulence introduced to the fluid as it travels through constrictive portions of the valve trim. The following illustration shows these constrictive points within two different control valve types (shown by arrows):



The act of choosing an appropriate control valve for the expected energy dissipation is called *valve sizing*.

Control Valve problems:

Control valves are subject to a number of common problems. This section is dedicated to an exploration of the more common control valve problems, and potential remedies.

Mechanical friction:

Control valves are mechanical devices having moving parts, and as such they are subject to friction, primarily between the valve stem and the stem packing. Some degree of friction is inevitable in valve packing, and the goal is to minimize friction to a bare minimum while still maintaining a pressure-tight seal.

In physics, friction is classified as either *static* or *dynamic*. *Static friction* is defined as frictional force holding two stationary objects together. *Dynamic friction* is defined as frictional force impeding the motion of two objects sliding past each other. Static friction is almost always greater in magnitude than dynamic friction. Anyone who has ever pulled a sled through snow or ice knows that more force is required to “break” the sled loose from a stand-still (static friction) than is required to keep it moving (dynamic friction). The same holds true for packing friction in a control valve: the amount of force required to initially overcome static friction between the valve stem and the packing usually exceeds the amount of force required to maintain a constant speed between a moving valve stem and a stationary packing.

The presence of packing friction in a control valve increases the force necessary from the actuator to cause valve movement. If the actuator is electric or hydraulic, the only real problem with increased force is the additional energy required from the actuator to move the valve (recall that mechanical work is the product of force and parallel displacement). If the actuator is pneumatic, however, a more serious problem arises from the combined effects of static and dynamic friction.

Flashing:

When a fluid passes through the constrictive passageways of a control valve, its average velocity increases. This is predicted by the Law of Continuity, which states that the product of fluid density (ρ), cross-sectional area of flow (A), and velocity (v) must remain constant for any flow stream:

$$\rho_1 A_1 \overline{v_1} = \rho_2 A_2 \overline{v_2}$$

This holds true for the control valves as they throttle the flow rate of a fluid by forcing it to pass through a narrow constriction. As fluid velocity increases through the constrictive passages of a control valve, the fluid molecules' kinetic energy increases. In accordance with the Law of Energy Conservation, potential energy in the form of fluid pressure must decrease correspondingly. Thus, fluid pressure decreases within the constriction of a control valve's trim as it throttles the flow, then increases (recovers) after leaving the constrictive passageways of the trim and entering the wider areas of the valve body:

A photograph showing a badly eroded valve plug (from a cage-guided globe valve) reveals just how destructive flashing can be:

A characteristic effect of flashing in a control valve is a "hissing" sound, reminiscent of what sand might sound like if it were flowing through the valve.

One of the most important performance parameters for a control valve with regard to flashing is its pressure recovery factor. This factor compares the valve's total pressure drop from inlet to outlet versus the pressure drop from inlet to the point of minimum pressure within the valve.

$$F_L = \sqrt{\frac{P_1 - P_2}{P_1 - P_{vc}}}$$

Where,

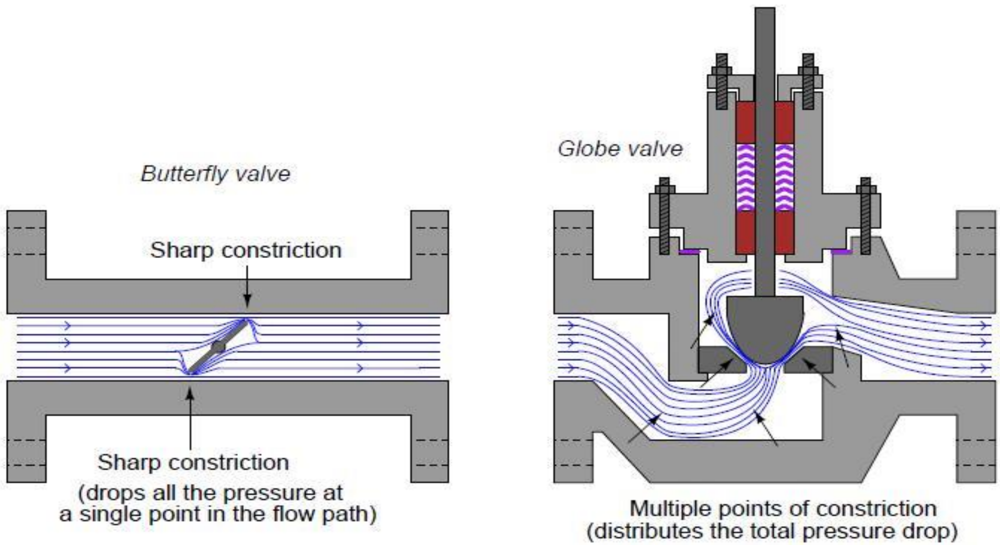
FL = Pressure recovery factor (unit less)

P1 = Absolute fluid pressure upstream of the valve

P2 = Absolute fluid pressure downstream of the valve

Pvc = Absolute fluid pressure at the ***vena contracta*** (point of minimum fluid pressure within the valve).

Compare these two styles of valve to see which will have lowest pressure recovery factor and therefore be most prone to flashing:



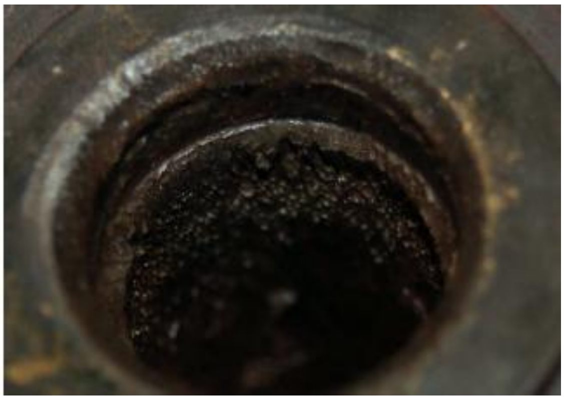
Clearly, the globe valve does a better job of evenly distributing pressure losses throughout the path of flow. By contrast, the butterfly valve can only drop pressure at the points of constriction between the disk and the valve body, because the rest of the valve body is a straight-through path for fluid offering little restriction at all. As a consequence, the butterfly valve experiences a much lower vena contracta pressure (i.e. greater pressure recovery, and a lower FL value) than the globe valve for any given amount of permanent pressure loss, making the butterfly valve more prone to flashing than the globe valve with all other factors being equal.

Cavitation:

After *flashing*, if the pressure recovers to a point greater than the vapor pressure of the liquid, the vapor will recondense back into liquid again. This is called ***cavitation***.

Fluid passing through a control valve experiences changes in velocity as it enters the narrow constriction of the valve trim (increasing velocity) then enters the widening area of the valve body downstream of the trim (decreasing velocity). These changes in velocity result in the fluid molecules' kinetic energies changing as well, in accordance with the kinetic energy equation Ek = 12mv2. In order that energy is conserved in a moving fluid stream, any increase in kinetic energy due to increased velocity must be accompanied by a complementary decrease in potential energy, usually in the form of fluid pressure. This means the fluid's pressure will fall at the point of maximum constriction in the valve (the *vena contracta*, at the point where the trim throttles the flow) and rise again (or recover) downstream of the trim:

Photographs of a fluted valve plug and its matching seat are shown here as evidence of flashing and cavitation damage, respectively:



The plug of this valve has been severely worn by flashing and cavitation. The flashing damage is responsible for the relatively smooth wear areas seen on the plug. Cavitation damage is most prominent inside the seat, where almost all the damage is in the form of pitting.

References:

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Control Valve Sourcebook – Power & Severe Service, Fisher Controls International, Inc., Marshalltown, IA, 1988.

Control Valve Handbook, Third Edition, Fisher Controls International, Inc., Marshalltown, IA, 1999.