

Chapter 6

Pressure and Surge Control

CHAPTER 6 PRESSURE AND SURGE CONTROL

TABLE OF CONTENTS

PART	6.1	PIPELINE PRESSURE CONTROL	6-1
	6.1.1	Need for Pressure Control	6-1
	6.1.2	Pressure Reducing Valves	6-1
	6.1.3	Grade Break at Tank	6-4
PART	6.2	SURGE CONTROL	6-6
	6.2.1	Pressure Tank as Surge Chamber	6-6
	6.2.2	Minimize Frequency of Pump Cycle	6-7
		Flow Control Valve	6-9
		Flow Controlled Pressure Switch	6-9
		Pump Cycle Timer	6-9
	6.2.3	Install Air Valve	6-11
	6.2.4	Use Slow Closing Valves	6-11
	6.2.5	Control Flow Rate at Float Valve	6-11
	6.2.6	Operation Plan	6-11

FIGURE

Figure	6.1	Typical Pressure Reducing Valve Installation	6-2
Figure	6.2	Pressure Valve Parts and Design Charts	6-3
Figure	6.3	Float Valve Box	6-5
Figure	6.4	Operation of a Surge Chamber	6-7
Figure	6.5	Remote Multi-Tank Installation	6-8
Figure	6.6	Flow Rate Controller Valves	6-10
Figure	6.7	Flow Controlled Pressure Switch	6-11

CHAPTER 6

PRESSURE AND SURGE CONTROL

6.1 PIPELINE PRESSURE CONTROL

6.1.1 Need for Pressure Control

There are frequent circumstances in long pipelines where the operating pressures at hydrants are too high. Due to the limitations of hydrant and float valve mechanisms, maximum pressure at a hydrant and/or float valve should be limited to not more than 80 psi. Where pressure exceeds 80 psi, it should be reduced before flow is turned into the valve.

The cost of high pressure pipe can sometimes be reduced by installing a pressure reducing station in the pipeline. This allows using a pipe with lower pressure rating. The cost savings must always be weighed against potential operation and maintenance problems which are frequently a result of installing a pressure reducing valve.

There are two ways to reduce pressure in a segment of pipeline: (1) Install a pressure reducing valve and (2) Install a tank with a float valve and a gravity pipeline extension.

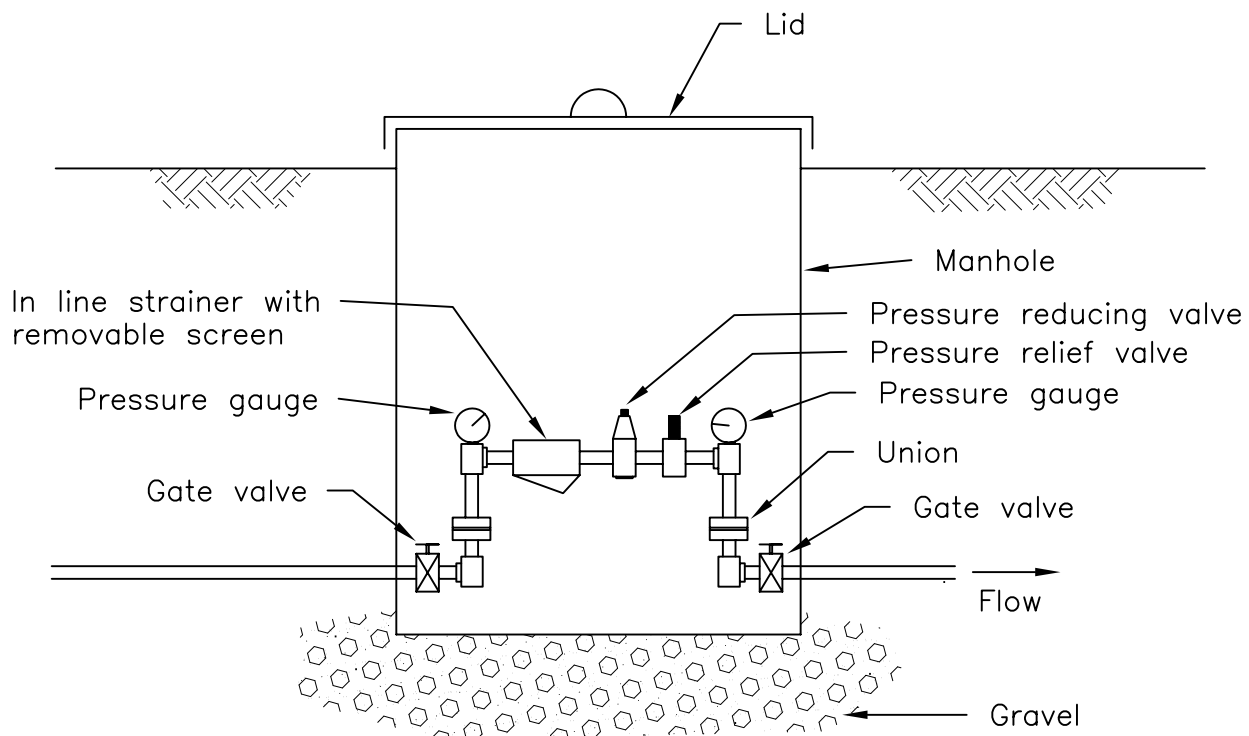
Pressure reducing valves or tank/float valves should be used as a last resort. They are mechanical devices that can and do sometimes fail. In many cases there is no other way to maintain pressures below 80 psi, so a pressure reducing device must be installed.

Examples in Chapter 9 show how to perform hydraulic calculations where pressure reduction is required.

6.1.2 Pressure Reducing Valves

Figure 6.1 illustrates a typical pressure reducing valve installation.

Figure 6.1
TYPICAL PRESSURE REDUCING VALVE INSTALLATION

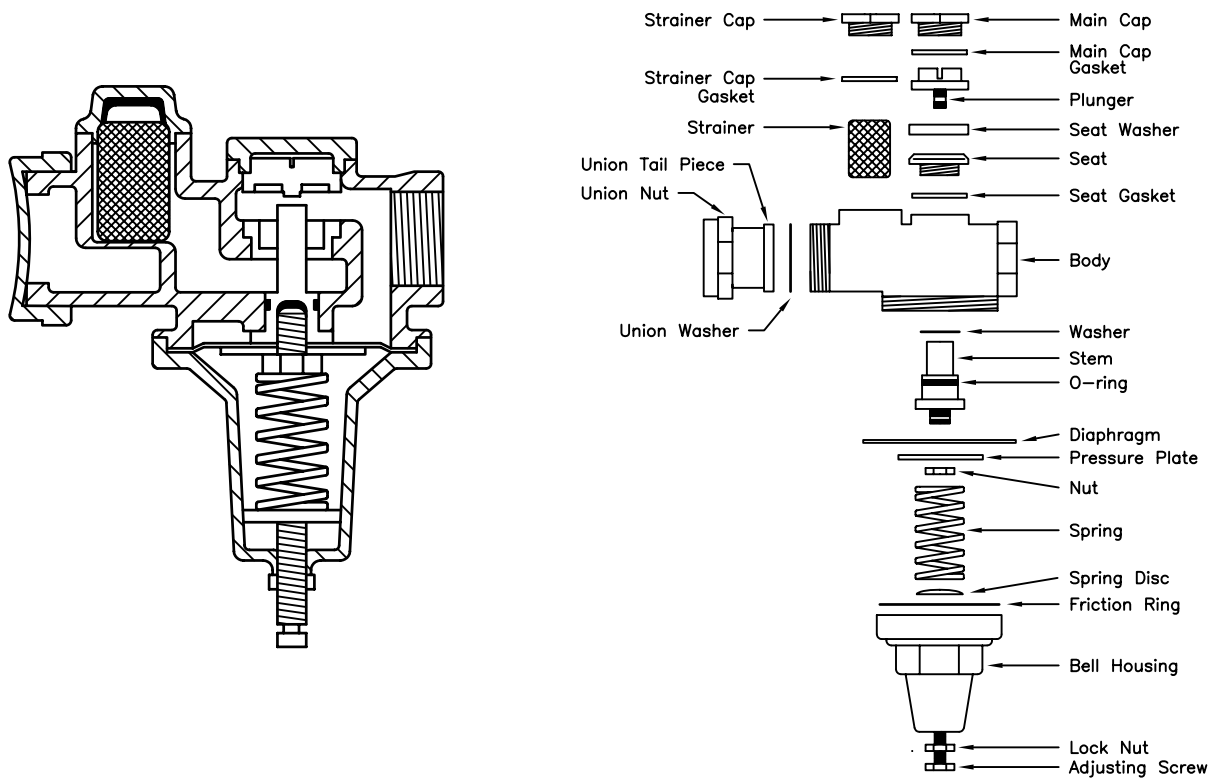


Pressure reducing valve size should be selected based on manufacturer's recommendations. Too small a valve will create very high velocities in the valve and cause rapid valve failure. Too large a valve will cause poor pressure regulation.

If the valve installation as shown in Figure 6.1 is at a high point in the pipeline, an air release valve or combination valve may also be required, as described in Chapter 7.

Figure 6.2 illustrates construction of a typical pressure reducing valve and a manufacturer design chart.

Figure 6.2
PRESSURE VALVE PARTS AND DESIGN CHARTS



Engineering Data

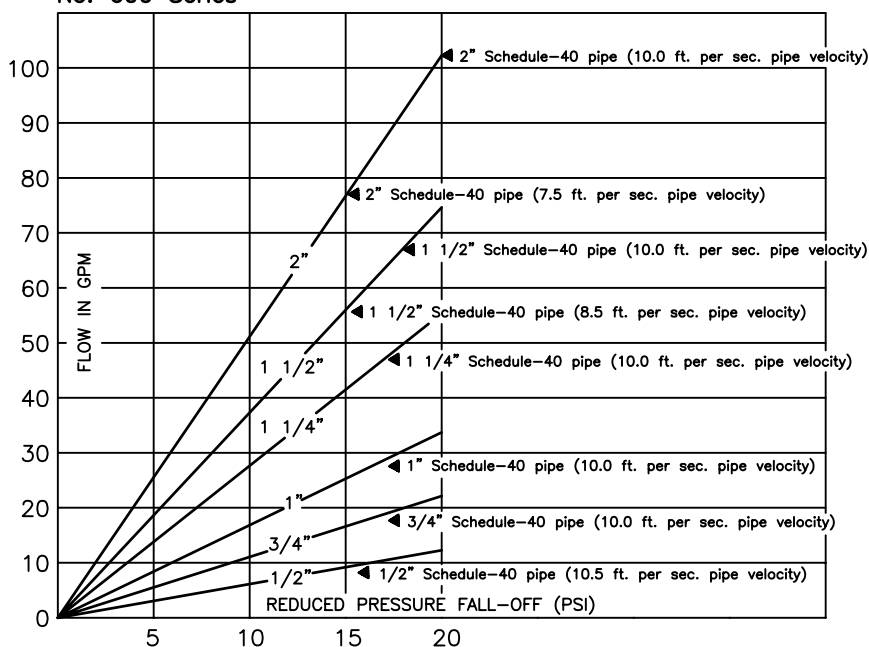
(water capacities)
Wilkins No. 600 series pressure
reducing valves.

Pressure diff. = inlet pressure
minus set pressure.

Fall-Off = set pressure minus
delivery pressure.

Pipe Size	Capacity in GPM based on		
	Average Velocity		10 Ft. Per Sec. Velocity
	Vel. (Ft.)	gpm	gpm
1/2"			9.47
3/4"			16.60
1"	(9.5)	25.0	26.90
1 1/4"	(9.0)	42.0	46.70
1 1/2"	(8.5)	54.8	64.50
2"	(7.5)	77.5	104.60

No. 600 Series



The valve illustrated in Figure 6.2 has a built-in strainer. Pressure reducing valves will not operate properly if debris get into the mechanism. Many pressure reducing valves have the small built in screens shown. Sediment and debris are enough of a problem in some pipelines that the screen soon becomes clogged. A more elaborate filter system may be required. If so, the types of filters used in home filter systems or trickle irrigation systems can be used.

Manufacturer's charts show the maximum capacity for each size of valve based on design velocity. The flow rates in stockwater pipelines are usually so low that maximum flow rate is usually not a problem.

There is a pressure reducing valve pressure loss called "Fall-off" that must be considered in design. When no flow is passing through the valve there is zero fall-off. When maximum rated flow is passing through the valve there is up to 20 psi pressure fall-off. So if the pressure reducer is set at 75 psi at no flow, the static hydraulic grade line would be at $(75 \times 2.31) = 173$ feet above valve elevation. If the valve were to operate at design flow, hydraulic grade line would start at the valve at $[(75 - 20) \times 2.31] = 127$ feet above valve elevation.

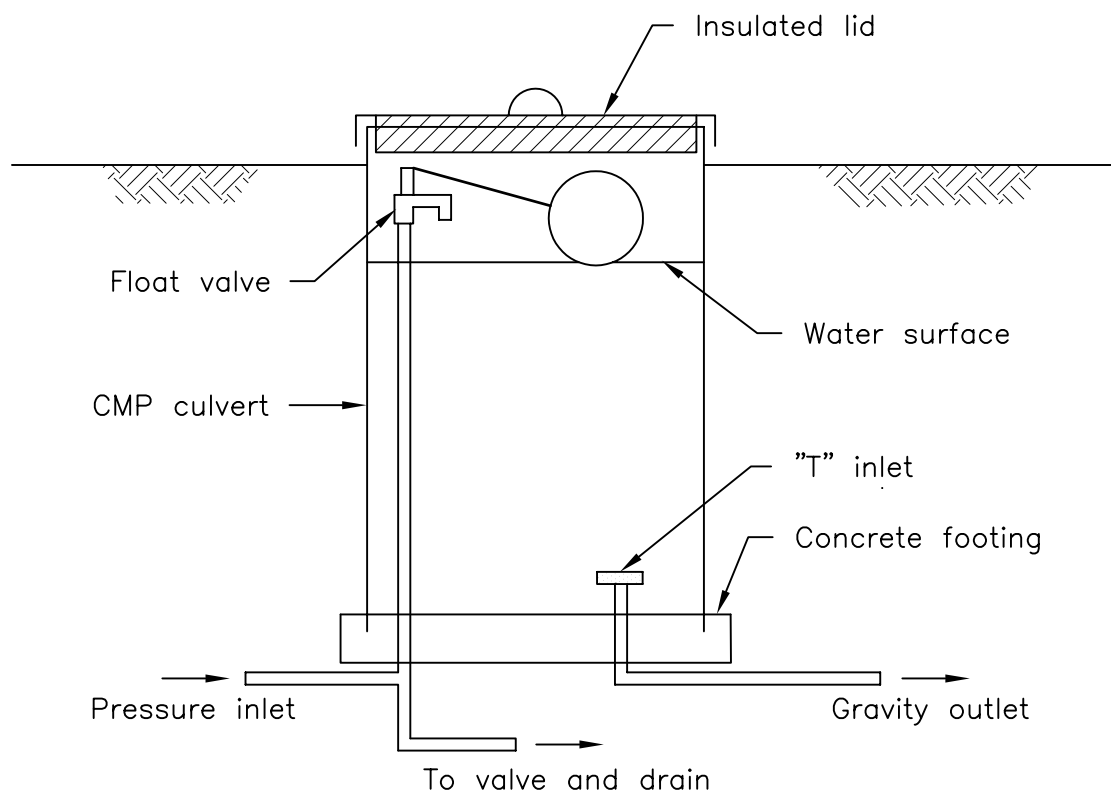
Figure 6.2 illustrates typical manufacturer information concerning valve fall-off values.

6.1.3 Grade Break at Tank

Starting a gravity pipeline at a tank is one positive way of controlling pressure in a segment of pipeline. If the float valve hangs up, the tank simply overflows. Both static and dynamic hydraulic grade line starts at the water surface in the tank. Only a usually insignificant pipeline entrance loss is experienced under design flow.

Figure 6.3 illustrates one type of tank/float valve installation. This is a small tank with a float valve strictly used for pressure regulation. A stock tank can be used in the same way. A strainer should always be added at the intake.

Figure 6.3
FLOAT VALVE BOX



6.2 SURGE CONTROL

Surge (water hammer) can be a serious problem in long stockwater pipelines. Consider what happens when a two mile long pipeline is suddenly shut off. The entire mass of water in the pipe is moving in the direction of flow. When the water is suddenly shut off, considerable force is required to stop the momentum of the large water mass.

Actual pressure build up depends on the total volume of water in the pipe, velocity at which the water is moving, and how fast the water is stopped. Surge pressures can be much greater than operating pressure, and can even be greater than static pressure in the pipeline.

In low pressure pipelines, surge is usually not a significant consideration. The pipe and appurtenances have high enough safety factors to withstand minor surges. Surge is almost always a factor that must be addressed in long, high pressure pipelines where water flow can be suddenly stopped for any reason..

A frequent surge problem is encountered on pumped systems. When the pump shuts off, the water starts to reverse in the line. A check valve closes, setting up a pressure wave and cyclic pressure surges. If the pump system contains an automatic pressure switch, the pump can rapidly cycle on and off causing damage to the pump, pipeline, and valves.

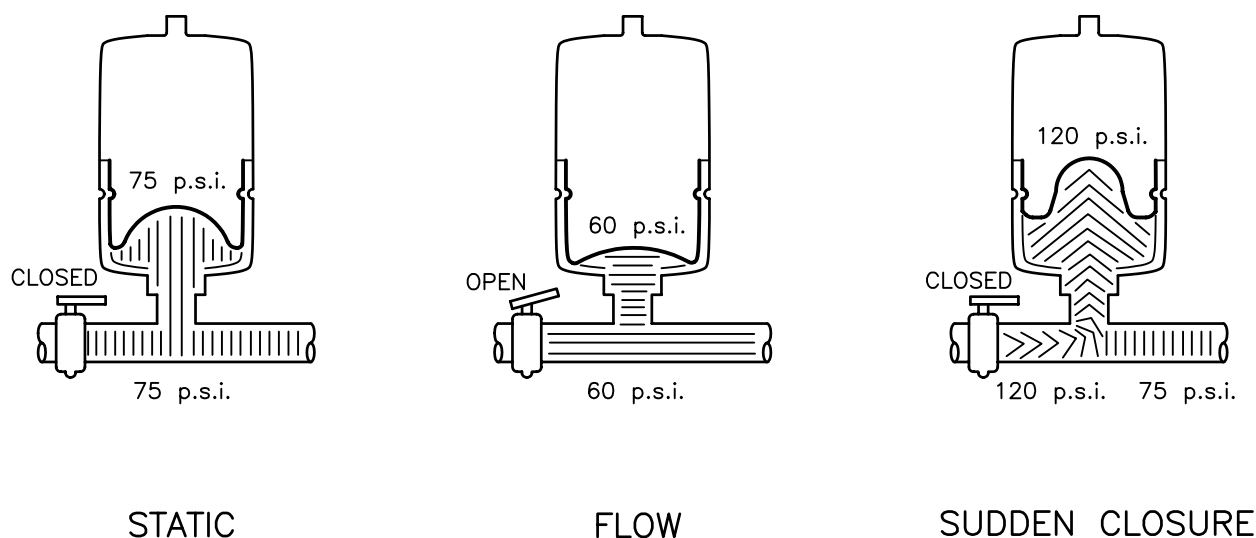
Another frequent cause of surges is rapidly turning off a hydrant. Frost free hydrants can be shut off very rapidly by slamming down the handle. This is sure to cause surges in the pipeline. Float valves will also be turned rapidly on or off if something causes the water in the tank to slosh around.

Ways in which surge can be controlled include:

6.2.1 Pressure Tank as Surge Chamber

For automatic pressure systems, a properly maintained pressure tank may act as a surge chamber. The air bubble in the pressure tank acts as a cushion for water reversing in the pipeline. Figure 6.4 illustrates how a surge chamber works.

Figure 6.4
OPERATION OF A SURGE CHAMBER



Sometimes when pressure at the pump is very high, a normal pressure tank cannot be used. In that case, it may be necessary to install a high pressure rated diaphragm-type pressure tank, or specially designed surge chamber. These are expensive but may be needed in high pressure automatic systems.

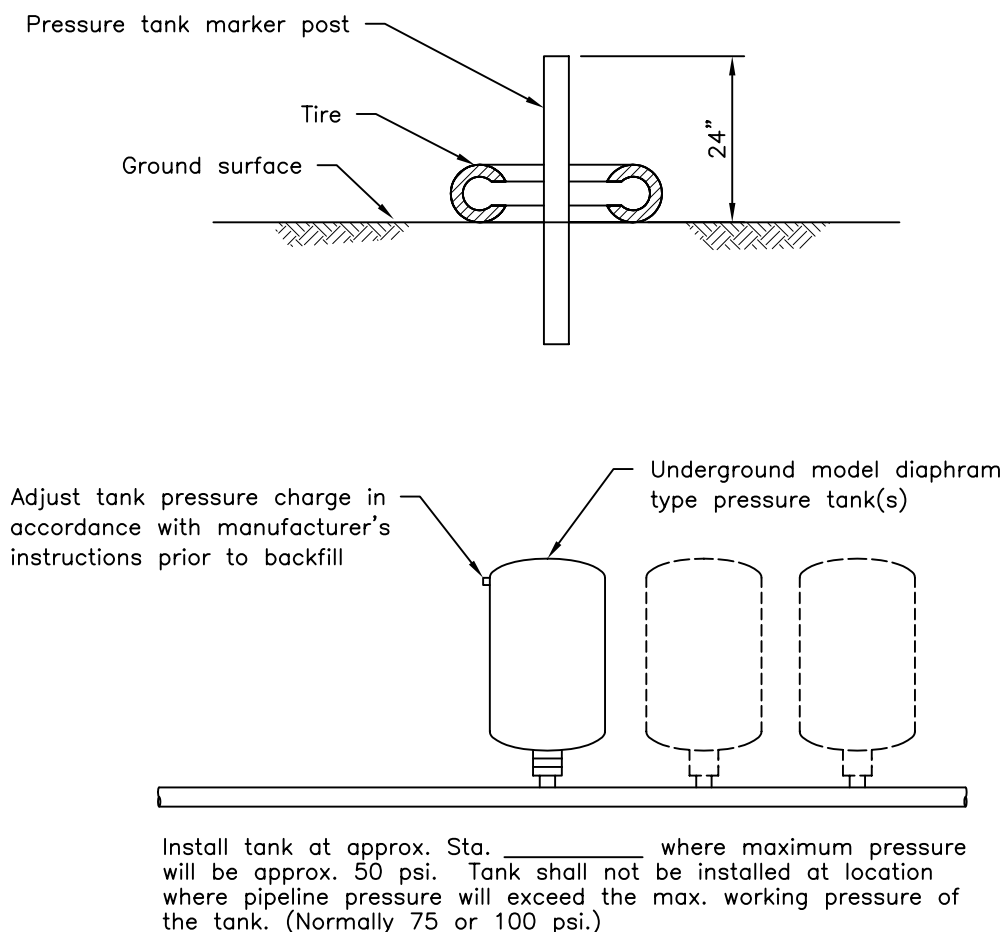
It is sometimes proposed that a homemade surge chamber be installed. This is a piece of pipe capped at one end and an air valve installed in the outer end. The chamber is filled with compressed air after the system is pressurized with water.

Homemade surge chambers are not recommended. Experience and studies have shown that this type of chamber soon waterlogs and becomes completely ineffective.

6.2.2 Minimize Frequency of Pump Cycles

Minimize the frequency of turning the pump on or off. This will reduce the number of surges that pipeline and system will have to endure. This can be accomplished by increasing pressure tank storage. Figure 6.5 illustrates a remote multiple tank setup for increased storage.

Figure 6.5
REMOTE MULTI-TANK INSTALLATION



Remote tanks can generate problems of their own. When the remote tank is far out on the pipeline, hydraulic conditions can be such that, during initial pump flow, friction loss in the pipe will cause pressure to build up to cut out pressure and turn the pump off before the remote tanks have filled to design pressure. As pressure in the system equalizes, the pump will again start. A rapid cycling can be set up which can be very destructive to pump and pipeline.

Three possible solutions to this problem are:

Flow Control Valve

If this problem is encountered, one solution is to install an adjustable flow rate control valve in the pipeline near the pump. With this valve, flow rate is adjusted downward until rapid cycling is stopped. Figure 6.6 illustrates this type of installation and two types of flow rate control valves. The valves shown are expensive.

Sometimes rubber orifice flow control valves of the type used to control flow to sprinkler heads or trickle system laterals in irrigation systems can be used to control flow in moderate pressure systems. These non-adjustable flow control valves are inexpensive.

Flow Controlled Pressure Switch

There is a pressure regulator/pressure switch combination valve which works so that once the pump comes on, it will not shut off until all flow in the system has stopped. This guarantees that the pump will not cycle except between flow events. Figure 6.7 illustrates this type of valve. There are two models with different flow rate ratings. At least two pump manufacturer's supply this type of valve as an accessory.

If either of the above two valves are used make sure that the pressure rating of the pipe between the pump and the valve is high enough to withstand the maximum pressure the pump is capable of generating. This will require a review of the pump curve. With these types of valves the pressure between pump and valve will reach the maximum that the pump is able to generate.

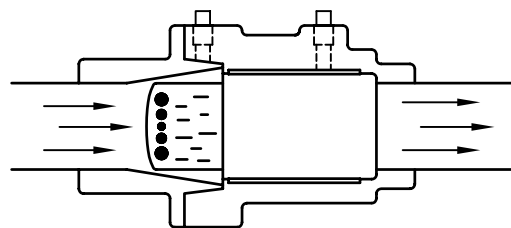
Pump Cycle Timer

Another possible solution is to install short period timers in conjunction with the pressure switch. The timer is set in a manner that will force minimum pump on or off cycle times. It will be especially important to have adequate pressure tank storage; tank, pipe and accessories rated for maximum pump pressure, and pressure relief valves installed if this alternative is selected.

Figure 6.6
FLOW RATE CONTROLLER VALVES

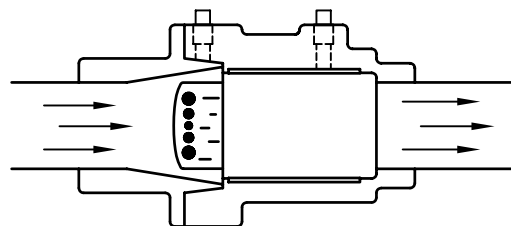
Below the control range

The cup is fully extended exposing the maximum orifice area. In this range the valve acts as a variable flow device, allowing flow to be varied. Once the rated flow is achieved, the cup compresses, blocking the exposed orifice area to limit flow.



Within the control range

The cup modulates in response to pressure differential fluctuations. This motion will vary the exposed orifice area to maintain a constant flow rate within a $\pm 5\%$ accuracy.



Above the control range

Once the pressure differential across the valve has exceeded the upper control limit, the cup compresses fully against a stop. Now with a minimal orifice areas exposed, the valve acts as a fixed orifice device to allow the continuation of flow.

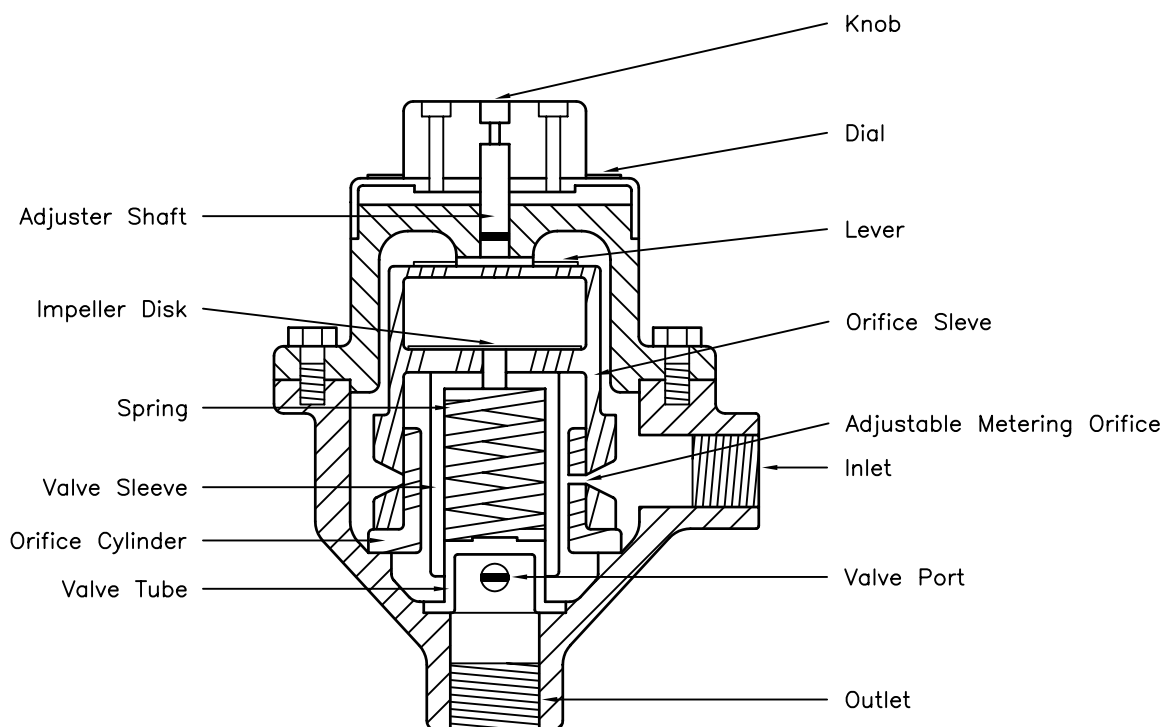
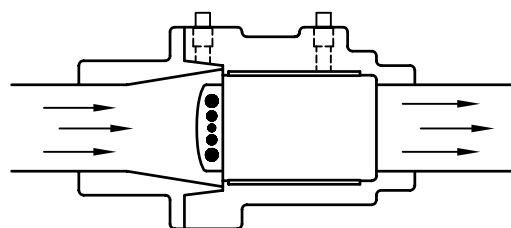
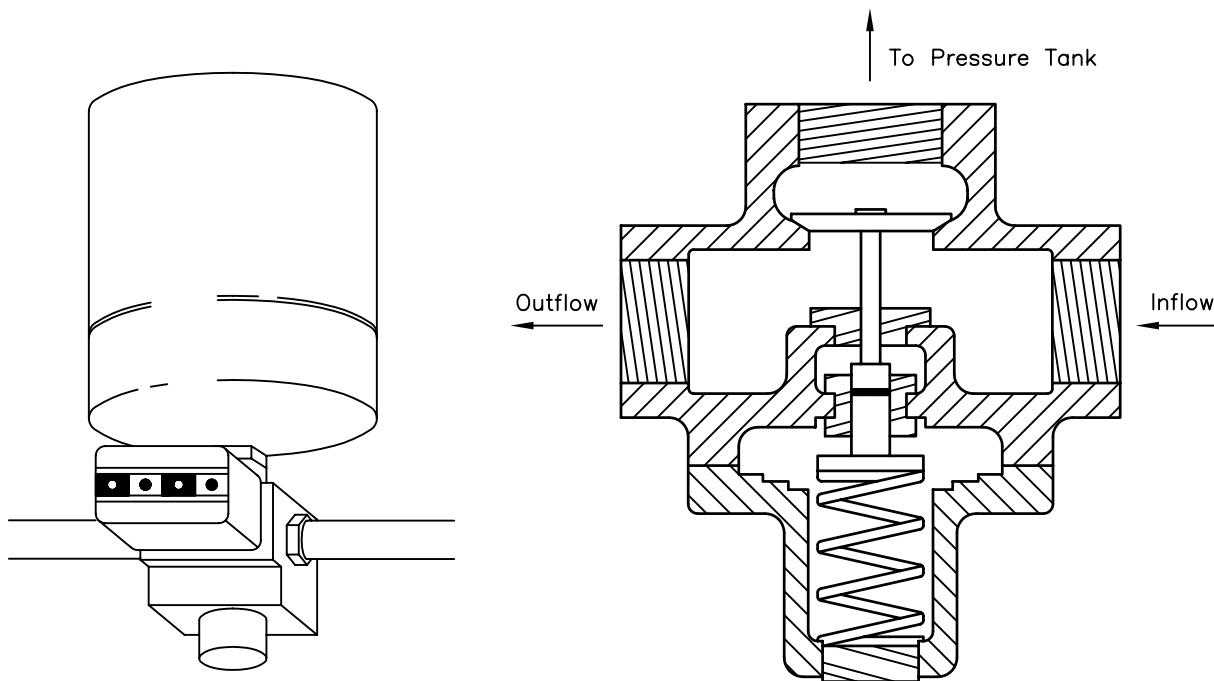


Figure 6.7
FLOW CONTROLLED PRESSURE SWITCH



6.2.3 Install Air Valves

Remnants of air in the pipeline can set up conditions that promote surges. Air valves or vents should be installed in the pipeline to remove air under pressure. See Chapter 7 for more details on air removal.

6.2.4 Use Slow Closing Valves

Install throttling type globe valves instead of frost free hydrants. Globe valves must be installed in access risers so that they are below frost line.

6.2.5 Control Flow Rate at Float Valve

Control the maximum flow rate through a float valve by installing an orifice or a flow control valve. Low cost rubber orifice type flow control valves of the type used in sprinkler systems can be installed just ahead of the float valve.

9.2.6 Operation Plan

Provide an operation plan to the operator cautioning to close valves slowly and otherwise operate the system in a manner which will minimize surges in the system.