Determining Required Valve Pressure Ratings

The rated close-off pressure for a combination of actuator, linkage and valve is the **differential** pressure it can close against. This pressure must be higher than the maximum differential pressure the valve will be subject to in the installation.

In a variable flow system (2-way valves) without pressure control, the close-off pressure is the maximum pressure the pump can produce. We do not subtract flow losses between the pump and the valve. When no water is flowing, the valve sees the full pump pressure.

In a constant flow system (3-way valves), the differential pressure across the valve is essentially constant. In order to get a safety margin, the close-off pressure is calculated 1.5 times the differential pressure. Since water is always flowing, the valve will never see the full pump pressure.

There are variable flow systems which use 3-way valves to provide minimum flow at the furthest terminals (10-15%). These three-way valves are subject to a variable differential pressure. The maximum differential pressure is the pump head minus the pressure drop across the balancing valve. These valves see more of the pump pressure as the 2-way valves close down.

Valves have a number of pressure conditions which must be considered. **They have two ratings — 1) body and stem static rating, and 2) disc and seat close-off rating.**

Static rating is the amount of total pressure which the body and stem seal must hold against without leaking.

Close off is the differential across the disc against which the valve can hold without leaking.

Steam valves should be selected for the boiler rating. For example, if an 18 psi boiler pressure is maintained, they the valve must hold against 18 psi (and 260℉).

Water valves require a bit more consideration. In Figure 32 there are several conditions which must be evaluated to determine the pressure ratings required of the valve.

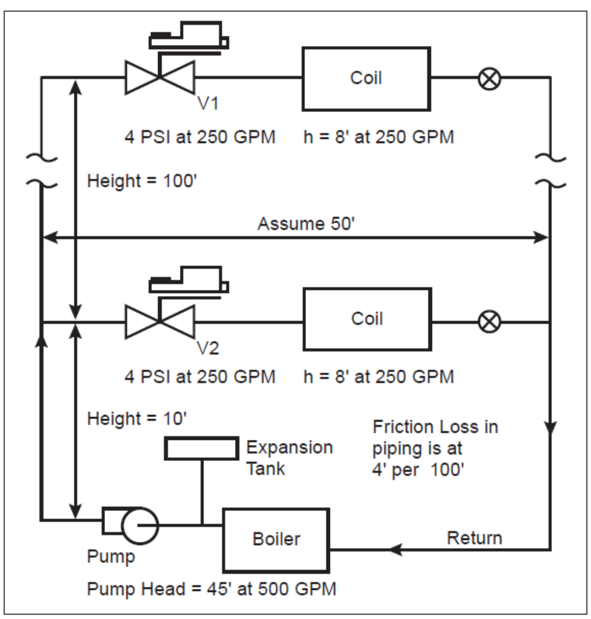

Figure 32 - Boiler, pump and piping system

Static head
The pressure on the pump when the system is off is the weight of the column of water above it.

V1 has almost no pressure on it. It is on the top floor, and there is no piping above it. The system has a fill pressure which is typically 20 psi.

V2 has 100' of water pressure on it. We do not know the diameter of the pipe, but it does not matter. We know that there is 1 psi per 2.3' column height. Thus 100' is 100/2.3 = 44 psi static pressure. The column of water is on both sides of the valve, but this is inconsequential.

Fill pressure
By applying a fill pressure that is 20 psi higher than the static pressure, a sufficient pressurization is achieved. This gives 44 + 20 = 64 psi for V2 in the example above. V1 would have only the fill pressure of 20 psi.

Pump pressure
When the pump is running and the valves are full open, then the head at the valve inlet is the sum of the various heads.

There is about 130' of pipe on the way to V1, and the piping loss typical average is 4' per 100' of run. The loss is about 5'.

V1 has the pressure of the pump or 45' less the piping losses of 5' on the way to the valve or 40'. This is 40/2.3 - 17 psi of pump pressure.

V2 has about 25' of pipe between it and the pump for 1' of friction loss. 45 - 1 = 44' of pump head or 44/2.3 = 19 psi of pump pressure.

Total pressure
The total for V1 will be 17 psi pump + 20 psi fill gives 37 psi. The total for V2 will be 44 psi column height + 19 psi pump + fill pressure of 20 psi = 83 psi. (The balancing valve will be taking a good deal of pressure loss in this circuit.)

Dead head pressure
Many systems do not have supply to return bypass pressure control. Both valves could be near closed and take full pump pressure.

When V1 and V2 are both closed, the whole pump pressure appears at the inlet of V1 and V2. In this system there is no pressure control, and it would be possible for the pump to dead head. There is usually some system pressure control. Three-way valves or a supply to return bypass would accomplish this. The pump curve becomes important in this case. Typically the pump curve has from 30 to 45 degree slope. At no or very low flow, the pump pressure could rise to say double the design operating point or 90'. The valves would have to withstand pump pressure of 90/2.3 or 40 psi. The pump curve must be examined. It is rare to allow the pumps to deadhead against the valves. The design engineer has the data necessary to specify this pressure.

Thus the body static pressure rating is the sum of the column, fill, and pump pressures. The fill pressure and any column heights must be added to the pump pressure.

If 3-way valves were used, or if there were enough valves and a load situation to provide diversity, the pump pressure would never rise to this point because it would be relieved by the bypass or other valves.

Close-off pressure
Close off is the maximum differential which will appear across the valve disc and seat. It is necessary to choose the worst condition.

The **system off** condition has no differential across the valve. The weight of the water on each size balances; the fill pressure appears on both sides.

In **normal operation** with both valves full open, the pressures do not include the height of the columns of water; the supply and return cancel out. The fill pressure is seen on both sides of the valve also. The only pressure is the pump differential head, less the friction loss on the way to the valve. Both valves have a given 4 psi drop when full open.

If one valve were closed and the other open, the pump pressure would rise as flow volume went down. (This affects the flow quality of the partially open valve.) The pressure rise can only be found by examination of the pump curve.

If pressure control exists, then the pressure may not increase or will increase to a specified level. That level is the differential or close off pressure in this case.

As **both valves close** against full pump pressure, the worst close off condition exists. As assumed above, this could be near 40 psi pump pressure.

This is the differential or close off pressure in this case. The deadhead condition exists. Although rare, some systems experience this condition.

Typically the ANSI 125 class is sufficient since the typical pressures met in HVAC systems are in the order of 30 psi. Tall buildings have the same close off as low rises, but the static pressures could be high.

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In a constant flow system (3-way valves), the differential pressure across the valve is essentially constant. In order to get a safety margin, the close-off pressure is calculated 1.5 times the differential pressure. Since water is always flowing, the valve will never see the full pump pressure. Since the valves above are sized for a 4 psi drop, 6 psi is the close off required.

There are variable flow systems which use 3-way valves to provide minimum flow at the furthest terminals (10-15%.) These three-way valves are subject to a variable differential pressure. The maximum differential pressure is the pump head minus the pressure drop across the balancing valve. These valves see more of the pump pressure as the 2-way valves close down.

In a typical globe valve, the differential pressure acts upon the plug and produces a lifting force. The force is calculated by multiplying the area of the seat with the differential pressure. The actuator must be strong enough to overcome the lifting force and the friction in the box packing. Globe valves require a special linkage so a linear stem movement is accomplished. The force must be sufficient to produce the required close-off pressure. In order to overcome the friction in the box-packing of the valve, about 15 lbs. should be subtracted from the rated force of the linkage. Calculate the area of the seat. It is usually the same as the valve size. For example: 1.5” valve. Area = $\div r^2$ therefore 3.14 x $(1.5/2)^2$ = 1.77 sq. in. The rated force of the linkage is 150 lbs. Close-Off Pressure = (150 - 15)/1.77 = 85 psi.

Ball valves are operated by a quarter turn motion. The seats are pretensioned and exert a certain force upon the ball. The required torque is therefore the same regardless of the differential pressure up to a certain value (which usually is quite high). When this value is exceeded, the torque increases in proportion to the differential pressure. In addition the geometry of the ball valve is such that pressures are mostly balanced. They have very high close off ratings.

Butterfly valves have high dynamic forces when modulating. Dynamic forces acts upon the disk and produce either positive or negative torque depending upon the position of the disk. When closed the pressure on the 2 half sides of the blade are mostly balanced but the rubber seals require a high torque at close-off.