2-way v/s 3-way CONTROL VALVES

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What is the difference between a 3-way and 2-way control valve?

Can a 3-way control valve be used as a 2-way control valve by blanking off the bypass port?

What effect does it has on the Kv of the valve?

These were the questions asked by a pair of young engineers at the recently concluded ACREX 2008 in Bangalore and hence this article.

Valve Construction

In any type of 3-way valve, there are 3 ports. For mixing application - 2 inlets + 1 outlet and for diverting application - 1 inlet + 2 outlets. In both the cases one of the ports is called a "bypass" port because it allows the water to bypass the coil/load.

In a 2 way valve there is no bypass port. Yes, a 3 way valve can be used as a 2 way valve by blanking off the bypass port.

There are three types of 3-way valves in terms of construction: the globe type, rotating shoe/ slipper type and flapper type. It is possible to use slipper and flapper valve either in mixing or in diverting applications, whereas the construction of globe type 3-way diverting valve is different from that of a mixing valve.

In a 2-way valve there is no bypass port. A 3-way valve can be used as a 2-way valve by blanking off the bypass port. In fact, in some cases it may be better than using a 2-way valve as is explained here.

Valve Selection

The behavior of a modulating control system is influenced by the size of the control valve. The optimum size is that at which the full power of the system is reached only when the control valve is completely open.

The principal function of a control valve is to ensure the progressiveness of flow and it is the authority of the valve, which determines the stability of the control system.

The valve authority is determined by the Pressure Ratio

Where

$$a = \frac{\Delta P_V}{\Delta P_L + \Delta P_V}$$

ΔP_V = pressure loss of completely open valve at nominal flow

ΔP_L = pressure loss of variable volume section at nominal flow

Valves should be rated for a ≥ 0.5, i.e., the pressure loss of the open valve (ΔP_V) must be equal to or greater than the pressure loss of the quantity-variable volume section (ΔP_L).

An undersized control valve will incur high pumping cost, but better flow regulation, where as an oversized control valve will reduce pumping cost, but valve movement at the beginning, and the end, of the valve travel will have minimal effect on the distribution of the liquid. The valve authority provides a compromise between these two extremes.

Flow Coefficient

The control properties of valves are calculated by means of the flow coefficient.

The flow coefficient, Kv in metric units or Cv in British units, is defined as the flow rate through a device for a unit pressure drop.

Kv for a control valve is defined as, flow rate in m^3/hr for a pressure drop of 1 bar across the valve. Mathematically, it is expressed as

$$Kv = \frac{\text{Flow rate} - m^3/hr}{\sqrt{\text{Pressure drop across the device} - \text{bar}}}$$

Valve Kv

In a 3-way valve, pressure drop across the main port regulates the flow through the coil whereas pressure

drop across the bypass port regulates the flow through the bypass line, which means there are two flow control devices built-into one valve body. The flow coefficients of both these ports are independent of each other and during Kv testing of one port, say main port, the other port, i.e. bypass port, is blanked off.

Kv of the valve (main port) is calculated as under:

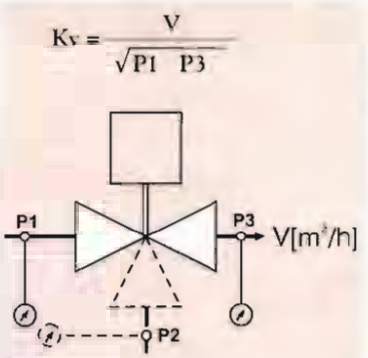
Kv = Flow coefficient in m^3/h at ΔPv of 100kPa (1bar)

$$Kv = \frac{V}{\sqrt{P1 \quad P3}}$$

V = Volume of water in m^3/h

P1 = Absolute pressure before the valve (inlet pressure) bar

P3 = Absolute pressure after the valve in bar

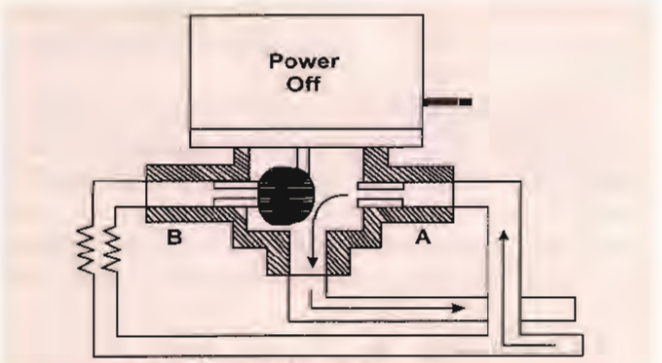


The Kv value of a 3-way valve provided by the manufacturer is the Kv of the fully open main port and it remains unchanged irrespective of whether the bypass port is being used or blanked off.

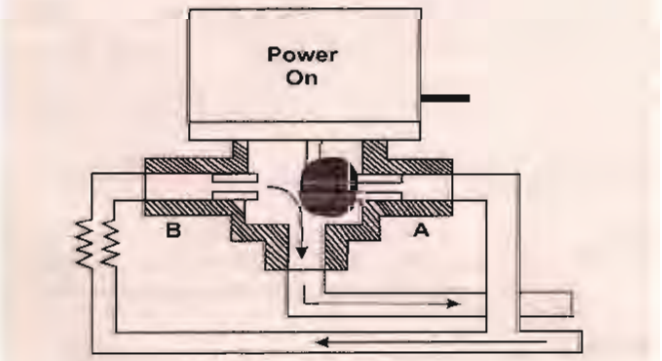
Benefits of Blanking Off

In case of flapper (FCU) valve it is actually better to use a 3-way valve and blank-off the bypass port. In a 3-way flapper valve water moves in through either of the open ports and flows out through the bottom port. The flapper moves from one port to the other port during its stroke.

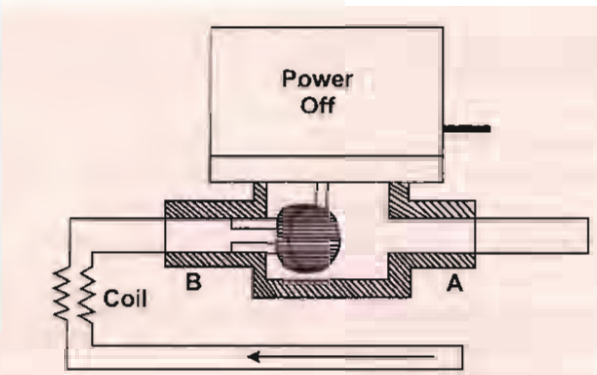
In 2-way flapper valve, the bottom is blanked off and the flapper travel is reduced by 50%. In the open position now, it stops in the middle so as to let the water flow from one port to the other. But in such a case the passage available is substantially reduced and resistance to water increases.



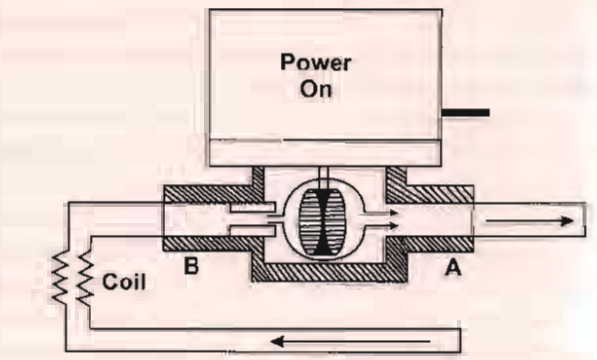
3- Way Valve
De-energized Mode



3- Way Valve
Energized Mode



2- Way Valve
De-energized Mode



2- Way Valve
Energized Mode

For the same body design and same port sizes the Kv of 2-way flapper valve is less than that of 3-way valve necessitating use of higher size 2-way valve for the same water flow rate and pressure drop.