MODULE-03 : Hydraulic Valves (General)

LECTURE- 08 : Different Types of Valves- Features and Operations.

Introduction

Devices which are used to regulate and control the flow and pressure in any assigned manner are called *control valves* or simply *valves.* With the tremendous growth and advancement in machineries involving fluid power the various sophisticated valves are developed to match with exact requirements. However, in this section we shall discuss only the basic features and operating principles of few ordinary and general purpose valves. Special valves, such as electro-hydraulic servo valves, proportional valves are discussed in section next the next section (Module 4).

Basic Consideration:

Both the flow and pressure are controlled by using the principle of orifice flow. The major factors that affect the valve performances are:

i) Rate of opening the orifice.
ii) Size of the orifice.
iii) Designed characteristics of orifice.
iv) Direction of opening.
v) Sequences of opening the orifices in a multi orifice valve.

Pressure Operated Valves:

There are several 'pressure operated valves'- pressure relief valve being the most common and an essential one in all hydraulic circuits the others are pressure reducing valve, pressure control valves etc.

(Pressure) Relief Valves (PRV)

A relief valve is usually incorporated in all hydraulic systems to operate when the pressure in supply line reaches a predetermined value, thus protecting components, in particular the pump

from being over loaded. PRV may be a (i) direct acting (spring operated) relief valve or (ii) balanced piston type pilot operated valve.

(i) Direct (Spring Operated) Relief Valve (Figs. 3.8-1 & 3.8-2)

In direct operated relief valve an orifice, which bypassed the oil from main supply line back to reservoir, is kept closed by a cone or piston on valve seats. The cone or piston is given a regulated force by a compressive spring the deflection of which is regulated by a screw operated by a hand wheel. For simple construction these are of low costs. However, when the orifice opens due to excess of set pressure and flow begins with down stream pressure is close to atmospheric pressure. It causes the pressure drops in upstream resulting in closure of cone or poppet. The pressure rises again and the cone or poppet becomes unstable and tends to open and close with short time intervals. Therefore, in case of relatively high flow and high pressure systems there will be chattering resulting in noise. The piston type is slightly better than the cone type in this regard.

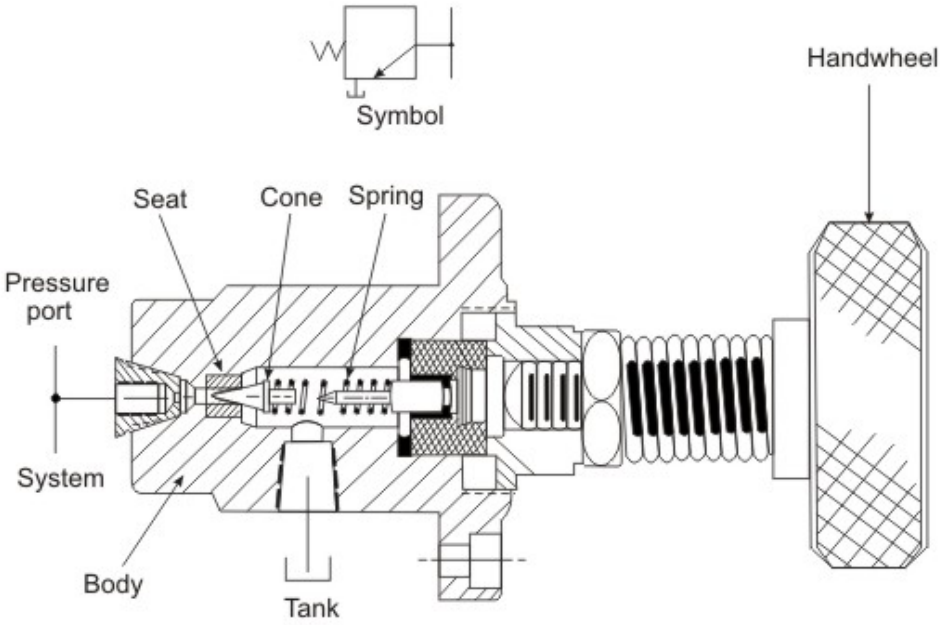


Fig.- 3.8-1 : Direct Acting Pressure Relief Valve, Cone or Poppet type.

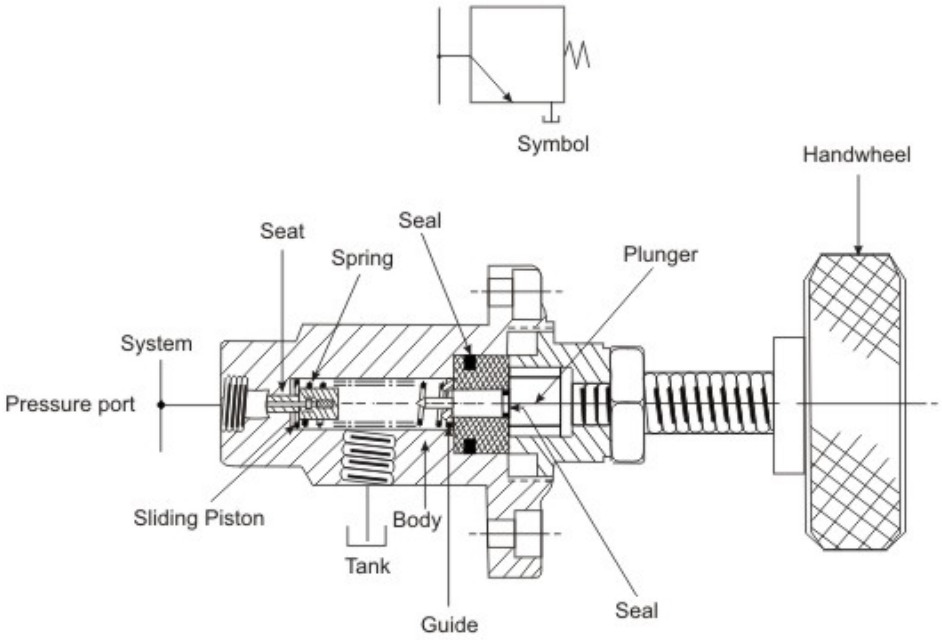


Fig.- 3.8-2 : Direct Acting Pressure Relief Valve, Piston type.

(ii) <u>Balanced Piston type relief valve or Pilot controlled relief valve</u>.

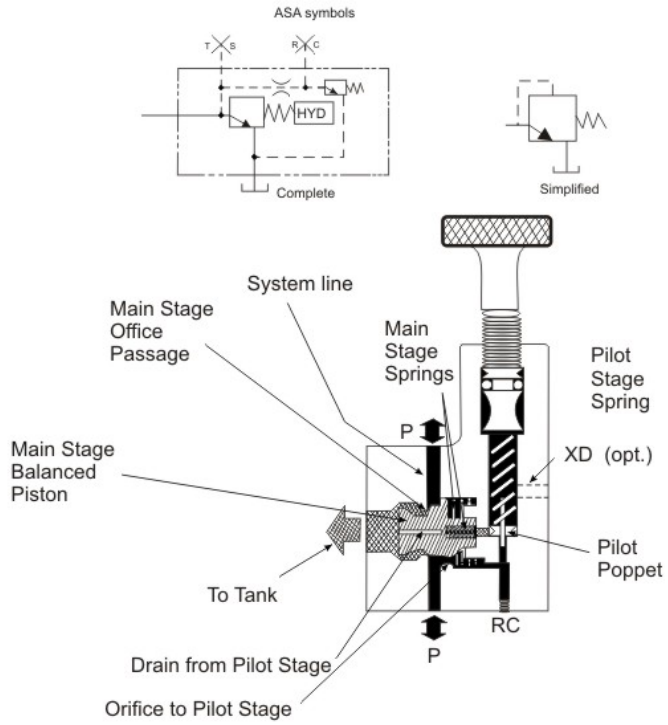
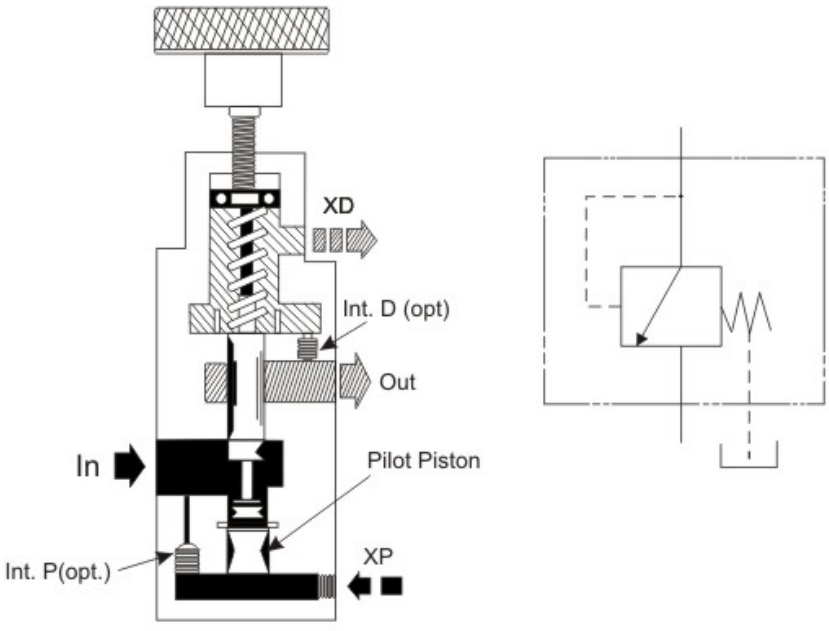


Fig.- 3.8-3 : Balanced Piston type (Pilot Controlled/ Operated) PRV

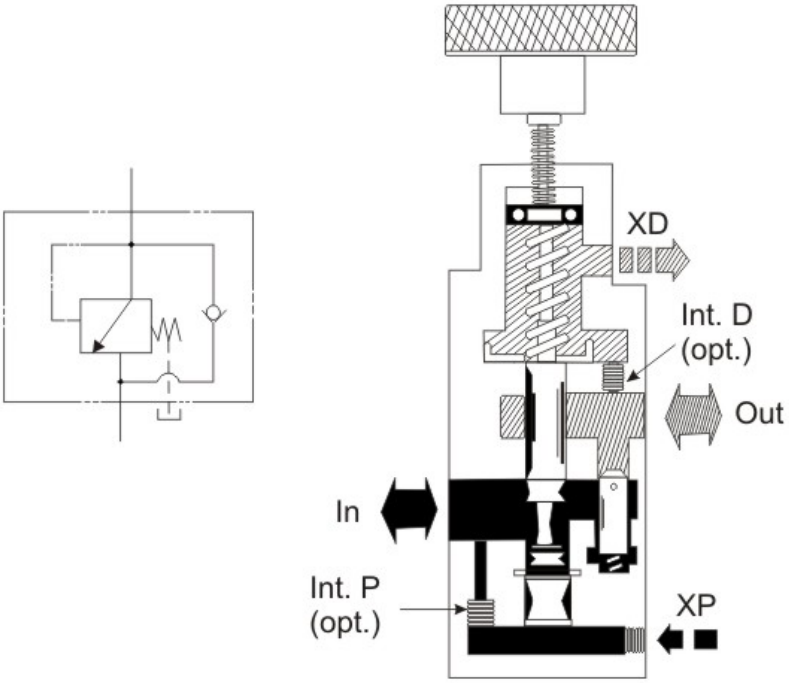
In the Fig. 3.8-3 the line shown by dark double arrows is the main system line. Line pressure directly acts on pilot poppet through orifice in main stage poppet. When system pressure exceeds set pressure the pilot poppet is lifted and a flow occurs to the tank through a drain flow passage through main stage poppet. This causes a *pressure difference* across the 'orifice to pilot stage' i.e. by the two acting sides of main stage poppet. The main stage move rightward and flow is diverted to tank via main stage orifice / passage. The small *differential pressure* by the two sides of main stage poppet and the main stage spring keep the main stage poppet balanced and stable for longer time and allows high rate flow through main stage passage of bigger size. Chattering does not occur. However, the cost is much higher than direct acting valve.

The port marked RC (Fig. 3.8-3) is used when a remote (open loop with in the valve system) control of the valve is desired. XD is an optional drain port.

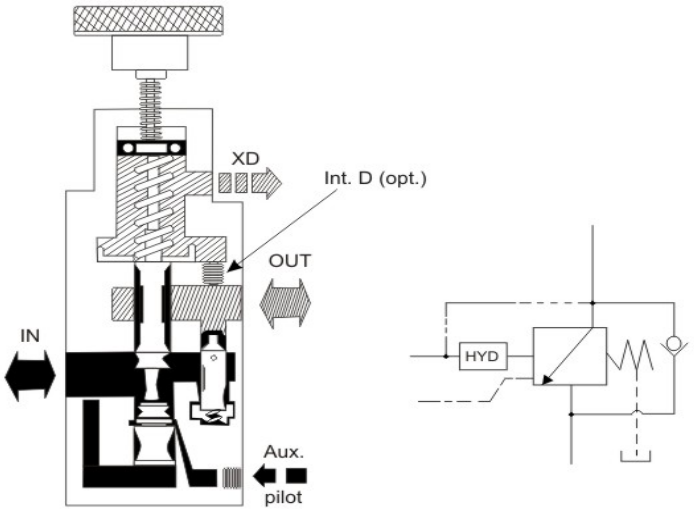
Sequence Valve



(a) : Sequence Valve Without Check (Non-return) valve



(b) Sequence Valve With Check Valve



(c) : Sequence Valve With Check valve and Auxiliary Pilot

Fig.- 3.8-4 : Sequence Valve

Multiple operations in sequences are often integrated in a system with a common source of supply. If the sequences are pressure dependent then these can be done by using a pressure relief valve with pilot part is operated externally (Fig 3.8-4 a). Also, a check valve in parallel allowing flow from downstream to upstream direction of the PRV can be added (Fig 3.8-4 b). The flow of fluid can be directed to a specific part of the circuit which is connected to the inlet port of the valve until the set pressure of the sequence valve is reached.

In another version (Fig 3.8-4 c) the auxiliary pilot pressure (Aux pilot in Fig) is not under the pilot piston (Fig 3.8-4 b) but exposed under the main spool (Fig 3.8-4 b). Normal operation i.e., pressure relieve controlled by pilot stage and flow diversion by operating the main spool through auxiliary port (which is connected to main system pressure) give two sequences. A sequence circuit with such *sequence valves*

Counter Balance Valve & Unloading valve

The sequence valve also can be used to maintain resistance against flow in one direction. The sequence valve, if used for this purpose or is made only for serving such purposes, it is then known as either a *Counter Balance valve* or an *Unloading valve,* depending on the purpose and circuit (discussed in next sections).

Pressure Reducing valve

Fig.- 3.8-5 shows basic features and operating principle of a pressure reducing valve. Inlet flow goes out through the outlet port via an orifice the area of which is regulated by the main spool loaded by the main spring. When the inlet pressure varies the pilot stage receive signals through the orifice and the main spool is reset in such a way causing the change in pressure drop across the main spool orifice to maintain a ***constant*** pressure at outlet. Obviously the outlet pressure is always less than the inlet pressure which is varied with in a limit for which the valve is designed. The magnitude of reduced pressure can be set adjusting the pilot knob. It is to be noted that flow rate remains unchanged. XD is the optional external drain port.

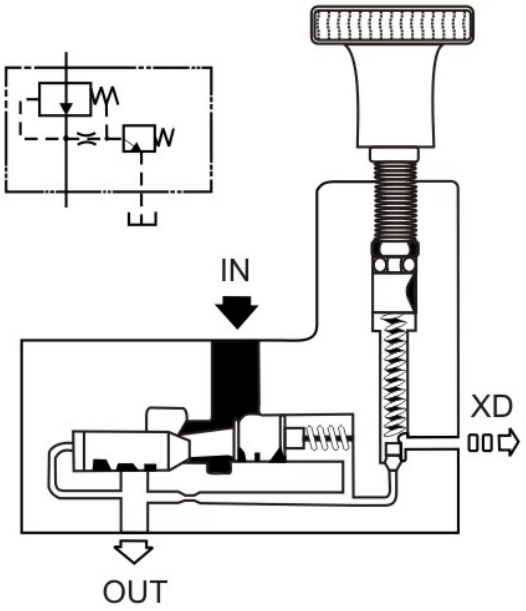


Fig.- 3.8-5 : Pressure Reducing Valve

Flow Control Valves

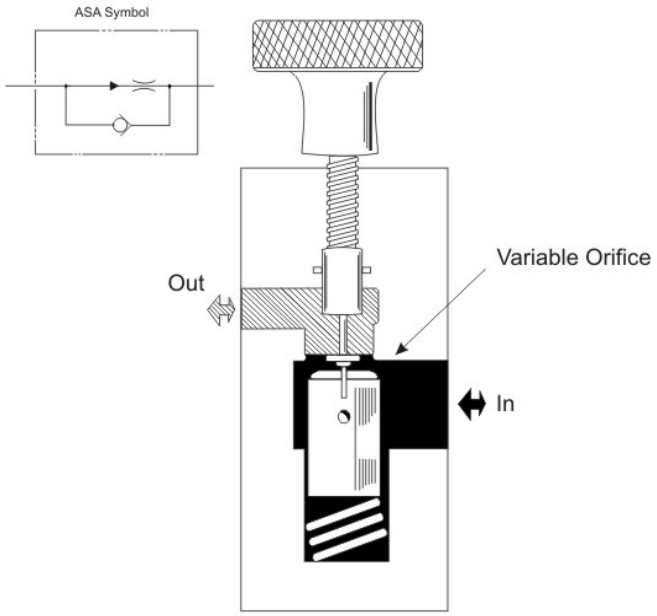
In flow control valves the flow-rate is affected by altering the area of an orifice (variable) inside the valve. To obviate the effects of fluctuation of pressure and temperature of the fluid, special devices are usually built into the majority of these valves. Flow-Control valves incorporating these devices are called pressure and/ or temperature compensated.

Non-Compensated flow control valves(Fig.- 3.8-6 a**).**

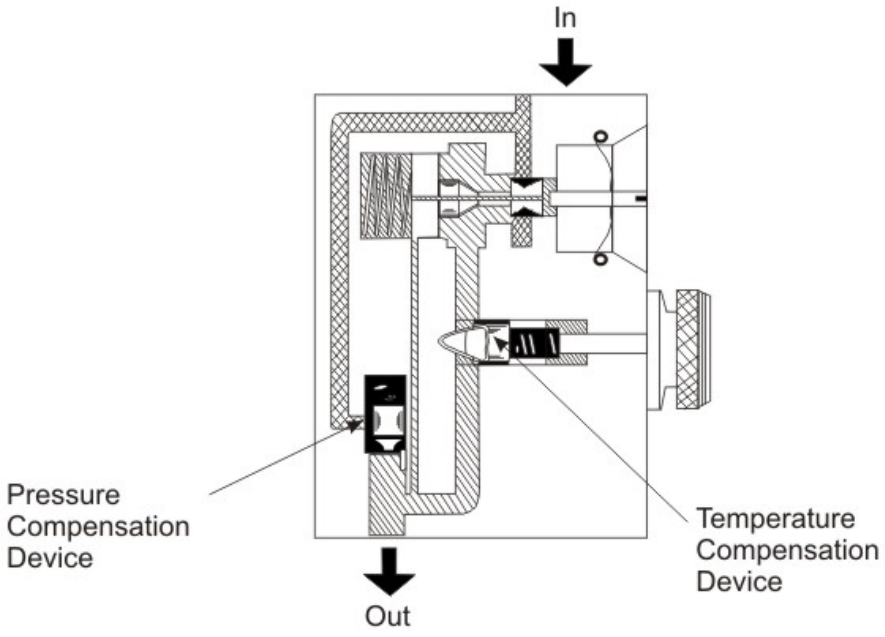
Referring to the illustration a the controlled output flow is achieved just by adjusting the knob of main spool i.e., by adjusting the variable orifice area. This is simple in construction and cheap. Problem arises when the pressure of the motor fluctuates due to change in load. Therefore, the flow also fluctuates. The use of a separate pressure reducing valve in series compensates such fluctuation to some extends.

The pressure compensated flow control valve (Fig.- 3.8-6 b).

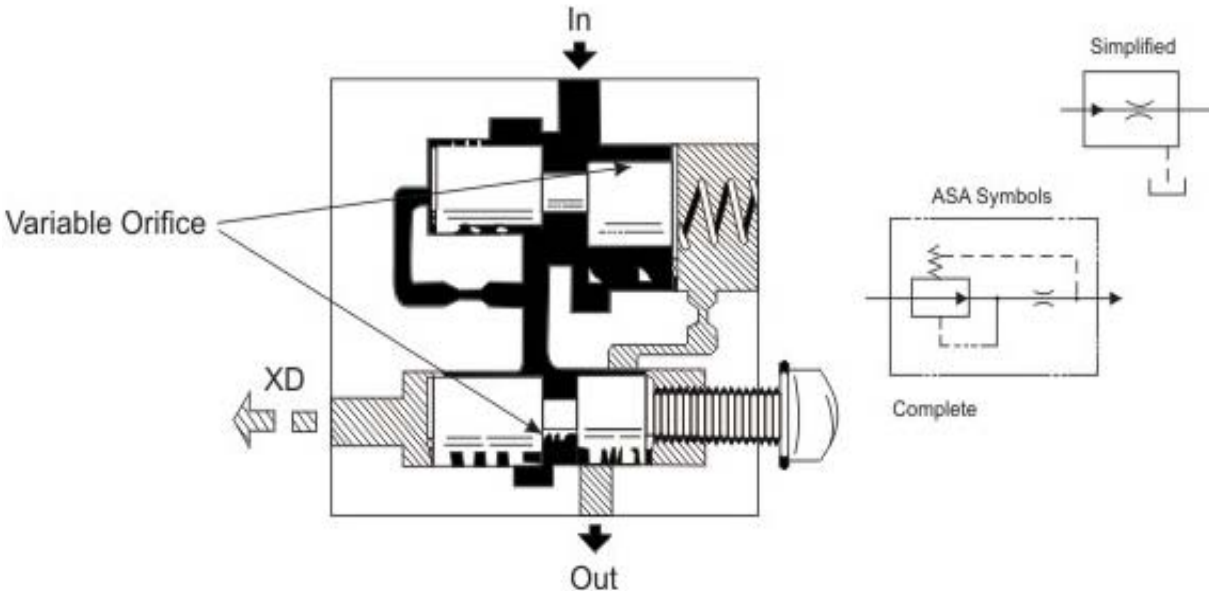
This is virtually combination of straight forward spool and screw and a pressure reducing valve. The pressure reducing valve section of the flow control valve controls the flow to the orifice so that the pressure drop across this orifice is constant.



(a) : Non-Compensated Flow Control Valve



(b) : Pressure Compensated Flow Control Valve



(c) : Pressure and Temperature Compensated Flow Control Valve

Fig.- 3.8-6 : Flow Control Valves

Pressure and temperature compensated flow control valve (Fig.- 3.8-6 c).

For temperature compensation different measures are taken. Two of them are as follows:

(i) Expanding pin on orifice: Due to increase in oil temperature the pin expands and the orifice area reduces. This maintains the quantity of flow equal with reduced viscosity and specific weight of oil for a range of flow rates.

(ii) Precision formed sharp edged control orifice: Variation in coefficient of discharge with the variation in oil temperature for flow through a sharp edged orifice maintains the flow rate for any particular setting.

Directional Control Valve :

The function of a directional control valves is to allow the fluid to flow from one part of a hydraulic to another. These valves usually designated by 'the number of flow ports i.e., ways'/'the number of spool positions', 'DC' or 'dc' valve. For an example '4/3 dc' valve (Fig. 3.8-7 and Fig. 3.8 a) means. '4 port/way, 3 position direction control' valve.

Way : No of flow ports. A four way valve comprises a pressure (flow) supply port P, two (system) ports A and B for the connecting two reverse flow ports of hydrostatic units which may be a pump or a motor or an actuator, and one tank (return) port T.

Position : Indicates the number of position of the spool. A three position valve (Fig. 3.8-7 and Fig. 3.8-8 a) usually means two different spool (end) positions for two different system flow directions and one neutral position in between.

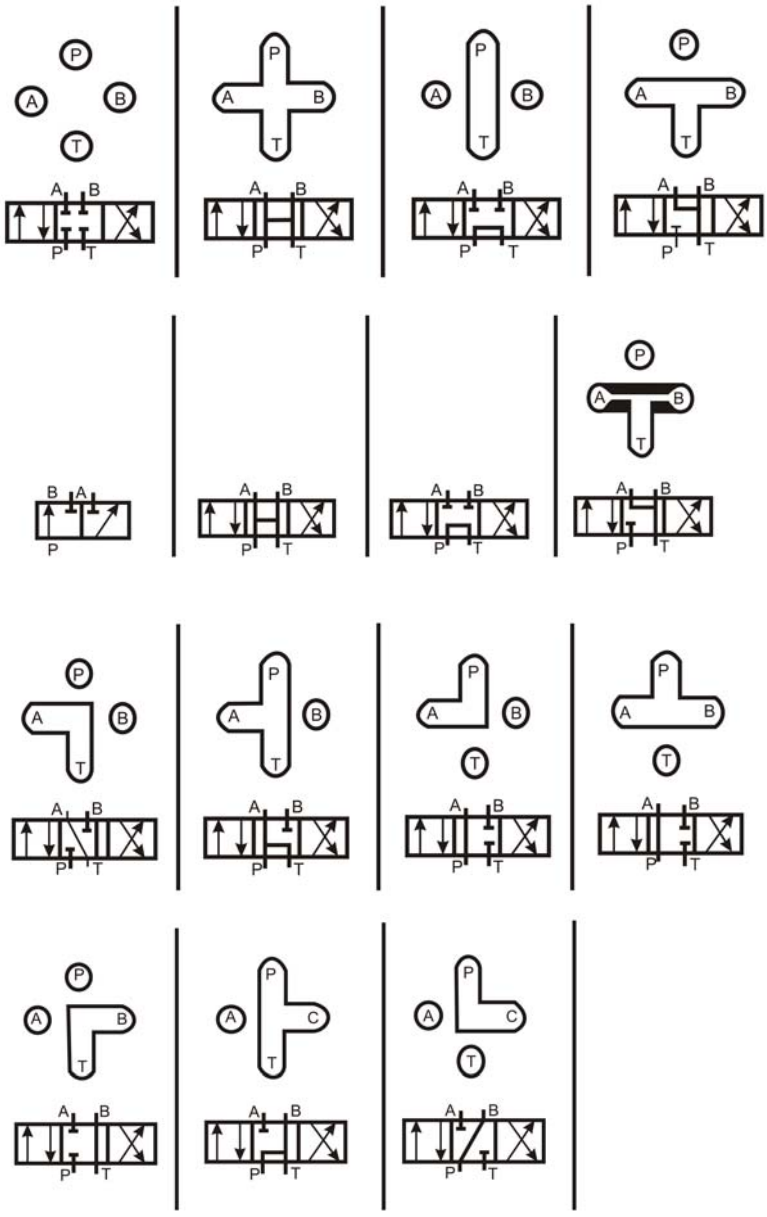


Fig.- 3.8-7 : Spool Positions, Port Connections and Symbols for DC Valves

The directional valve may be from all ports closed in neutral to all ports opened at neutral position. To achieve these features the valve bodies and the spool are made of different though and blind/blocked holes.

Spools : - Are made solid, hollow with through holes or partial holes, and hollow with solid spindle inside it . Various spool configurations are depicted in Fig.- 3.8-7.

Closed Centre & open centre:

The term closed centre indicates that the flow through the valve has been stopped, as the spool moves from one position to other. This type of spool can be altered to give a form of acceleration and deceleration, compression, or decompression, by grinding angles on the edges of the spool, which will open and close the ports in a more gradual manner than a straight cut off. Fig. 3.8-8 illustrates a 'close centre' dc valve.

The open centre spool, on the other hand, opens all ports as it crosses the centre position from one side to the other.

In another version it is possible to keep few ports are interconnected where as other port(s) are blocked while the spool moves from one position to other. Such a valve is called tandem centre valve.

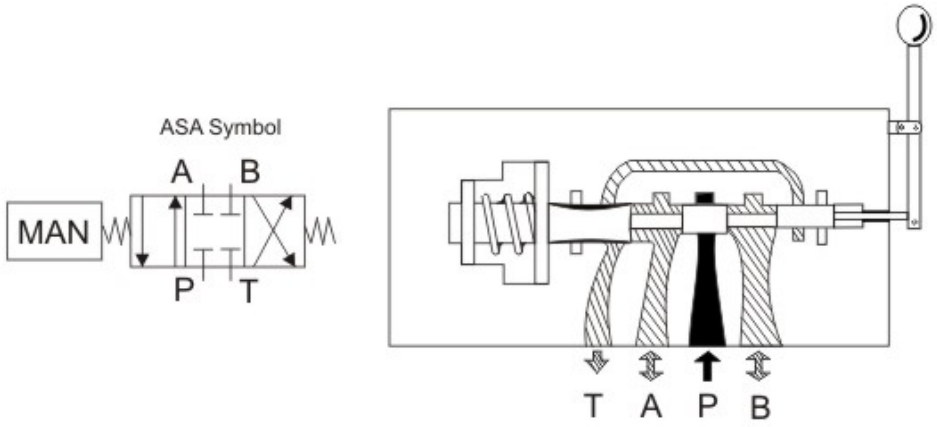


Fig.- 3.6-8 : Close Centre Direction Control Valve

Merits & Demerits.

An open centre valve experiences minimum power consumptions as flows occur at minimum pressure at ideal and non system working times. However, its (pressure build up) response is slow when the spool position is changed for system work. A close centre valve on the

other hand has more power loss but better response. A tandem centre valve is to balance these two. Depending on the applications these valves are selected. For an example is the system operation is frequent on-off type with short ideal times then close centre dc valve is preferred.

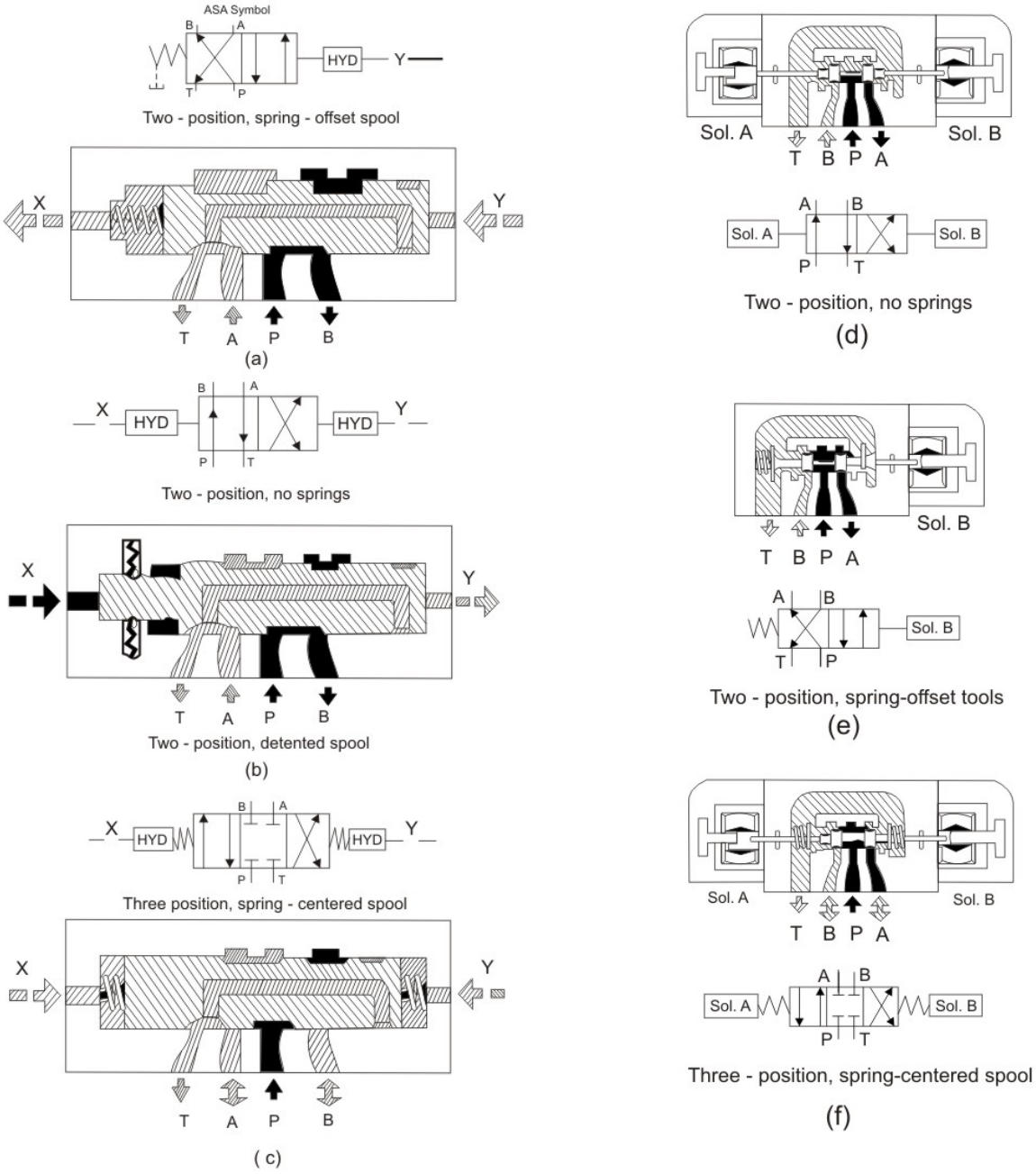


Fig.- 3.6-9 : Different Port & operational Configurations- Direction Control Valve

Spool control: In case of dc valves spool's position control is on-off type. In the simplest form it is manual operated, which is widely used in almost all non-stereo type control. Where as in stereo type, automated or semi automated control pilot operated spool control is preferred. In valve symbols type of control is symbolically mentioned (See Fig. 3.8-7)

(i) Hand operated with detents or spring position gives a control over flow.

(ii) Pilot-operated may be (a) Hydraulic, (b) Solenoid or (c) Pneumatic.

Fig. 3.8-8 & Fig 3.8 -9 show different types of dc valve with various spool operations and configurations, and their symbolic representation.

In servo valve section (Module-4) spool configurations and operations will be discussed further.

Check Valve: Check valve also called as 'non-return valve' (Fig. 3.8-10) allows flow in only one direction. It might also be pilot operated by an external signal XP for flow in both directions.

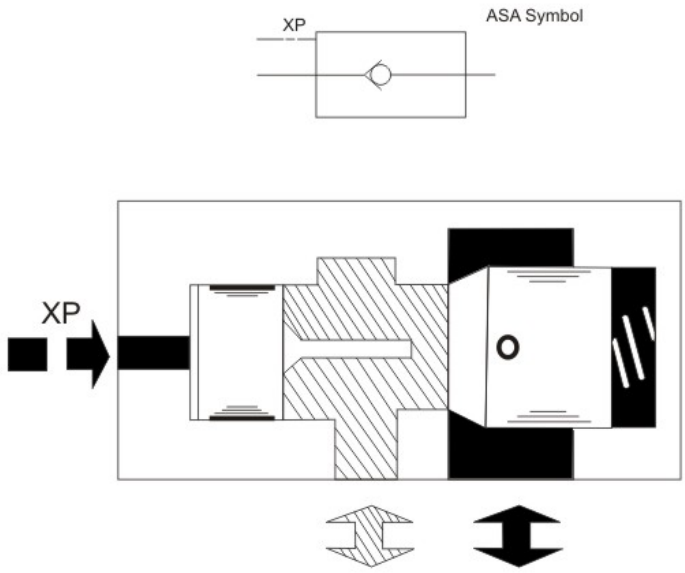


Fig.- 3.8-10 : Pilot operated Check Valve

Bibliography:

1. J. Korn (Editor) : Hydrostatic Transmission Systems, Intertext Books. London, (ISBN 0 7002 0080 0), 1969.