Unit 3 Control Valves

Marks Distribution for this Unit

Unit No	Unit Title	Teaching Hours	R Level	U Level	A Level	Total Marks
III	Control Valves	12	04	08	04	**16**

R-Remember, U-Understand,A-Apply
* Refer syllabus for details about Bloom's taxonomy

Syllabus content

3.1 Classification of Control Valves

3.2 Pressure control valves
Relief valve, Unloading valve, Sequence valve, Counter balance valve, pressure reducing valves

3.3 Direction Control valves
Check valve, 2/2,3/2,4/2,4/3,5/2,5/3 D.C. Valves used in hydraulics and pneumatics

3.4 Standard centre position and Methods of actuation

3.5 Flow control valves
Non compensated flow control valve, Pressure and temperature compensated flow control valves

3.1 CLASSICICATION OF CONTROL VALVES

Q.1. Classify Control valves.

Ans : Numerous types of valves are used in hydraulic systems for various functions, These valve are broadly classified as below,

Classification based on function.

Pressure control valves.

Flow control valves

Direction control valves.

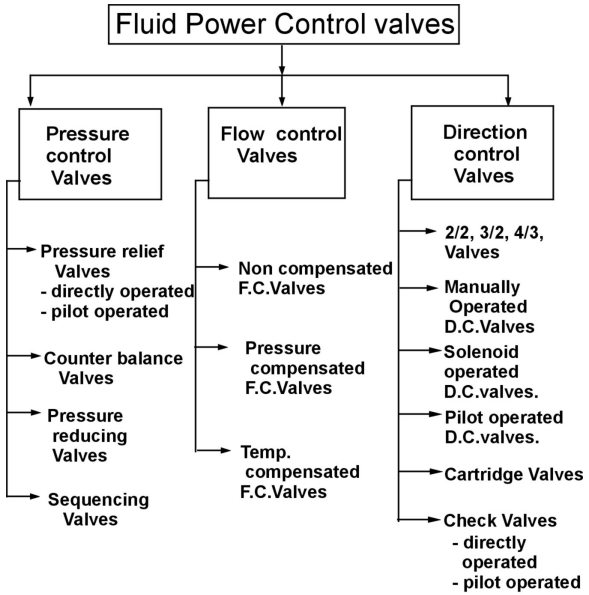
Classification based on Method of actuation.

Directly operated valve

Pilot Operated valve

Manually actuated valve

Electrically actuated valves.



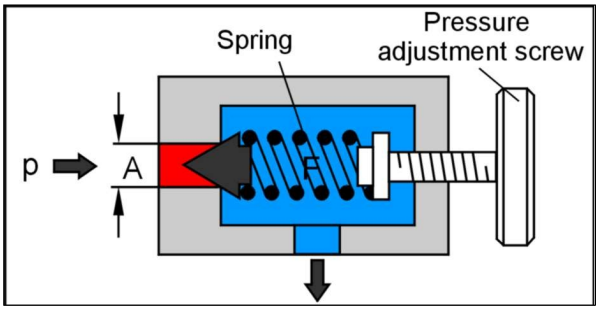
3.2 Pressure control valves

Q.2. Why pressure relief valve is used in hydraulic circuit?

Ans :
Pressure Relief Valve used because;
1. To Maintain desired pressure levels in the circuit.
2. To set maximum pressure in hydraulic system.
3. Protect the pump and other system components from overloading.
4. It acts as a relief and safety device

Q.3. Explain with sketch pressure relief valve.

Ans :In its simplest form directly operated pressure relief valve consists of a casing fitted with a cone (or spool) which block the flow of pressurized fluid due to spring force (F). The spring force can be adjusted by tightening or loosening the screw.



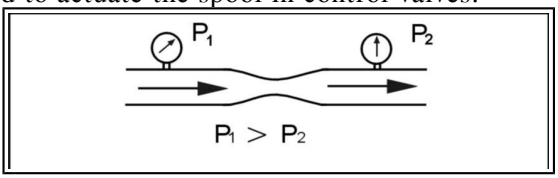
If input pressure p is effective on an area A. The resulting force F, when exceeds the spring force, the valve body (cone or spool) moves in a direction opposite to the force of spring and opens a connection between the inlet and outlet. The pressure level, which is to be maintained, is thus controlled by spring force..

Q.3.What is the need of pilot operated pressure relief valve?

Ans :When relief valve is to be used for higher pressure and higher flows, its size increases considerably and spring goes on becoming much heavier. Eventually a stage is reached where these springs are so strong that they can not be adjusted and where they need too much space. For this reason appropriate sized and easy to use pressure control valves for large flow through quantities are provide with pilot operation.

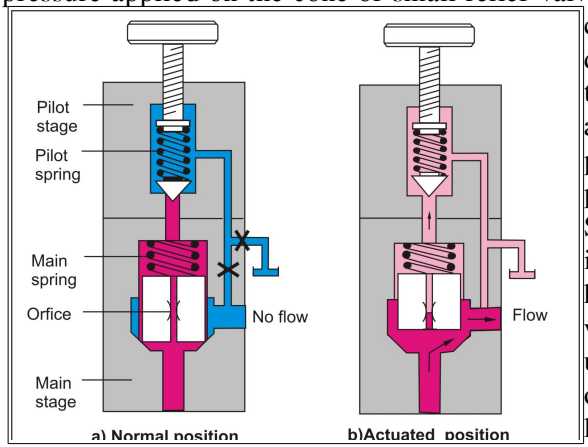
Q.4. Explain with sketch working of pilot operated pressure relief valve?

Ans : All the pilot operated valves (Whether it may pilot operated pressure valve or pilot operated flow or pilot operated direction control valve) work on the same principle of flow through orifice. It is well known that when the fluid flows through an orifice its pressure drops due to internal resistance to flow (back-pressure). Thus as shown above P1 > P2. This principle is used to actuate the spool in control valves.



Construction: The valve as shown in fig 8.5 consists of two stages namely main and pilot stage. The main valve is biggest in size (to allow more flow), and the pilot stage is a small directly operated relief valve with small spring. The input pressure is applied to the lower end of the main valve, and the same is applied to the cone of pilot valve through an orifice. The orifice can either be located in the spool or housing.

Operation: The pressure applied at the end of main stage is same as the pressure applied on the cone of small relief valve. (One point should very clear that pressure difference occurs only when there is flow through orifice and when there is no flow pressure is equal on all parts it is connected to). Since area of cone is intendedly kept small, hence for a given pressure very small spring can be used (Since pressure is ratio of force and area, as area is less for same pressure force is also less in same ratio). Thus small springs can control higher pressures, but they can not allow the required flow. Hence bigger spool is applied in second stage to allow



higher flows. When the pressure in the system exceeds the limit, which is set by spring of pilot stage, the cone is lifted allowing smaller flow to drain. The flow through the orifice causes the pressure difference on bottom and the top of the spool, which results in differential force which moves the spool in upward direction, opening the passage of fluid to drain, and thus allowing higher flow of fluid to drain.

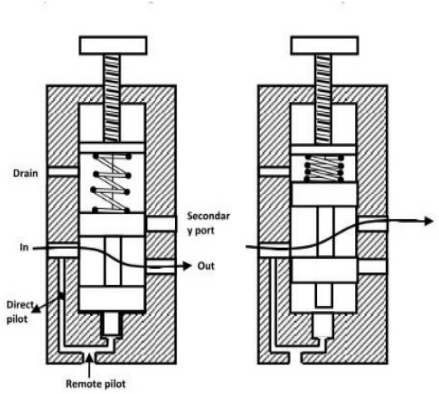
Q.5. What is sequencing valve? Explain with sketch

Ans : The function of a sequence valve is to provide flow to a second consumer in the case when the pressure level at a particular consumer has reached a threshold valve. As the name implies it is used for sequencing the operations one after another.

Constructional details :

The Construction of a sequence valve is shown in fig it is nothing but a pilot operated relief valve, in which the drain is connected to second consumer. As shown it has two spools attached to each other. The spools are drilled with internal orifice. The drain is directed to the main drain.

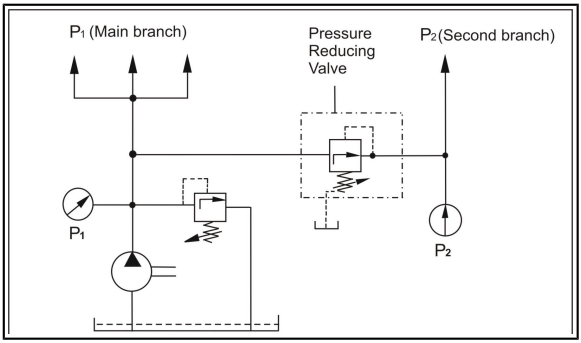
Operation :



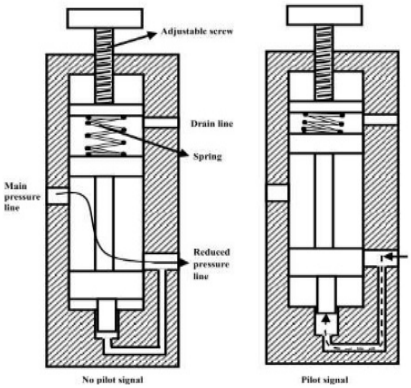
In normal position the sequence valve is closed. When the operation of consumer 1 is completed, the pressure starts building, and when reaches set value of pilot relief valve, it lifts the spool up and this movement causes the blocking of flow to first consumer and opening to second consumer.

Q.6. What is the function of Pressure reducing valve? Explain with sketch pressure reducing valve?

Ans :**Function of pressure reducing valve :** The function of pressure relief valve is to limit the pressure in the complete system to a given level. The task of a pressure reducing valve, on the other hand, is to reduce pressure in a particular branch of the circuit to different level on demanded by consumer in that branch.



Construction and Working :



Working

• This type of valve (which is normally open) is used to maintain reduced pressures in specified locations of hydraulic systems. It is actuated by downstream pressure and tends to close as this pressure reaches the valve setting.

• A pressure-reducing valve uses a spring-loaded spool to control the downstream pressure. If downstream pressure is below the valve setting, the fluid flows freely from the inlet to the outlet.

• When the outlet (downstream) pressure increases to the valve setting, the spool moves to the right to partially block the outlet port. Just enough flow is passed to the outlet to maintain its preset pressure level. If the valve

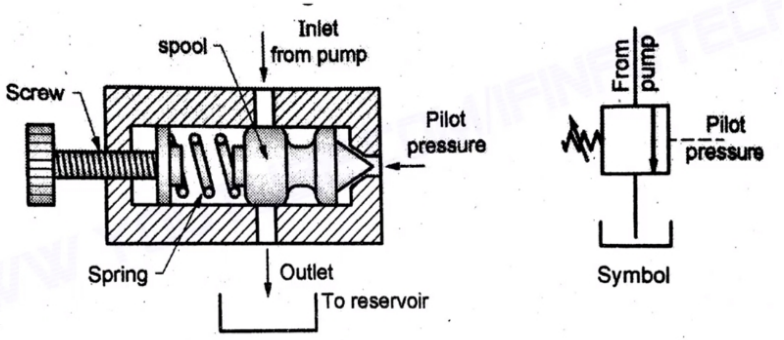
closes completely, leakage past the spool causes downstream pressure to build up above the valve setting.

Q.7. What is the function of Unloading valve?Explain with sketch Unloading valve?

Ans :**Function of Unloading valve : Unloading valve is a pressure control device that is used to dump excess oil to tank at little or no pressure.**

Using the pressure relief valve to direct the oil to tank when the actuator doesn't needs it causes lot of energy loss. Because the pump has to force oil against the pressure of pressure relief valve setting. This results in lot of heat development and also loss of energy. This problem is solved by unloading valve, the unloading valve allows the pump to deliver back the oil to tank at literally zero pressure, thus saving the energy.

Construction and working of Unloading valve:



UNLOADING VALVE AND ITS SYMBOL

As shown in figure its construction is similar to the pressure relief valve except that the actuation is by pilot pressure. When the pilot pressure reaches the required level, the valve shifts to left and all excessive oil is drained to the tank as very less or zero pressure.

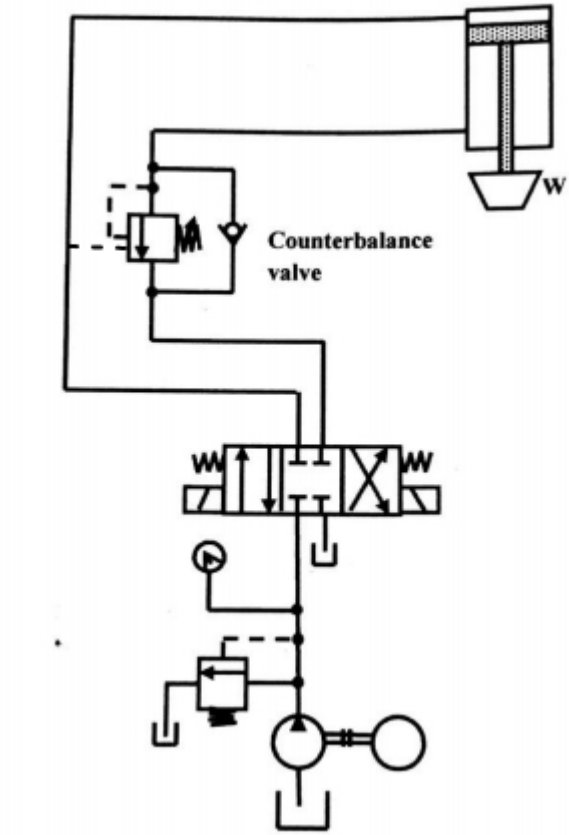
When the pilot pressure drops means the actuators are needing the oil, the spring causes the spool to move to right resulting in closure of valve and hence the pump oil is not sent to tank but to actuator.

Application: It is used in system with accumulator, and also in high low pump circuit.

Q.8. What is the function of Counter balance valve?Explain with sketch Counter balance valve?

Ans :**Function of counter balance valve :** The function of counter balance valve is to prevent a load from accelerating uncontrollably. This situation can occur in vertical cylinders in which the load is weight.

Construction and working circuit:

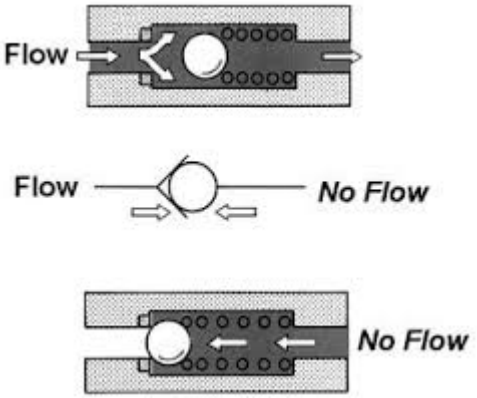


As shown in figure when the main DC valve is at centre position there is possibility that the cylinder may fall down due to gravity and load effect. It is prevented by the counter balance valve. The counter balance valve is only actuated when there is pressure in the upper line, thus preventing the dropping of the cylinder.

3.3 Direction control valves

Q.9.What is check valve? Explain with sketch

The purpose of check valve is to block the flow of fluid in a given direction, but to permit unrestricted flow in the opposite direction. For this reason they are also known as " Non return valves". The flow blocking is required absolutely leak free hence these valves are always of poppet type construction. Check valves are the inherent elements in any hydraulic circuit, they are meant for various purposes in the hydraulic circuit.



Check valves can be used for any function that requires the flow to be blocked in one direction and allowed in another direction. Following are some typical applications,

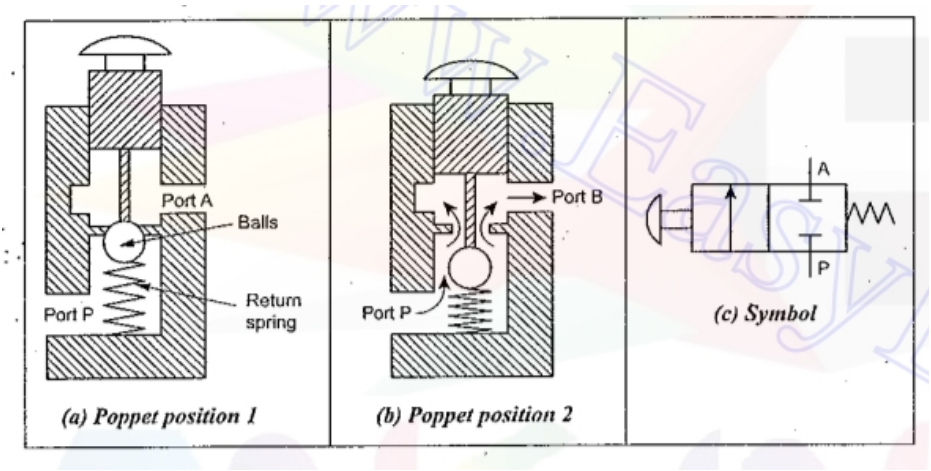
1) Holding load,
2) With flow control valve.
3) Anti-cavitation valve with pumps or motors,
4) Bypass for clogged suction line,
5) By pass for clogged return line.

Q.9.Explain with sketch 2/2 Direction control valve

Ans :

A 2/2 valve is one which has 2 port connections and two positions only. The valve shown below is normally closed type(it can be normally open type also). Its construction is simply a spring loaded ball which is actuated by pressing the button. In normal position the connection between port 'P' and port 'A' is closed. But when the operator presses the valve manually, it opens the connection between the port P and Port A., thus allowing the fluid to pass to port A.

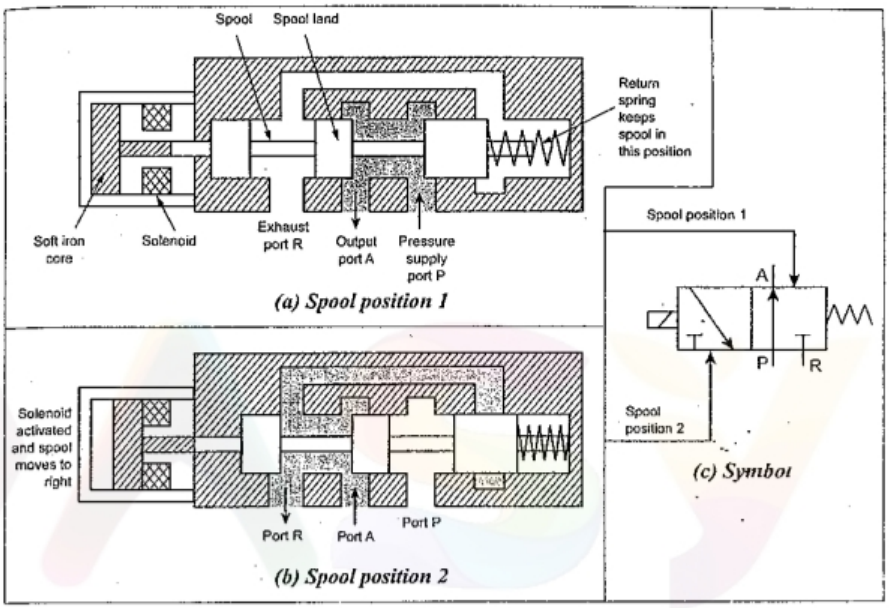
This valve is used for actuating single acting cylinder, which doesn't needs oil/air for returning. It may be gravity or spring return cylinder.



Q.9.Explain with sketch 3/2 Direction control valve

A 3/2 valve is one which has 3 port connections and two positions only. The valve shown below is normally open type(it can be normally closed type also). Its construction is simply a Spool which separates the different ports,which is actuated by force. In normal position the port 'P' and port 'A' are connected. But when the operator presses the valve manually, it connects A to R and port P is idle.

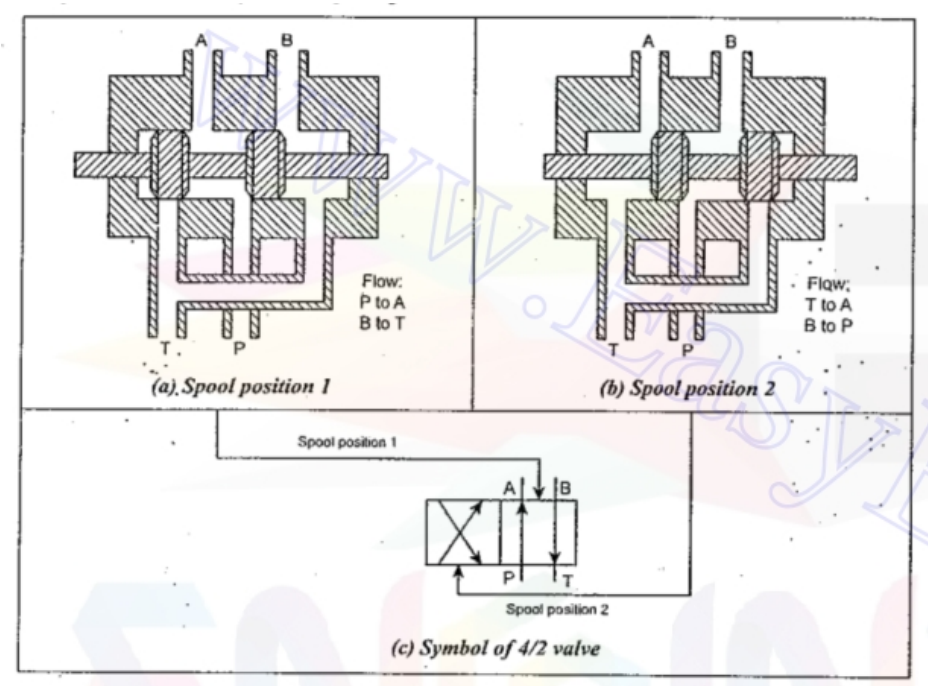
This valve is used for actuating single acting cylinder, Its symbol is also shown besides.



Q.9.What is 4/2 DC valve? Explain with sketch

A 4/2 valve is one which has 4 port connections and two positions only. This valve is useful for double acting cylinder. The valve shown below has a spool which separates the ports, in normal position port T is connected to A and Port B is connected to T.

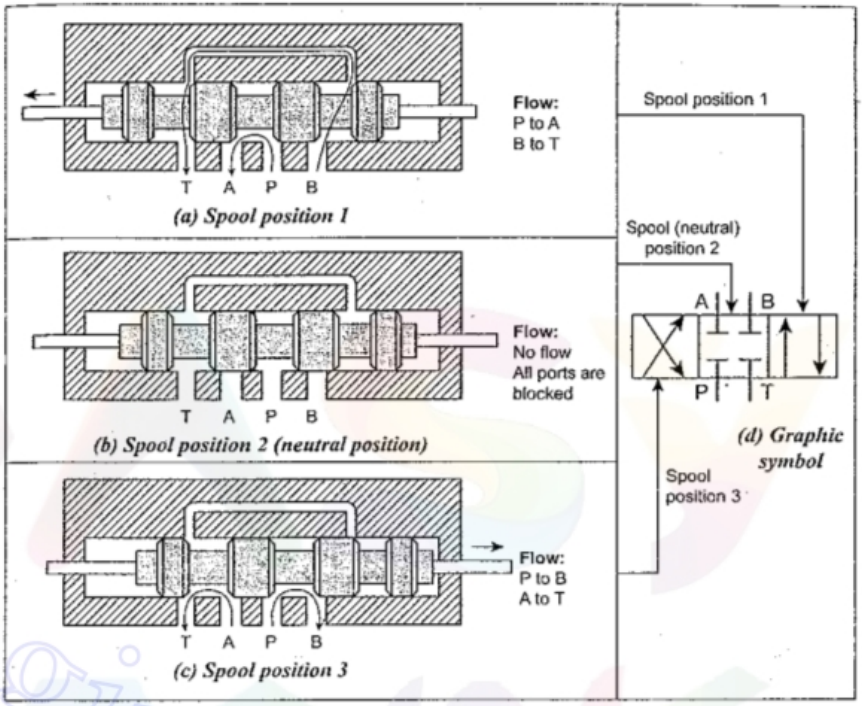
When the spool is shifted by some means, it alters the connections and connected the Port P to B and Port A to T. Thus it reverses the connections.



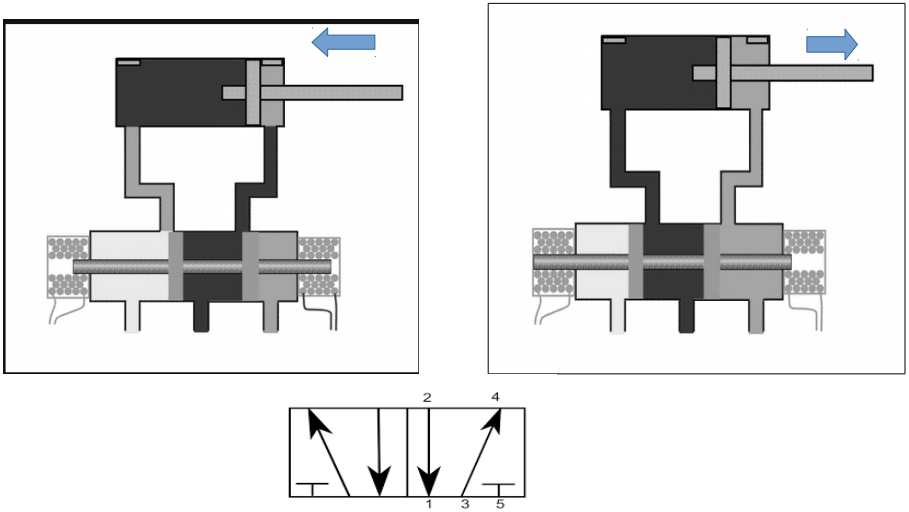
Q.9.What is 4/3 DC valve? Explain with sketch

A 4/3 valve is one which has 4 port connections and three positions only. This valve is useful for double acting cylinder. The valve shown below has a spool which separates the ports.

When the spool is at centre, the oil is not moving to any port and all the ports are disconnected from each other. When the spool is shifted to right,by some means, it connects P to B and A to T. Whereas when it is shifted to left it connects P to A and B to T.



Q.9.What is 5/2 DC valve? Explain with sketch



As shown in figure above the 5 ports and two position valve is a bit modification of 4/2 valve, with one additional port.

A 5/2 valve is one which has 5 port connections and two positions only. This valve is useful for double acting cylinder. The valve shown below has a spool which separates the ports, in normal position port P is connected to B and Port B is connected to T and R is idle port

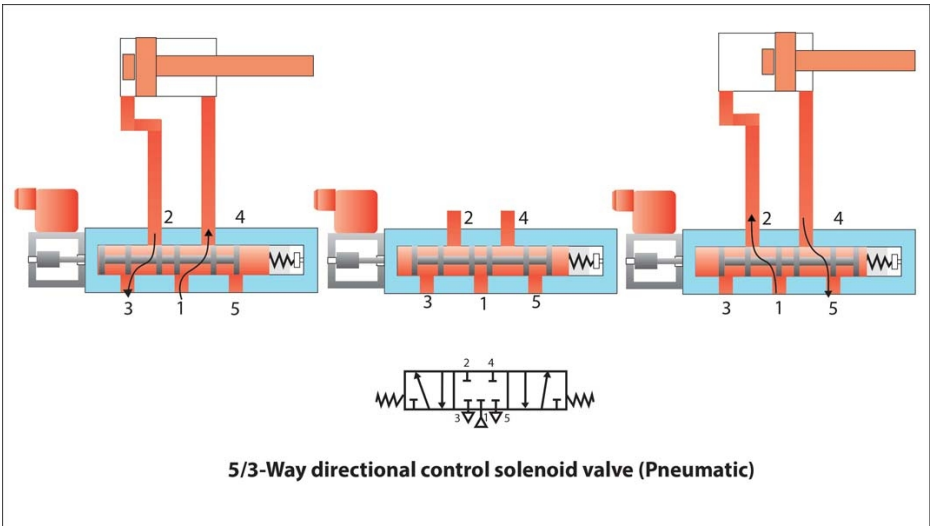
When the spool is shifted by some means, it alters the connections and connected the Port P to A and Port B to R , and T port is idle this time. Thus it reverses the connections, causing the cylinder to move in reverse direction.

Q.9.What is 5/3 DC valve? Explain with sketch

As shown in figure above the 5 ports and three position valve is a bit modification of 5/2 valve, with one additional position.

A 5/3 valve is one which has 5 port connections and three positions . This valve is useful for double acting cylinder. The valve shown below has a spool which separates the ports, in neutral central position all ports are disconnected with each other. When shifter to right position port P is connected to A and Port B is connected to T and R is idle port

When the spool is shifted by some means, it alters the connections and connected the Port P to B and Port A to R , and T port is idle this time. Thus it reverses the connections, causing the cylinder to move in reverse direction.

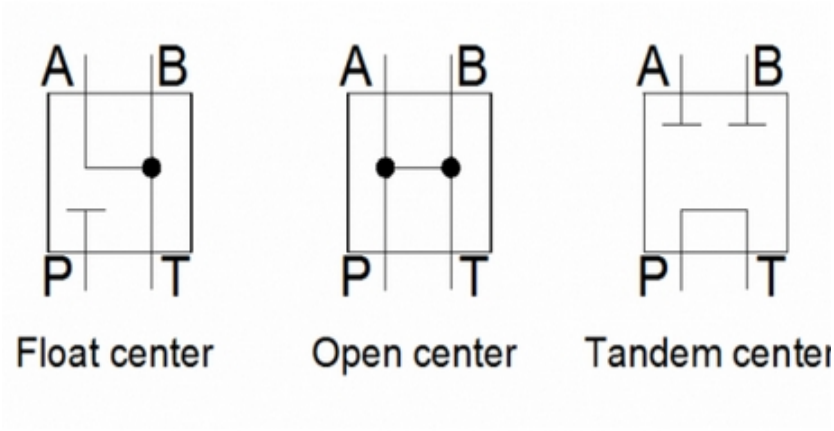


5/3-Way directional control solenoid valve (Pneumatic)

3.4 Centre positions

Q.13.What are the different centre positions of the DC valve?

Following are the different types of centers in a direction control valve.



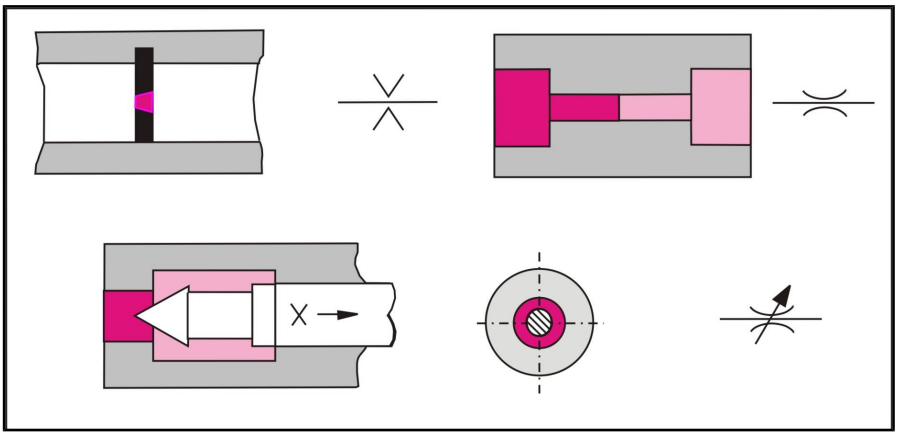
1) Float centre : Float centre type valves have their Pump port blocked in neutral position. Such type of valves need pressure compensated valves.
b) Open center: The open center valve provides the same benefits as the float spool, but can be used with fixed displacement pumps. The pump flow is naturally unloaded to tank, and the spool also provides a drainage flow path for any accessory valves attached to the A and B work ports.
c) Tandem Centre: The tandem center valve is also used for fixed flow systems where fluid is unloaded to tank in neutral and work port flow is blocked. This spool is common on gear pump systems operating cylinders with no work-holding requirement.

3.5 Flow control valves

Q.16. State the function of flow control valve? Draw non compensated flow control valves.

Ans: Flow control valves are used to regulate the flow of fluid in a hydraulic system. The speed at which the actuator (cylinder or motor) moves is decided by the flow. Where as the force exerted by actuator is determined by pressure. A variety of flow control valves are used.

Flow is controlled either by throttling or diverting it. Throttling involves reducing orifice (opening) size until all of the flow cannot pass through the orifice; where as diverting involves routing part of the flow around the circuit so that the actuator receives only the portion needed to perform its task

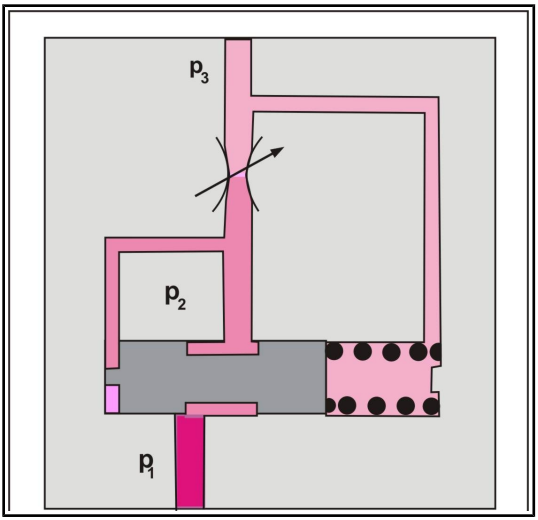


Q.17. Explain with sketch pressure compensated flow control valve.

If constant flow is demanded by the consumer, (independent of pressure (load) variations) in such situations pressure compensated flow control valves are used.

Principle of operation :

Pressure compensated flow controls maintain nearly constant flow despite variations in circuit pressure. Like the non-compensated units they incorporate a metering orifice. Flow pressure drop across this orifice is used to shift a balanced spool against a control spring. This spool movement is used to maintain constant pressure drop across the orifice, which in turn produces a constant flow.



It is seen that flow through a restriction changes paraboloidal with pressure drop across metering orifice. Hence to keep flow through an orifice constant one has to keep the pressure drop (P_2-P_3) across the orifice constant. This is achieved in the pressure compensated flow control valve by spool movement.

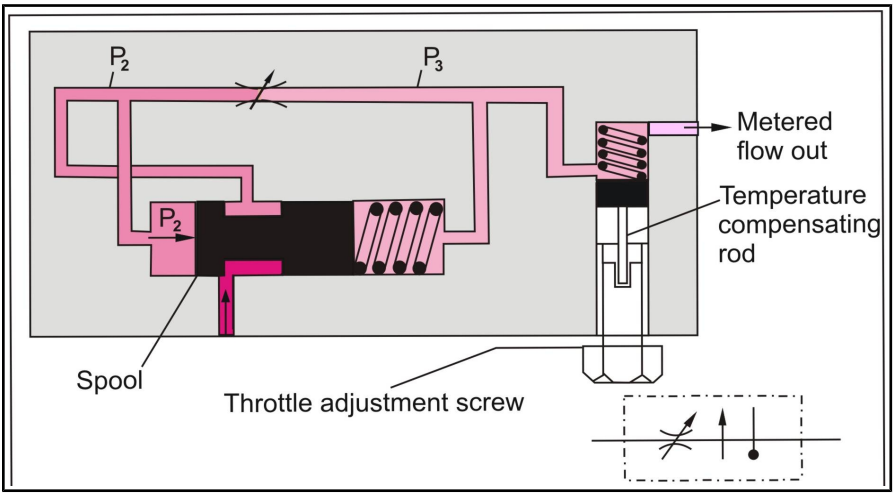
Change in pressure is given by

$$\Delta p = \frac{Spring\,constant}{Area}$$

Thus from above equation it is obvious that, the pressure drop across orifice can only changed by changing spring tension. Now in case of pressure variation i.e. change in pressure P3, the spool moves to cause the corresponding changes in P2 and thus maintaining the difference (P2-P3) a constant and hence the flow remains constant. Thus the valve delivers the flow at constant rate irrespective of pressure changes.

Q.18. Explain with sketch pressure-temperature compensated flow control valve.

The pressure compensated flow control valve maintains nearly constant flow despite variations in the circuit pressure. But there is an another parameter which affects the flow, that is temperature .The effect of temperature is that the viscosity of oil decreases (causing oil to be thinner) this leads to increased velocity and hence increased flow.



Constructional details of a combined pressure and temperature compensated flow control valve is shown in fig 8.18. The pressure compensation part of this valve is same as earlier described pressure compensator. The flow from pressure compensator passes through temperature compensator, which consists of a spool held against a special alloy temperature-compensating rod by a spring. A throttle adjustment screw is provided to adjust the spool setting.

As the temperature of fluid increases resulting in decreases in viscosity of oil. This result in increases in oil velocity and hence increases the flow.

As the compensator rod gets heat due to temperature rise it expands proportional to temperature rise, causing the spool to move against the spring, closing the throttle. Thus it reduces the cross sectional area of the flow in the proportionate of velocity rise (i.e. viscosity reduction).

https://www.youtube.com/watch?v=L1NmCtlphUc

unloading valve

https://www.youtube.com/watch?v=4GC6OV5gwyo