Unit 4 Compressor, Pneumatic components and accessories

Marks Distribution for this Unit

Unit No	Unit Title	Teaching Hours	R Level	U Level	A Level	Total Marks
III	Compressor,Pneumatic components and accessories	08	04	04	04	**12**

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

Syllabus content

4.1 Types of Compressors

4.2 Pneumatic components

Construction and working of FRL unit, Dual pressure valve, Shuttle valve, quick exhaust valve, time delay valve.

4.3 Pneumatic accessories

Oil reservoir, pipes,hoses,fittings,oil filters,air filters,seals and gaskets, intensifiers,accumulators,heat exchangers and mufflers

4.1 TYPES OF COMPRESSORS

Q.1. Classify air compressors.

Ans :

Basically, compressors are of two types,

Positive displacement air compressors, in which the pressure in the air is induced by mechanically reducing its volume.

Dynamic type air compressors, in which the pressure in the air is induced by dynamic effect, i.e., imparting motion to air and later converting velocity into static pressure.

Various types of air compressors

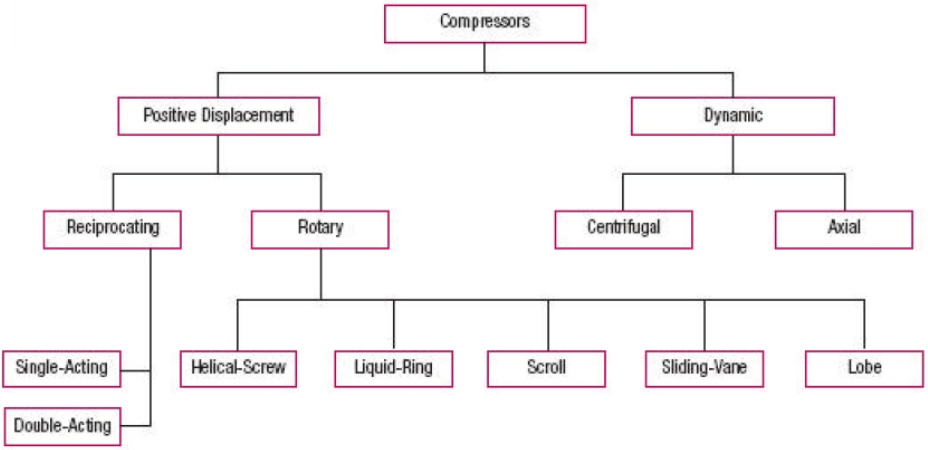
Further, the air compressors can be classified on different basis as follows,

By portability: as portable compressor, stationary compressors.

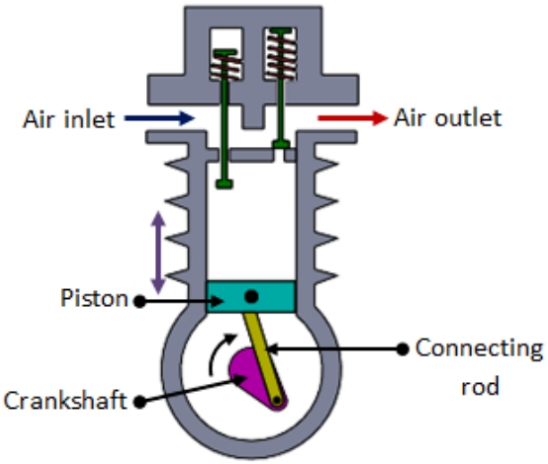
By drive: e.g. diesel engine driven, motor driven etc.

By stages of operation: e.g. single stage, double stage etc.

By geometry of cylinder arrangement: e.g. vertical, horizontal, V-type etc.



Q.2. Explain with sketch single acting single stage reciprocating air compressor.



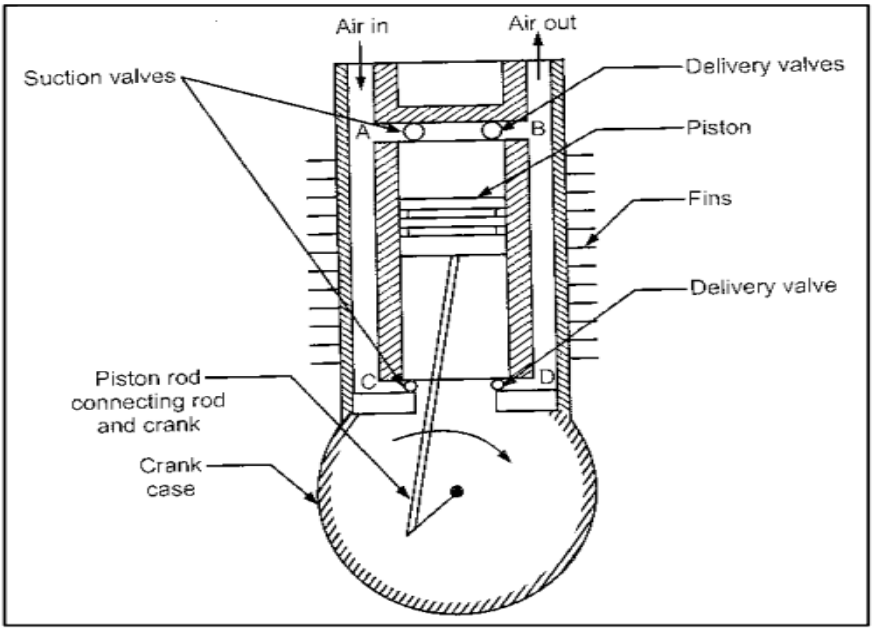
Ans: Piston compressors are commonly used in pneumatic systems. The simplest form is single cylinder compressor shown in figure. It produces one pulse of air per piston stroke. As the piston moves down during the inlet stroke the inlet valve opens and air is drawn into the cylinder. As the piston moves up the inlet valve closes and the exhaust valve opens which allows the air to be expelled. The valves are spring loaded. The single cylinder compressor gives significant amount of pressure pulses at the outlet port. The pressure developed is about 3-40 bar. The main limitation of this compressor is that it supplies the pulsating air. Further if more pressure is required it goes on becoming more bulky in size.

Q.3. Explain with sketch Double acting single stage reciprocating air compressor.

Ans:

Double acting reciprocating air compressor is similar to double acting reciprocating pump. It is comprised of following parts:

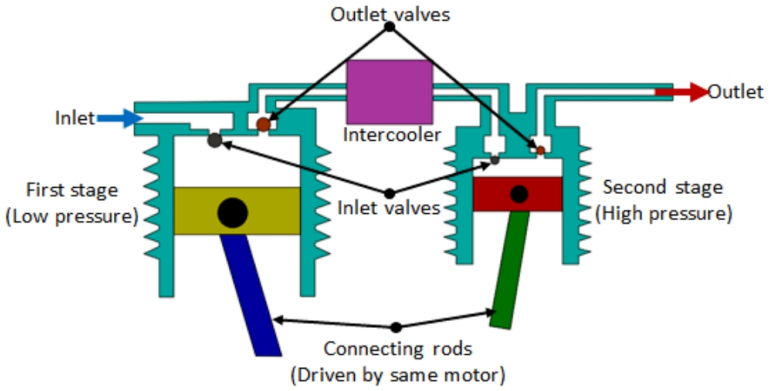
1) Cylinder
2) Piston and piston rod and connecting rod.
3) Crank and crank case
4) Two suction valves and two delivery valves.
5) One inlet port and one outlet port It uses four bar mechanism.



There are 4 valves (2 suction valves and 2 delivery valves) shown at A, B, C, D in figure. There are cooling fans similar to single acting compressors. The crank rotates on electric motor/engine/turbine. In this compressor, compression of air takes place on both side of the piston. When crank rotates, the piston starts reciprocating. When piston comes down and attains, 'Bottom dead center piston' the air comes in through port 'A' due to vacuum created due to downward movement. When piston starts moving upward, the air starts compressing. When piston attains, 'Top dead center piston', the stroke is complete and air is fully compressed which goes out through delivery valve 'B' to air receiver. During this upward movement the vacuum is created on other side (Piston rod side) of piston. Suction valve 'C' opens and air comes in. When piston starting comes down, this air which came through valve 'C', gets compressed and compressed air goes out through delivery valve 'D' to air receiver. In this downward movement air comes in through valve 'A' and entire cycle repeats.

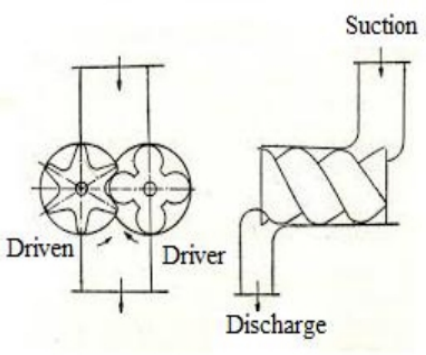
Q.4. Explain with sketch single acting two stage reciprocating air compressor.

Ans:



As the pressure of the air increases, its temperature rises. It is essential to reduce the air temperature to avoid damage of compressor and other mechanical elements. The multistage compressor with inter-cooler in-between is shown in Figure above. It is used to reduce the temperature of compressed air during the compression stages. The inter- cooling reduces the volume of air which used to increase due to heat. The compressed air from the first stage enters the inter-cooler where it is cooled. This air is given as input to the second stage where it is compressed again. The multistage compressor can develop a pressure of around 50bar.

Q.16.Explain with sketch Screw type rotary air compressor.



A screw compressor is one of the rotary type air compressors, which is being widely used in modern plants, with sophisticated controls. A screw compressor as the name implies, consists of two rotating screws. Both screws are synchronized either by external timing gears or by one screw driving the other by contact. As the screw rotates air is drawn into the housing, trapped between the screws and carried along to the discharge port, where it is delivered in a constant pulse free stream.

Working :

As rotors rotate, the air is drawn through the inlet port to fill the space between the male lobe and female flute. As rotors continue to rotate, the air is moved past the suction port and sealed in the interlobe space. The trapped air is moved axially and radially and is compressed by direct volume reduction as enmeshing of lobes of compressor progressively reduces the space occupied by the gas with increase in pressure. Simultaneously, with this process, the oil is injected into the system. The oil seals the internal clearances and it absorbs the heat energy generated during compression. The compression of air continues until the inter-lobe space communicates with dis- charge port in the casing.

The compressed air leaves the casing through the discharge port. The working parts of compressor never get severe operating temperatures, since the cooling takes place right inside the compressor. The oil is separated out in the oil separator and cooled down in an oil cooler and is re- turned back to compressor through an oil filter.

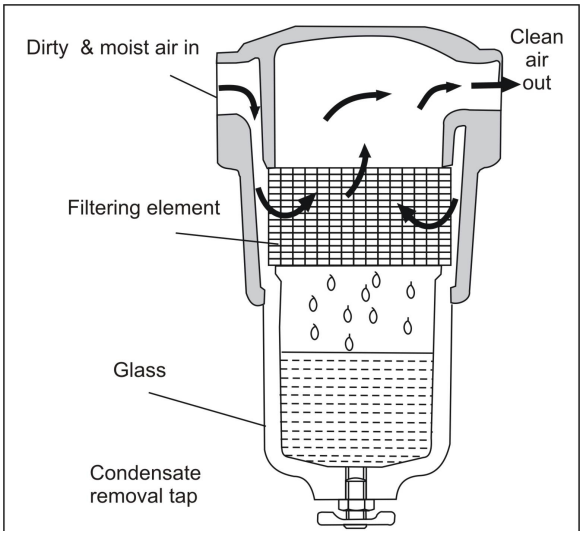
4.2 Pneumatic Components

Q.5. Explain with sketch 'Air Filter'.

Ans :

An ideal air filter would be one, which would remove all foreign materials and allow dry, clean air to flow without restriction. The primary function of filter is to remove dirt and smoke particles in air. It also performs secondary function of condensing and removing water vapor that is present in the air passing through it.

Filters are classified according to the method of removal of dirt particles (as mechanical type, electrically polymerized type), mesh size of filtering element (as fine, coarse and micro-filters) and filtering material (as synthetic type, impregnated felt type etc.)



The choice of type of filters depends upon the quality of air required, the normal air conditions, and accessibility to filter for repair or replacement of filtering element. Figure 19.1 shows a typical filter (mechanical type and using impregnated felt as the filter element).

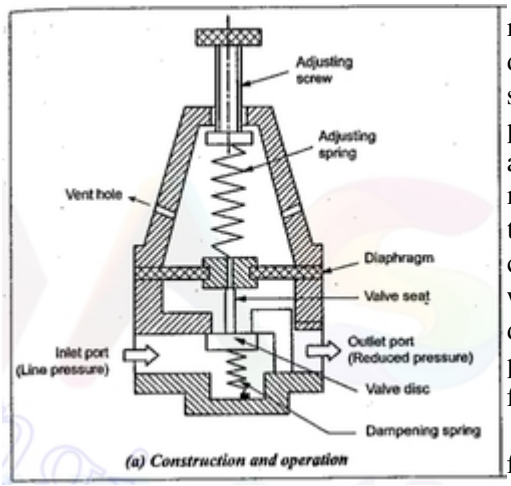
The filter has an inlet port from which moist and dirty air enters, the air then passes through the filtering element and while passing, the dirt particles remain in the outer mesh. As well due to pressure drop the moisture contained in air gets condensed and drops in the glass tube below. A liquid condensate removal tap is provided at bottom of glass tube for liquid condensate removal. The filters are rated by the mesh size as well the capacity of air flow.

Q.6. Explain with sketch Pressure Regulator.

Ans:

A pressure regulator also called pressure-reducing valve is necessary to maintain the pressure at a desired level. The regulator also acts as a pressure guard by preventing pressure surges or drops from entering the air circuit. The regulators are diaphragm type or the piston type.

Construction:



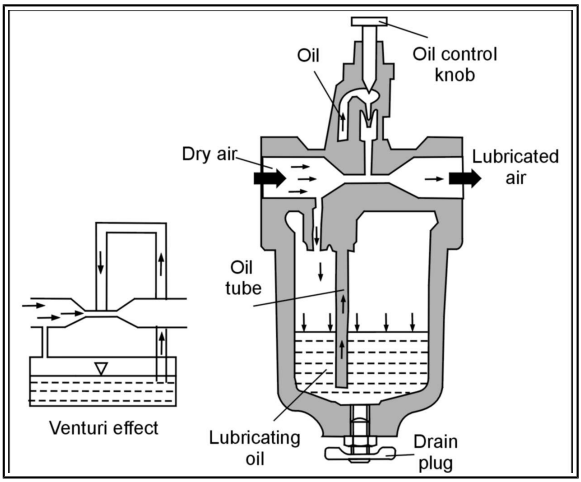
(a) Construction and operation

The diaphragm type pressure reducing valve consists of a diaphragm, made up of synthetic rubber, allows the proper movement for opening and closing of valve, without mechanical friction. The topside of diaphragm is in contact with lower spring rest where as the bottom side of diaphragm is contact with valve pin. This pin moves the valve from its seat.

With the adjusting screw in fully retracted position, the valve is closed. As the adjusting screw is turned to compress the regulating spring, the valve is opened. The pressure at which air leaves the valve depends upon the size of valve opening. The valve acts automatically to maintain relatively constant outlet pressure. Thus if air pressure on discharge side of valve increases momentarily, it acts against the diaphragm to decreases the pressure exerted by the regulating spring on the valve. The valve moves upward, towards the closing position, greater throttling action takes place, and the pressure is reduced. Thus, the valve performs regulatory action.

Q.7. Explain with sketch Lubricator used in Pneumatic system.

Ans: In pneumatic systems since the working medium is air, additional means of lubrication are required to keep friction and wear to a minimum. It has been observed that two identical air cylinders, one with absolutely no lubricant and other with proper lubricant, showed a great difference in their seal life, and lack of proper lubrication leads to rusting and pitting in the tubes due to air moisture.



There are number of types and designs of lubricator available from different manufactures.

The figure above shows a common design in which venturi effect (as that of used in automotive carburetor) is used to mix oil into air. Due to the pressure difference between oil surface and venturi throttle, the oil is forced up into the tube and it is carried away by air. The lubricator similar to a filter has a sight feed glass, which shows quantity of oil present in the flask. Metering of oil is accomplished by a needle valve, which provides variable sized orifice. The lubricator can be filled manually shutting off the air pressure. The oil is atomized by air in the venturi tube.

Q.8. Explain with sketch the function of each element in FRL unit used in pneumatics. Also show its symbol.

Ans:

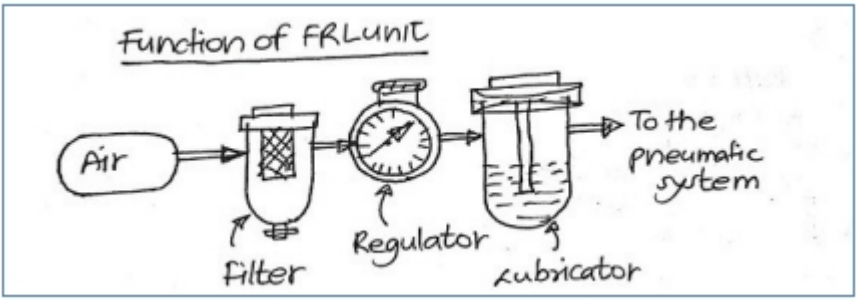
It is service unit used in Pneumatic system which is combination of three devices named as Filter, Regulator and Lubricator. Function of FRL Unit:

1. Filter: It is used for separate out or filter out contaminants present in the compressed air.

2. Regulator: It is pressure control device used for regulating pressure of compressed air to the desired pressure at a steady state condition.

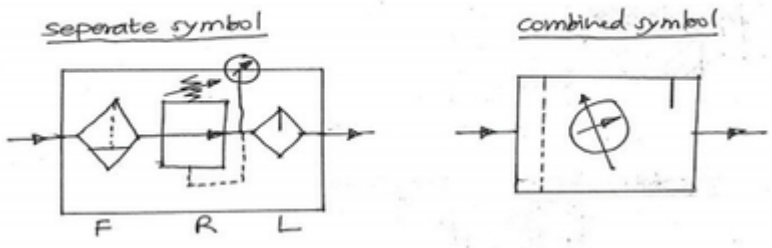
3. Lubricator: It is a device which is used for addition of lubricating oil particles in compressed air for lubrication of sliding or moving pneumatic components.

Sketch of the combined unit



Symbol of the FRL unit together and separates

Separate symbol **combined Symbol**

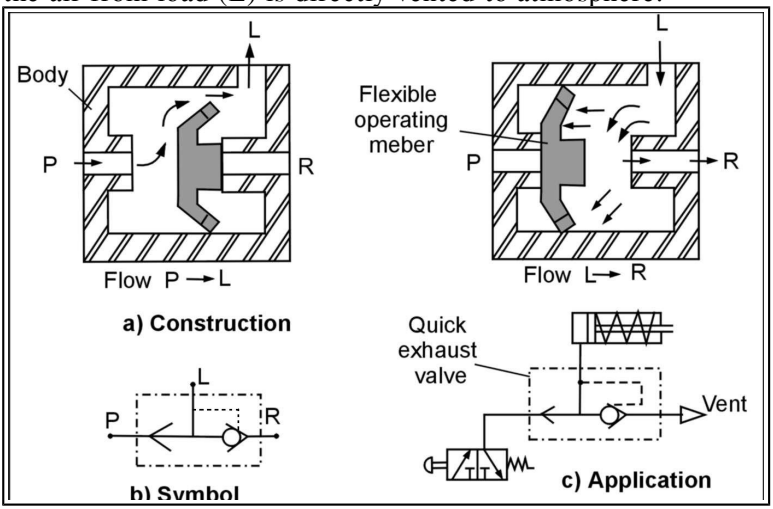


Q.9. Explain with sketch the Quick Exhaust valve used in Pneumatics

Ans:

A quick exhaust valve, as the name implies is used for quick exhaust of the air from the actuator. In normal system (without quick exhaust valve), the air has to return through piping and valves. But since air is to be ultimately drained to atmosphere (and not to be returned to reservoir as in hydraulic system), it is efficient to drain it (called venting) directly to atmosphere as it leaves the actuator, this reduces the back pressure as well saves energy, required for driving out the air. This speedups the return stroke also.

Construction of a quick exhaust valve is shown in figure below. Similar to shuttle valve it has three ports namely pressure (P), load (L) and vent (R). It has an operating member (generally a movable disc). In normal forward stroke the disc moves to right opening port "P" to load "L", as well closing the vent 'R'. In return stroke, the returning air pushes the flexible disc to left, closing the port "P" and at the same time opening the vent "R". Thus the air from load (L) is directly vented to atmosphere.



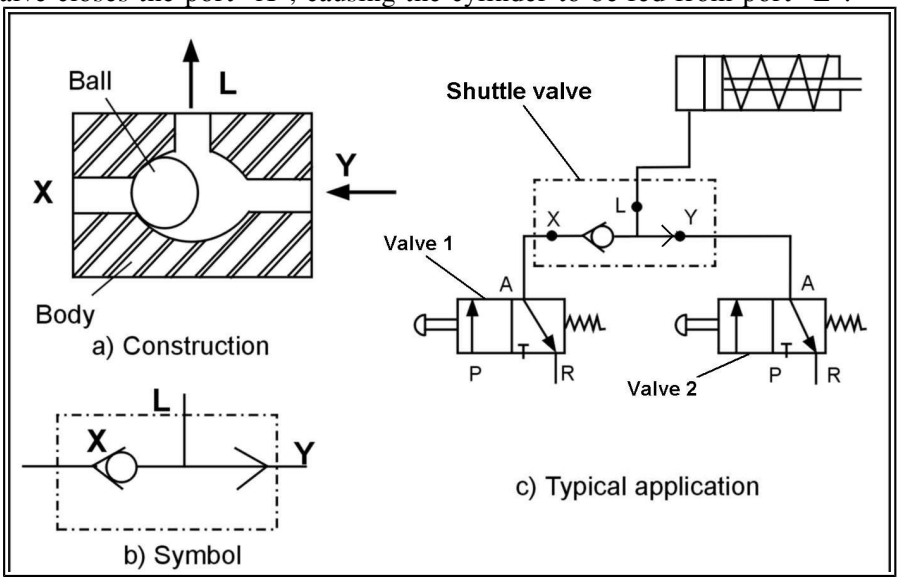
Q.10. Explain with sketch the Shuttle valve used in Pneumatics

A shuttle valve also called as double check valve, which allows pressure in a line to be obtained from alternative sources.

Construction, symbol and application of a ball type shuttle valve is depicted in figure below . It consists of an operating element (which may ball or cone), which is free to move in a body, depending upon the side from which pressure is obtained. It has three ports namely X,Y and L.

The port "L" is output (load) port. The air is supplied to port "L", by the valve either from "X." or "Y", from whichever pressure is applied, but at the same time, the valve closes the flow "X" to "Y" or viseversa.

An application of shuttle valve to operate single acting cylinder from two sources is also shown in figure 18.10. When valve 1 is actuated, the compressed air is applied to the port "X", the shuttle valve closes the port "Y" and supplies air to the cylinder through port "L", and when valve 2 is actuated, the compressed air is applied to the port "Y", the shuttle valve closes the port "X", causing the cylinder to be fed from port "L".

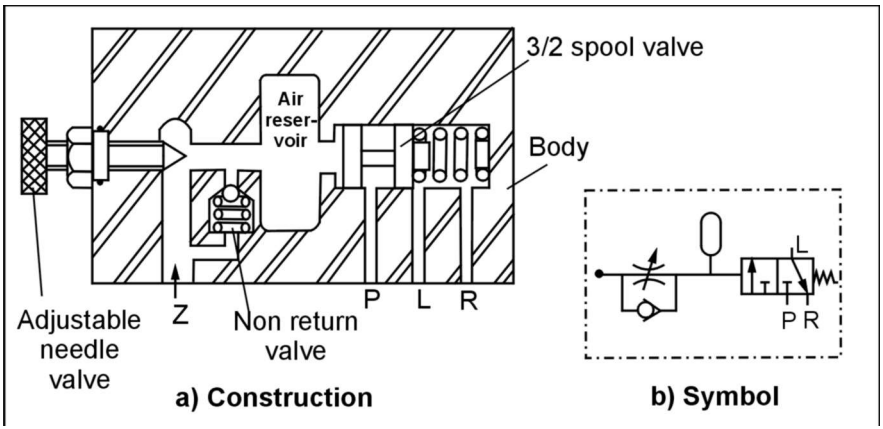


Q.11. Explain with sketch the Time Delay valve used in Pneumatics.

Pneumatic time delay valve is used when time based sequencing is required. Construction and symbol of valve is shown in fig.18.12. It is simply a 3/2 direction control valve, which is impulse operated from one side. Time delaying is achieved by delaying the impulse actuation. The valve has an in-built air reservoir and in-built non-return flow control valve.

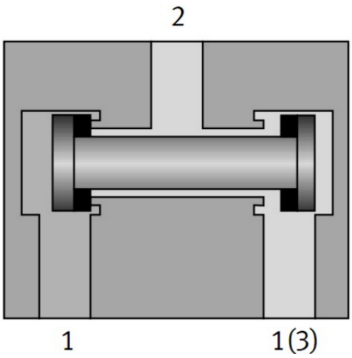
When impulse is applied to port "Z" for valve actuation, the air passes through needle control valve, which controls the rate of flow, further the valve spool is not actuated until the air reservoir is filled completely and pressure is built-up. (This time difference between impulse application at "Z" and actual spool actuation is the "delay", which is adjustable through needle valve).

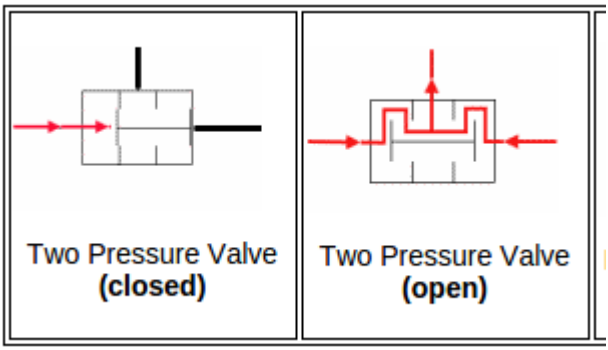
This valve is found applicable in time based sequencing, which is common industrial application, e.g. clamping, indexing, feed motions etc.



Q.12. Explain with sketch Dual pressure valve used in Pneumatics.

A two pressure valve requires two pressurised inputs to allow an output from itself. This is achieved by a similar system to the one shown below, one active input slides the shuttle valve shut blocking any air flow, add two active inputs and the shuttle remains centralised allowing flow through the valve.





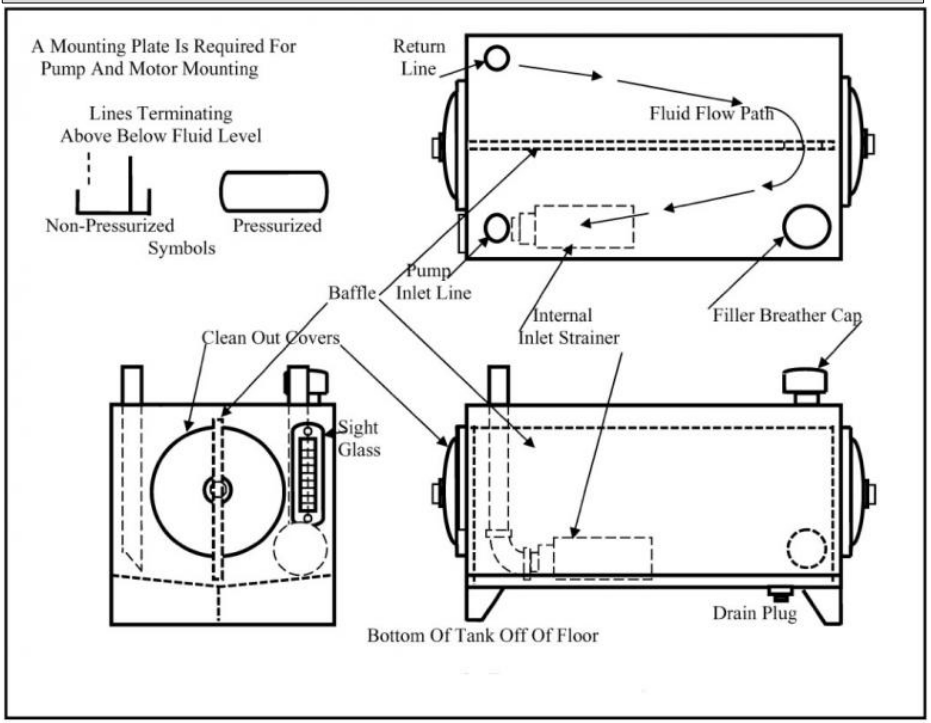
These valve types are commonly associated but not limited to safety circuits, for example a two push button operation system whereby an operator is required to use both hands to activate two push buttons, this would ensure the operators hands are out of reach of any hazardous operations.

4.3 Hydraulics and Pneumatic accessories

Q.13. State the functions to be performed by oil reservoir in a hydraulic circuit?

Ans : Following are the functions performed by the oil reservoir,
1) Storage of Hydraulic oil volume
2) Removal of Heat
3) Removal of Trapped air
4) Settlement of Contaminants

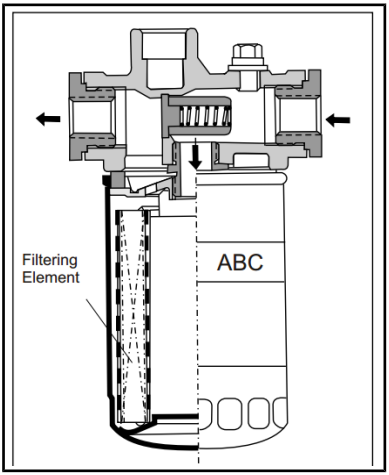
Q.14. Explain with sketch Hydraulic reservoir?



A hydraulic reservoir consist of following components,
1) Suction line and Return line : These two lines should be located as far away from ech other as possible, in order to guarantee that the oil volume is circulated effectively. Both lines should be sufficiently above the bottom

to prevent sludge from stirring and getting inside the suction line.
2) Baffle plate : Suction and return lines are separated by the baffle plate. This is set up near the tank floor, and reaches closer to oil surface. This causes the flow of oil withn the tank and leads the return oil along the walls of the tank in order to improve cooling of oil.
3)Filter spout and air breather : The oil tank is filled through a filling strainer. This is a fine mesh through which the oil is filled in the tank. In order to maintain atmospheric air pressure inside the tank, and air breather must be provided for the pressure compensation. Air breather is mostly combined with the filler spout.
4) Oil level indicator: Its function is to display the level of oil inside the tank.
5) Inspection covers and cleaning openings : Inspection covers, mostly fitted with the glass are provided in the side of the tank. From openings, it must be possible to reach all points in the tank for interior cleaning purpose.
6) Oil drain tap(plug) ; the bottom of the tank is sloped, to move the deposit of sediment(sludge and water) at the lowest point in the tank. From where it can be drained off by means of a drain tap.
7) Tank covers : The design of tank covers depends upon what is to be mounted on it. If the pump is mounted on it its design is different. The pump can be mounted vertically or horizontally on it.

Q.15. Explain with sketch Hydraulic oil filter?



Many fluid power systems fail simply because there is too much contamination in the medium. In fact, some estimate that 75% of all fluid power failures can be attributed to contamination issues.
This is why no fluid power system can be complete without the use of a filter. Hydraulic filters keep the hydraulic fluid contaminant free. Figure below shows the commonly used filter, the bottom shell is removable for replacement of the filtering element. Such unit is

installed in the return or suction line.

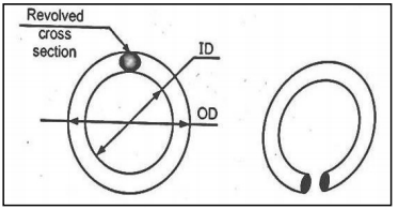
The oil enters from the right side and then passes through the filtering paper cartridge(replaceable) then passes to the right side. While passing the oil leaves the contaminant inside the filter cartridge.

Q.16. What is the purpose of hydraulic oil seal? Explain any one type of oil seal.

Ans :Purpose of oil Seal

1) To stop leakage of oil
2) To maintain the pressure
3) To keep out contamination in the system
4) To enhance the working life of the system
5) To enhance the functional reliability of components over a longer period

'O' Ring Seal:



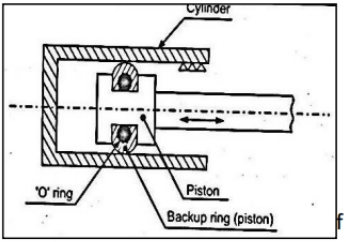


Figure shows 'O' ring seal. These are most common and simple seal with circular crosssection like 'O'. Hence called O-ring is used as static as well as dynamic seal. The material used for O-Ring is synthetic rubber and is specified by its ID/OD. The round cross-section are non-positive seals. O-rings are fitted with back ring the following figure depicts sealing of cylinder and piston by using 'O'-ring with backup ring.

Q.17.What are the Factors to be considered for selection of seal and causes of its failure

Ans: Factors to be considered for selection of seal

1. Shaft Speed The maximum allowable shaft speed is a function of the shaft finish, runout, housing bore and shaft concentricity, type of fluid being sealed and the type of oil seal material.
2. Temperature The temperature range of the mechanism in which the seal is installed must not exceed the temperature range of the seal elastomer.
3. Pressure Most conventional oil seals are designed only to withstand very low-pressure applications (about 8 psi or less). If additional internal pressure is present or anticipated, pressure relief is necessary.
4. Shaft Hardness Longer seal life can be expected with shafts having a Rockwell (RC) hardness of 30 or more. When exposed to abrasive contamination, the hardness should be increased to RC 60.
5. Shaft Surface Finish Most effective sealing is obtained with optimum shaft surface finishes. The sealing efficiency is affected by the direction of the finish tool marks and the spiral lead. Best sealing results are obtained with polished or ground shafts with concentric (no spiral lead) finish marks. If you must use shafts with spiral finish leads, they should lead toward the fluid when the shaft rotates.
6. Concentricity When the bore and shaft centers are misaligned, seal life will be shortened because the wear will be concentrated on one side of the sealing lip.
7. Shaft and Bore Tolerances The best seal performance is achieved when close shaft and bore tolerances are present. Other factors include shaft eccentricity, end play and vibration.
8. Runout Runout must be kept to a minimum. Movement of the center of rotation is usually caused by bearing wobble or shaft whip. When coupled with misalignment, this problem is compounded. Contrary to popular belief and common practice, the installation of flexible couplings cannot correct or compensate for misalignment.
9. Lubricant Seals perform much better and longer when they are continuously lubricated with oil that has the correct viscosity for the application and that is compatible with the seal lip elastomer material. The consideration of seal incompatibility, particularly with certain additives and some synthetic lubricants, should not be ignored.

Causes of failure

1. Improper installation is a major cause of hydraulic seal failure. The important things to watch during seal installation are:
(a) cleanliness,
(b) protecting the seal from nicks and cuts, and
(c) proper lubrication
2. Hydraulic system contamination is a another major factor in hydraulic seal failure 3. Chemical breakdown of the seal material .
4. heat degradation problems may involve reducing sea life.

Q.18.State any four reasons of failure of pneumatic seals.

Ans –
1. Incompatibility of seal material with operating system
2. Excessive heat
3. Excessive load
4. Excessive clearance
5. Excessive pressure
6. Improper fitting
7. Improper groove geometry
8. Abrasion
9. Wear

Q.19. State the function of accumulator?What are the different types of accumulators? Explain any one type of accumulator?

Ans :

Function of Accumulator: It is a pressure vessel used in hydraulic system for following function

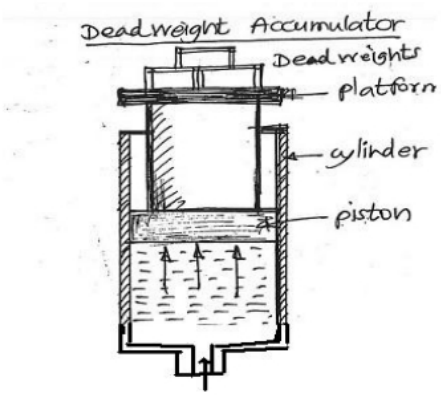
1. Primary function is to store hydraulic energy of pressurized oil during idle period and make available again when it is required by the system.
2. To meet peak demands of hydraulic energy, smooth out pressure shocks/surges .

Different types of accumulator:

According to element used for store oil under pressure types of accumulator are:

1. Dead weight type accumulator: The dead weights may be of some heavy materials like iron or concrete blocks are placed on the piston platform.
2. Spring loaded Accumulator: The compression spring with high stiffness is used to exert force on the piston to store hydraulic energy of oil.
3. Gas charged Accumulator: The gas bladder is charged with dry nitrogen gas and force is created with the help of gas pressure inside the bladder.

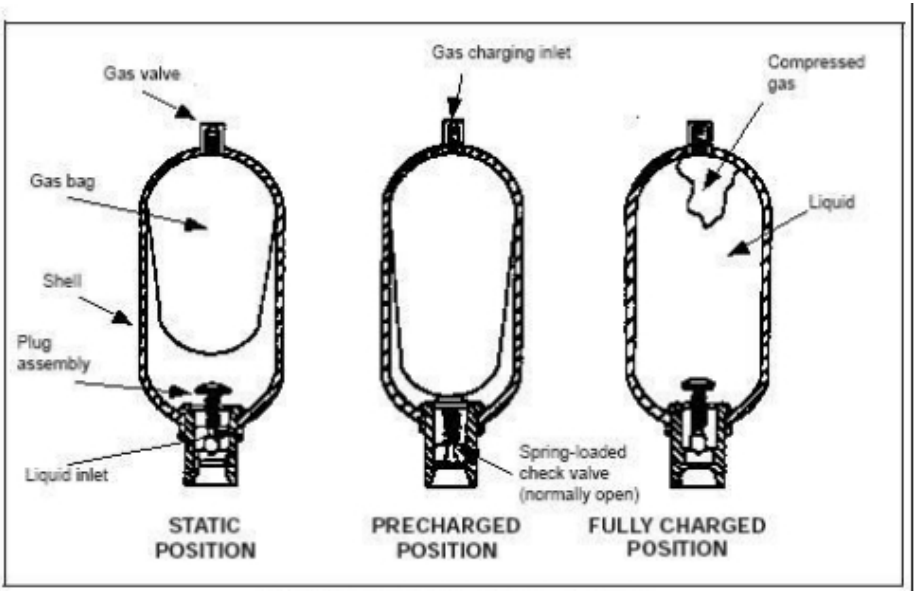
Dead Weight type accumulators



Working;

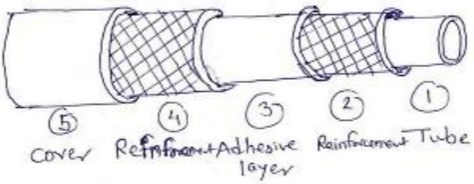
1. It consists of piston loaded with dead weight and moving within a cylinder which exerts pressure on the oil.
2. The oil will enter from the inlet provided at the bottom and pushes the piston in upward direction against the load exerted by the dead weight placed on the platform.
3. When piston moves to the upper end the accumulator get charged and it can be used whenever oil energy is needed.

Q20Explain with sketch Working of bag type accumulator



This accumulator consists of a seamless high-pressure shell, cylindrical in shape, with domed ends and a synthetic rubber bag that separates the liquid and gas (usually nitrogen) within the accumulator. The bag is fully enclosed in the upper end of a shell. The gas system contains a high-pressure gas valve. The bottom end of the shell is sealed with a special plug assembly containing a liquid port and a safety feature that makes it impossible to disassemble the accumulator with pressure in the system. The bag is larger at the top and tapers to a smaller diameter at the bottom. As the pump forces liquid into the accumulator shell, the liquid presses against the bag, reduces its volume, and increases the pressure, which is then available to do work.

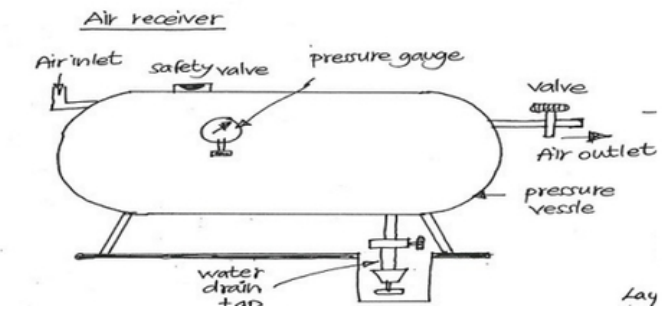
Q.21. Explain with sketch Pneumatic hose layers and state function of each layer?



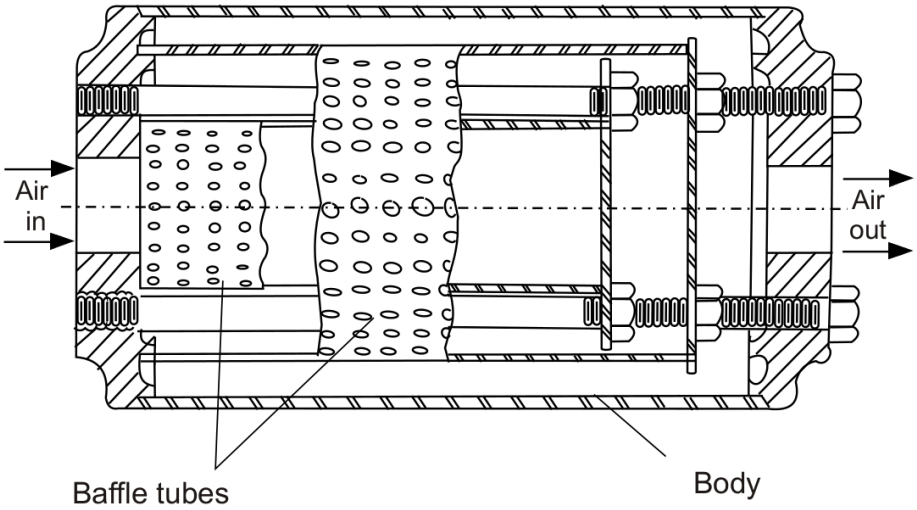
Pneumatic hose is made of several layers with metal wire braiding between them.

S.N	Layer	Function	Material
1	Tube	Conveys the hydraulic compressed air	Polyethylene
2	First reinforcement	Protects and strengthens the tube	Metal wire(steel or copper)
3	Adhesive layer	Holds the reinforcement layers, protects against vibrations	Rubber
4	Second reinforcement	Protects the first reinforcement	Woven yarn (cotton, nylon , polyester synthetic fiber)
5	Outer cover	Protects from abrasions, duct, vibrations, sunrays	Polyethylene

Q.22. Explain with sketch air receiver?



Q.23. Explain with sketch Muffler used in pneumatic system?



Muffler is a device which is used in the pneumatic system to reduce the noise created by exhausting air. It does exactly what a silencer does in an automobile.Mufflers are attached to the exhaust port of air valves, cylinders or motors. Several designs have been developed, some of them patented by various manufacturers but with the central core of dissipating the exhaust energy.

Figure above shows a common type of muffler in which the air is passes through series of baffles, which are perforated metal tubes. Which are fitted one in another. As the air stream enters from left end and passes throught the series of baffles the air looses its velocity and hence the noise is lost while exhausting.