MODULE 3

3.17 ACCUMULATORS

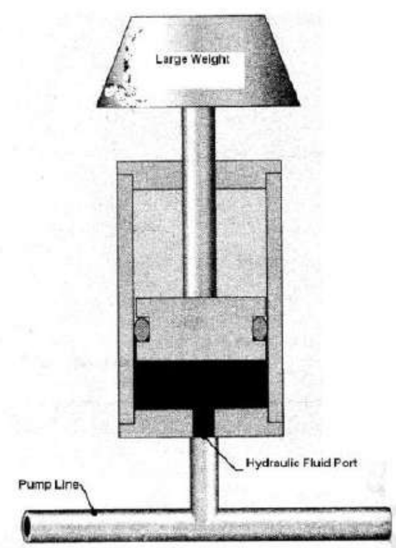
Accumulators are devices that store hydraulic fluid under pressure. Storing hydraulic fluid under pressure is a way of storing energy for later use. Perhaps the most common application for an accumulator is supplementing the pump flow in a hydraulic system in which a high flow rate is required for a brief period of time.

Types;

1. Weight loaded accumulator
2. Spring loaded accumulator
3. Gas charged accumulator
4. Piston type
5. Bladder type
6. Diaphragm type

3.17.1 WEIGHT LOADED ACCUMULATOR

It is basically a vertically mounted cylinder with a large weight as show in Figure.

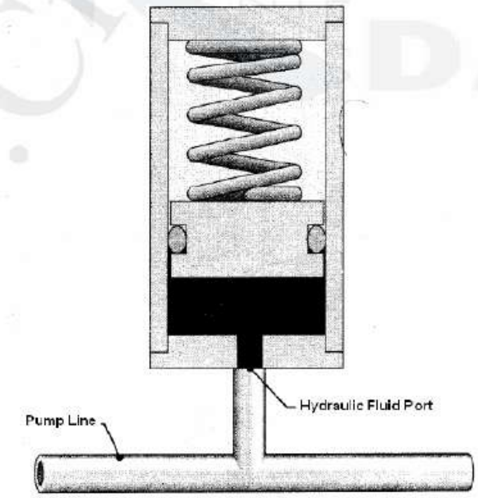


Weight Loaded Accumulator

When hydraulic fluid is pumped into this accumulator, the weight is raised. The weight then applies a force to the piston, which generates a pressure on the fluid side of the piston. The advantage of this type of accumulator over all of the other, it applies a constant pressure on the fluid throughout its entire range of motion. The disadvantage is that a very large weight must be used to generate enough pressure. Because of that this type is seldom used.

3.17.2 SPRING LOADED ACCUMULATOR

A spring loaded accumulator stores energy in the form of a compressed spring as shown in figure.



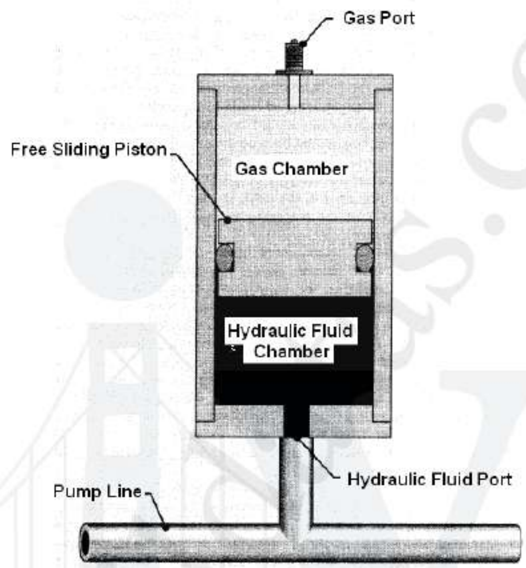
Spring Loaded Accumulator

Hydraulic fluid is pumped into the accumulator, causing the piston to move up and compress the spring. The spring then applies a force on the piston that exerts a pressure on the hydraulic fluid. The pressure is constantly decreasing as hydraulic fluid is drawn out because the spring decompresses and therefore exerts less force on the piston. This type is not commonly used in hydraulic circuit because a large spring must be used to generate enough pressure.

3.17.3 PISTON TYPE ACCUMULATOR

The basic construction of a piston type, gas charged accumulator is shown in Figure.

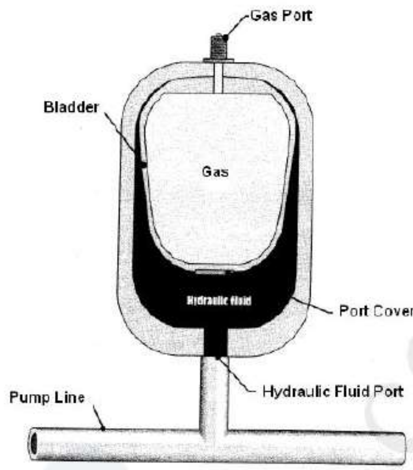
Its operation begins when the gas chamber is filled with a gas to some predetermined pressure called the pre-charge, which causes the free-sliding piston to move down. Once the accumulator is pre-charged, hydraulic fluid can be pumped into the hydraulic fluid port.



As the hydraulic fluid enters the accumulator, it causes the piston to slide up, thereby compressing the gas. Compressing the gas increases its pressure, and this pressure is then applied to the hydraulic fluid through the piston. Because the piston is free sliding, the pressure on the gas and the hydraulic fluid is always equal. Whenever the pressure in the system drops below the pressure in the accumulator, fluid will flow out of the accumulator and into the system. As the hydraulic fluid flows out of the accumulator, the gas decompresses and loses pressure, which in turn causes the pressure on the hydraulic fluid to be reduced. The gas used to pre-charge accumulator is usually nitrogen because it is an inert gas and does not support combustion.

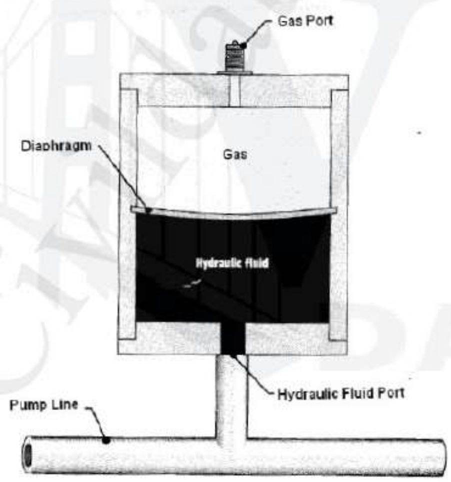
3.17.4 BLADDER TYPE ACCUMULATOR

The basic construction of a bladder type accumulator is shown in Figure. These accumulator functions in the same way as a piston accumulator, storing energy in the form of a compressed gas. However, instead of the gas and hydraulic fluid being separated by a piston, they are separated by a synthetic rubber bladder. The bladder is filled with nitrogen until the desired pre-charge pressure is achieved. Hydraulic fluid is then pumped into the accumulator, thereby compressing the gas and increasing the pressure in the accumulator, just as with the piston type. The port cover is a small piece of metal that protects the bladder from damage as it expands and contacts the hydraulic fluid port.



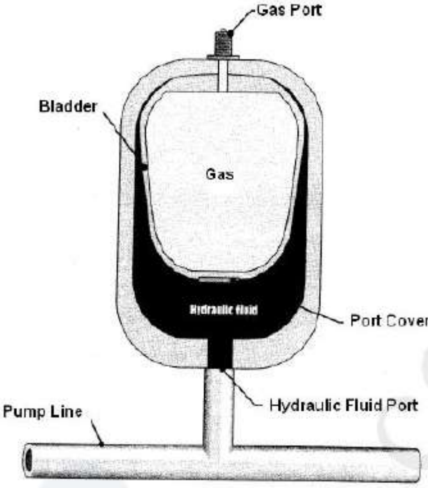
Bladder Type Accumulators

3.17.5 DIAPHRAGM ACCUMULATOR



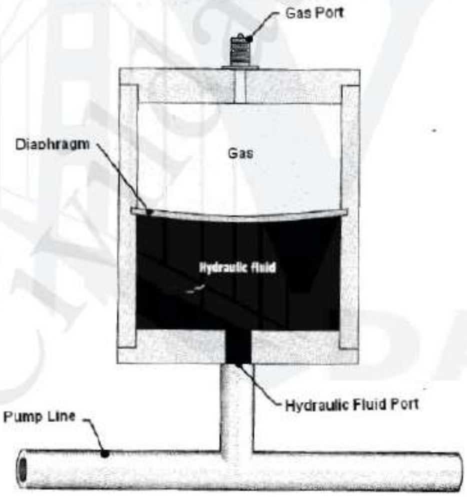
Diaphragm Accumulators

The vessel is separated into two components by a flexible diaphragm. One compartment is connected to the hydraulic system and the other to the high pressure gas system. Thus the diaphragm serves as an elastic barrier between the oil and the gas. When the oil is delivered into the accumulator, it deforms the diaphragm. The gas is compressed when the charged oil pushes the diaphragm against it. This gas pressure is used as the potential energy to force the oil out when it is required in the circuit. The advantage of bladder and diaphragm accumulators over the piston type is that they have no sliding surface that requires lubrication and can therefore be used with fluids with poor lubricating port cover is a small piece of metal that protects the bladder from damage as it expands and contacts the hydraulic fluid port.



Bladder Type Accumulators

3.17.5 DIAPHRAGM ACCUMULATOR



Diaphragm Accumulators

The vessel is separated into two components by a flexible diaphragm. One compartment is connected to the hydraulic system and the other to the high pressure gas system. Thus the diaphragm serves as an elastic barrier between the oil and the gas. When the oil is delivered into the accumulator, it deforms the diaphragm. The gas is compressed when the charged oil pushes the diaphragm against it. This gas pressure is used as the potential energy to force the oil out when it is required in the circuit. The advantage of bladder and diaphragm accumulators over the piston type is that they have no sliding surface that requires lubrication and can therefore be used with fluids with poor lubricating qualities. They are also less sensitive to contamination due to lack of any close fitting sliding components.

3.17.6 NON-SEPARATED TYPE ACCUMULATOR

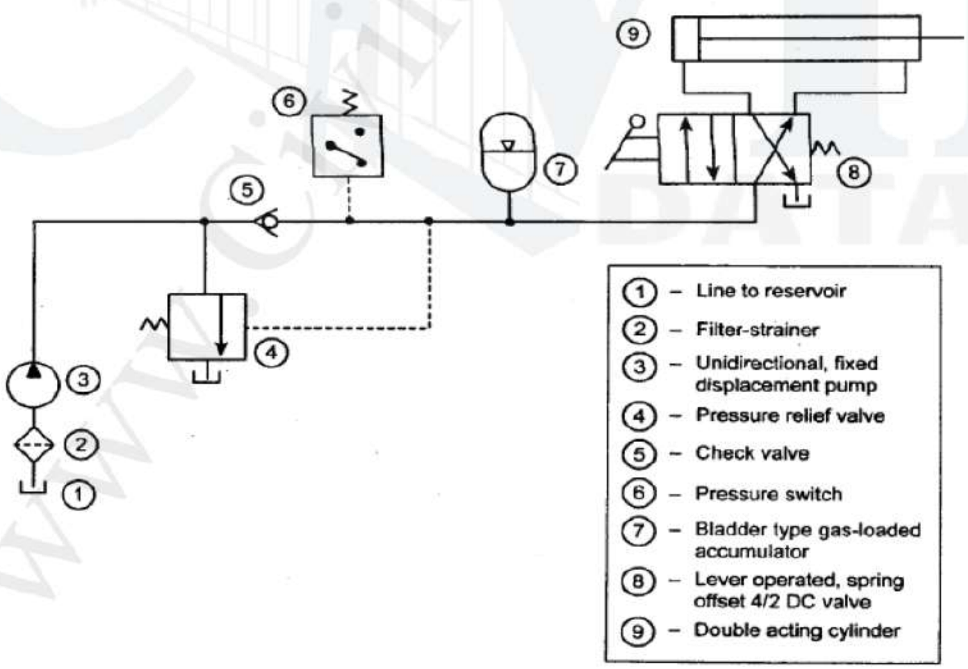
It consists of a fully enclosed shell containing a gas charging valve on the top and an oil port on the bottom. The confines at the top and oil remain at the bottom and there is no physical separator between them. Since the gas has direct contact with the oil, this type is termed as non separator type accumulator. Due to the absence of separator, the gas is absorbed and also entrapped in the oil. This accumulator type is not preferred for use with high speed pumps because the entrapped gas in the oil may cause cavitations and damage to the pump. The problems of aeration of the oil often limit their use in hydraulic system.

3.18 APPLICATIONS OF ACCUMULATORS

Accumulators are used as

1. Leakage compensator
2. Auxiliary power source
3. Emergency power source
4. Hydraulic shock absorber
5. Fluid make-up device

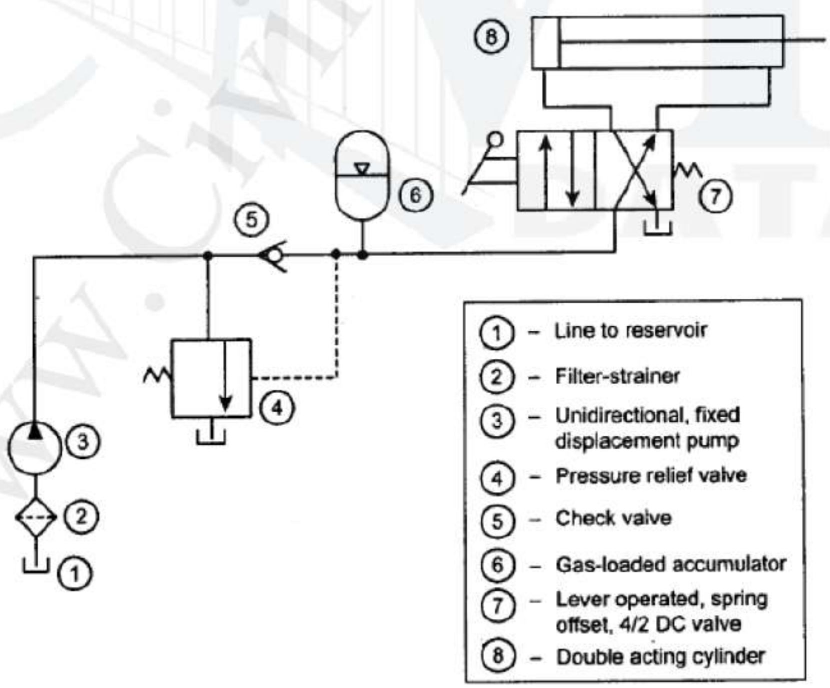
3.18.1 ACCUMULATOR AS LEAKAGE COMPENSATOR



The stored energy of the accumulator can be used to compensate any possible loss of energy due to internal or external leakage in a system. This application is extremely helpful in circuits, such as are used for hydraulic presses, which require high pressure for long periods. First operator places work piece on the press and shifts handle of the 4/2 DC valve. Now the oil flows to blank end of cylinder and piston extends. The pressure builds up and oil fills the accumulator. When maximum pressure is reached, the pressure switch stops the pump motor. In these applications, the cylinder and piston arrangement is required to press the work piece for a longer period of time. During this period, the internal and external leakage may reduce the cylinder pressure. The leakage oil is replaced with the oil from the accumulator. This leakage replacement of oil is carried for a longer period of time. The maximum length of time is determined by the volume of the accumulator and the rate of leakage in the cylinder. When the pressing cycle has been completed, the operator shifts the handle of the 4/2 DC valve to original position. Thus a cycle is completed.

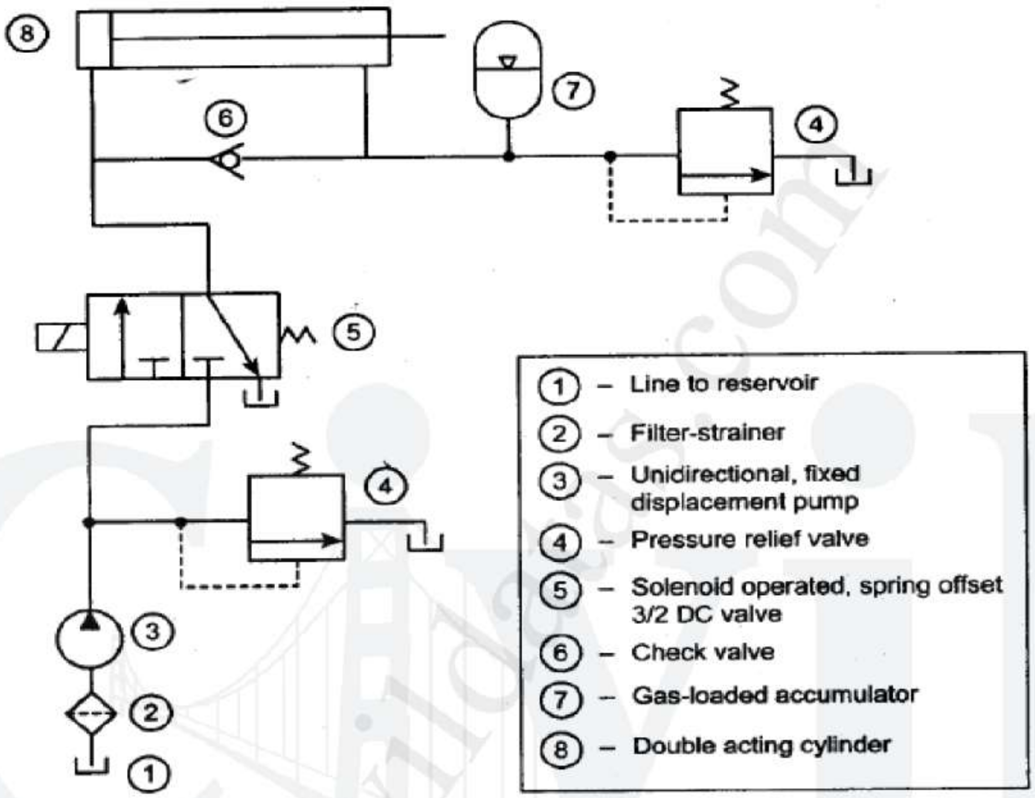
3.18.2 ACCUMULATOR AS AUXILIARY POWER SOURCE

As we know, the electric motor or pump motor is a primary power source. In this application, the accumulator stores the oil during one portion of the work cycle and releases the oil during the remaining cycle. Thus accumulator serves as a secondary power source. Figure shows the circuit using accumulator as a secondary power source. After placing the work piece on slide table and shifts handle of 4/2 DC valve. Now oil flows from the accumulator to blank end of slide cylinder. This extends the piston until slide table reaches end of stroke. When the cylinder is in the fully extended position, the accumulator is charged with the oil by the pump. Then the operator shifts the handle of 4/2 DC valve for the retraction of the cylinder. Now the oil flows from the pump as well as from the accumulator to retract the cylinder quickly.



3.18.3 ACCUMULATOR AS EMERGENCY POWER SOURCE

In some hydraulic applications, it is necessary to retract the pistons of cylinder to their starting position; even there may be an electrical power failure. In such applications, the accumulator can be used as an emergency power source to retract the piston of the cylinder.

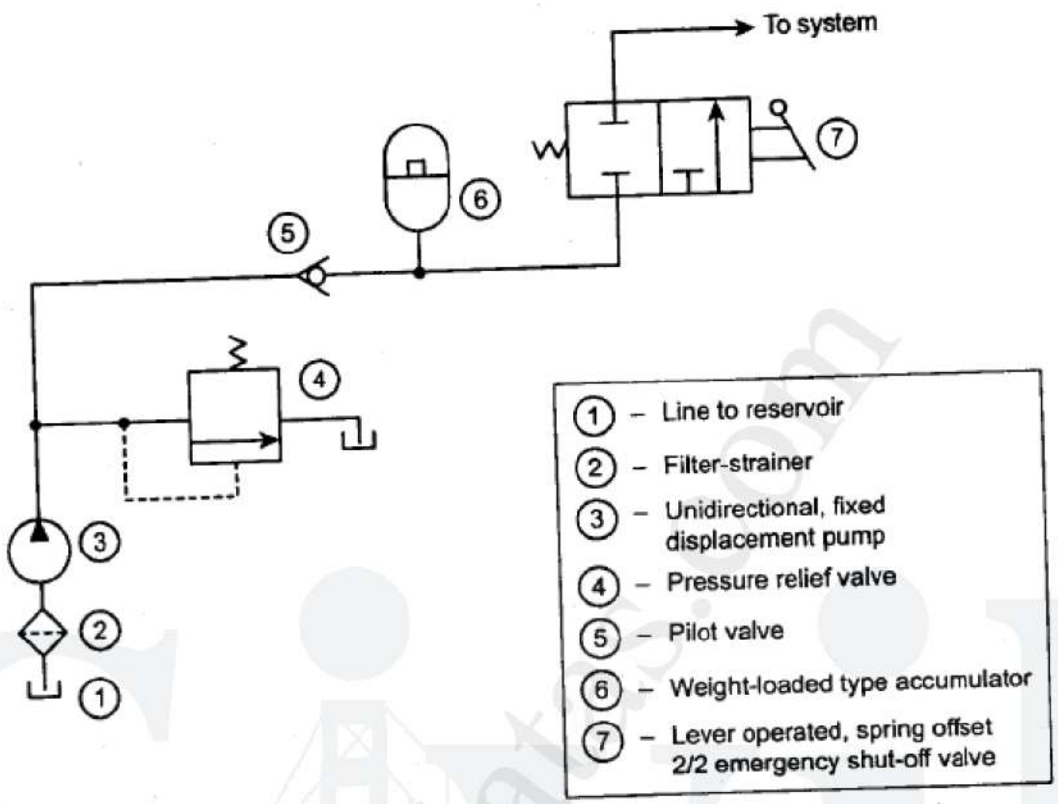


Accumulators as Emergency Power Source

When operator depresses push button energizing solenoid of the 3/2 DCV, oil flows to blank end of cylinder. At the same time, the oil also unseats check valve. So the oil under pressure flow to rod end of cylinder and into the accumulator. When there is a power failure, the solenoid will de-energize. In the absence of solenoid energy, the spring pressure forces the valve to shift to its spring offset mode. Now the oil stored under pressure is forced from the accumulator to the rod end of the cylinder. Thus the piston of the cylinder retracts to the starting position.

3.18.4 ACCUMULATOR AS HYDRAULIC SHOCK ABSORBER

In many high pressure hydraulic systems, the sudden stoppage of a hydraulic fluid flowing at high velocity in pipelines can cause considerable damage to the piping. This hydraulic shock, also known as water hammer, may snap heavy pipes, loosen fittings and cause leaks. By installing an accumulator, this high pressure pulsations or hydraulic shocks can be absorbed. Figure shows the circuit employing accumulator for serving as a hydraulic shock absorber.



Accumulators as a Hydraulic Shock Absorber

The accumulator installed near the shut-off point in order to be more effective in quickly absorbing the shock wave. When the system demands to shut-off the supply suddenly, a 2/2 shut-off valve is used for the purpose. When operator shifts handle of the 2/2 emergency shut-off valve, the fluid flow is stopped suddenly. This results in high-pressure pulsations or hydraulic shock. The pressure pulsation is blocked by check valve. The surges between the check valve and the shut-off valve are used to store the oil in accumulator and thus the pressure pulsations of the oil in the pipe line are absorbed.

11.9 RESERVOIR

The fluid reservoir is the storage tank in which the hydraulic fluid is contained. They are usually made of steel sheets, welded at the joints and it is vital to remove all the scale and rust from the inside and be thoroughly cleaned before being put into use. The inner side of the tank should be painted with a sealer to minimise oxidation.

A reservoir tank normally contains a fluid level gauge in the form of a transparent window. The lowest level of the tank at any time should not be permitted to go lower than approximately 300 mm above the pump's inlet mouth. The pump's intake pipe is fitted with a removable mesh strainer of about 125 microns.

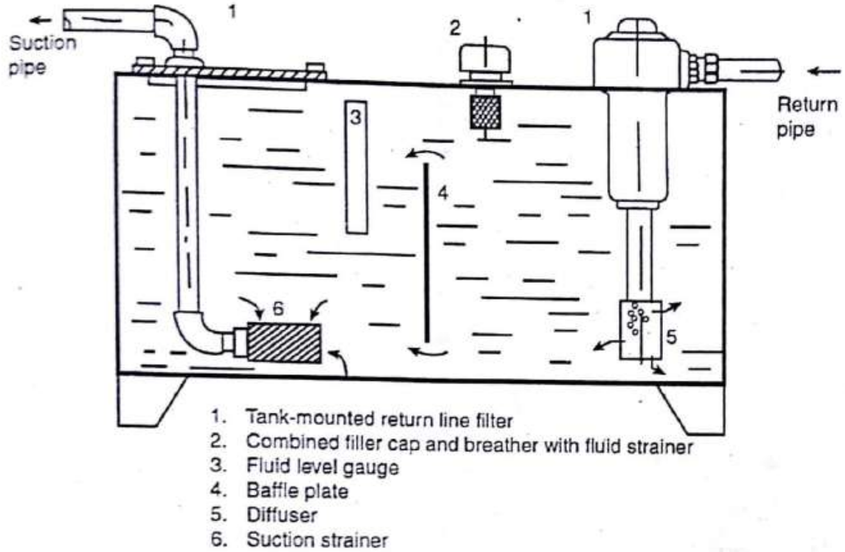


Figure 11.9 Reservoir

All fluid return pipes should terminate below the fluid surface and should be fitted with diffusers, to prevent the returning fluid from disturbing the sediments which may have settled at the bottom of the tank.

A vertical plate known as a Baffle plate is provided between the pumps inlet and return lines for preventing the continuous recirculation of the same fluid into the system. The purpose of a baffle plate is that the foreign particles from the returning fluid are allowed to settle down without any disturbance and the trapped air is allowed to escape.

As the fluid level in the tank goes up and down during the various operations, a hole is provided at the top for the inlet and exit of air and is known as 'air breather'. Through this hole the fluid faces the greatest danger of being contaminated. To prevent dust from going inside, a filter is provided in the air breather.

11.9.1 Functions of a Fluid Reservoir

a. To provide a chamber in which any change in volume of the fluid in the hydraulic circuit can be accommodated. For example, when cylinders extend, there is an increase in volume of the fluid in the circuit.

b. To provide a volume of fluid which is relatively stationary to allow entrapped air to separate out and heavy contaminants to settle.

c. To make up for any leakage occuring in the system.

d. To provide a filling point for the system.

e. To provide a radiating surface for allowing the fluid to cool.

7.2 FLUID CONTAMINATION

All substance suffer from contamination or impurities. Hydraulic fluids are no exception. The source of contamination of the hydraulic fluid are numerous. They can be categorised as follows.

Contamination During Hydraulic System Construction

Dirt is introduced into the hydraulic system at the time of fabrication of components and during the manufacture of the system. Some of the contamination found in oil sample, taken out from a new machine after a short run are metal chips, tubing burrs, welding scale and beads, rubber particles, hose debris etc. When components are replaced in the system, a variety of contaminants are introduced in the system.

Contaminants Produced within the Hydraulic System

When hydraulic components slide, friction causes and eventually generate wear particles that get carried through the hydraulic system. Abraded iron particles and packing material debris get wedged between sliding surfaces aggravating the wear. Moreover tubings and fittings (particularly steel) will corrode and scale especially if unused for a long time.

Contamination from the Workplace Environment

Sources of contamination surrounding hydraulic equipment are dirty air, metal particles from nearby machinery, extraneous oil and by-products. For example, a hydraulic fork lift in a cement factory or a hydraulic hoist in a foundry may have severe contaminants such as water, oil, chips and dust.

Contamination from Fluid Decomposition

Hydraulic oil is composed of hydrocarbon compounds combined with small amounts of oxygen. When heated or continuously exposed to light, the fluid becomes more succeptible to oxidation, which can lead to the formation of a gel like sludge at low temperatures. At higher temperatures, the sludge breaks up and becomes fluid suspended contamination.

7.3 FILTRATION OF FLUIDS

Majorly, the improper function or failure of the hydraulic system can be attributed directly to fluid contamination. This increases the downtime and maintenance costs while reducing productivity and profits. As the pressure ratings in hydraulic systems increases and the tolerance clearences within the components decreases, contamination control of the fluid beomes critical and it must be an integral part of the fluid power system.

To keep the hydraulic fluid clean and free from harmful contamination strainers and filters are used.

7.3.1 Strainers

Strainers may be defined as a device for the removal of solids from a fluid wherein the resistance to motion of such solids is in a straight line.

Strainers are designed from a fine mesh wire screen or a screening element made of specially processed wire of varying thickness, wrapped around a metal frame. Strainers do not provide the fine filtering action as filters do, because they offer less resistance to flow. Strainers may be used in a pump inlet line to protect the pump from large sized particles. It is important that the capacity of the strainer be sufficient to keep the pressure drop at a minimum. Pressure drop increases during the operation as dirt clogs the small screen openings. If the pressure drop reaches the critical value, cavitation occurs and the pump life is shortened.

There are a number of arrangements for using strainers in a pump inlet line. If a single strainer is insufficient for the demands of a given pump, two or more can be used.

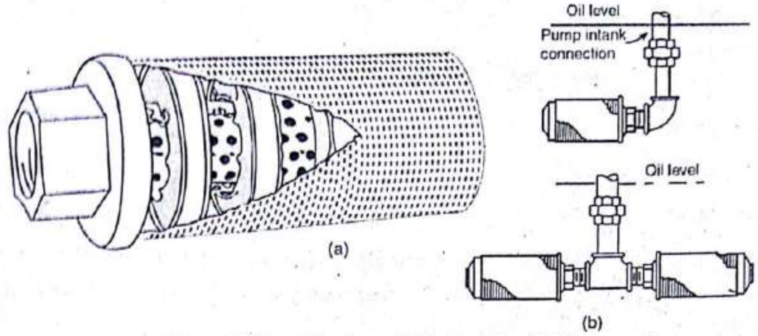


Figure 7.9 a) Strainer b) Strainer Installation

7.3.2 Filters

A filter may be defined as a device for the removal of solids from a fluid wherein the resistance to motion of such solids is in a tortuous path.

Filter elements are rated in micron (238, 149, 74, 40, 20, 10) as absolute and nominal filtration. The 'absolute' rating indicates the size of the filter element pores through which the fluid must flow and gives the maximum size of the solid that can pass through the element.

As the filter element removes contaminating particles from the fluid, they build up on the surface. This reduces the size of the pores through which the fluid must flow. So the term 'nominal filtration' indicates the ability of the filter to remove about 98% of the solid particles from the fluid which are equal to or lesser than the absolute rating of the filter. Thus, a filter rated 60 microns absolute may have a nominal rating of 35 microns.

Filter provides a finer filtration than strainers and can be applied at several different places in the circuit.

The performance of the filter to obtain a required level of filtration is given by the parameter Beta ratio. This ratio is given by the following equation

$$\text{Beta ratio } \beta x = \frac{\text{Number of upstream particles (before filter) greater than } x\ \mu\text{m}}{\text{Number of downstream particles (after filter) greater than } x\ \mu\text{m}}$$

x is the selected particle size for the given filter. For example, a fluid has 7000 particles of size $10\mu m$ or greater passes through a filter. After the filter, if the fluid is found to have 140 particles, then the β_{10} ratio is 50 $\left(\text{i.e., } \frac{7000}{140}\right)$

The efficiency of contaminant removal from the fluid through the filter element is known as removal efficiency and is related to β -ratio

$$\text{Removal efficiency } \eta_x = \left(1 - \frac{1}{\beta_x}\right) \times 100$$

Hence, a filter having a β_{10} ratio equals to 2 will only stop 50% of particles of $10\mu m$ and greater; filter having a β_{10} ratio equals to 10 will stop 90% of particles of $10\mu m$ and greater. The higher the β -ratio, the more efficient is the filter element. The micron size at which $\beta_x = 75$ is generally considered to be an equivalent to the absolute rating of the filter.

7.3.3 Filter Media

There are several basic types of filter media. But the major classification is

1. Mechanical
2. Absorbent
3. Adsorbent

Woven wire cloth It consists of a finely woven wire cloth, made of stainless steel. It is a mechanical type filter media and is commonly used to remove the coarse insoluble particles.

Paper filter It is made of special cellulosic materials which are impregnated with a resin to provide greater strength. The popular type of constructions are as follows.

1. Folding sheets of paper into accordion like pleats.
2. Stacking cellulose discs with alternate spacers.

The paper media may be used as an extended area filter, where the particles removed depend on the amount of surface exposed and the porosity of the filter cake that is formed.

Woven media It is a cloth of yarn (natural or synthetic). 'Warp' is the yarn that runs through the length of a cloth; 'shoot' runs perpendicular to the warp and these two form a weave. Many types of weaves are available such as square, dutch, twill, dutch twill.

Sintered metal powders The metal powders are in granular form and they are joined to form a rigid porous structure. The grains can be joined by an adhesive or by sintering at temperature below the melting point. The degree of filtration depends on the compression and compactness of the grain chosen.

Ceramic and plastic media Plastic and ceramic materials can also be used, but a higher pressure drop is expected. The resistance to mechanical shock is low for ceramic, and the resistance to thermal shock is low for plastic.

7.3.4 Types of Filters

Surface filter The surface type filter accomplishes all its filtering action at the surface of the media. The filter consists of a replaceable filter element made of resin impregnated paper having pores of sizes up to 5 μ . The paper is pleated and formed into a cylinder.

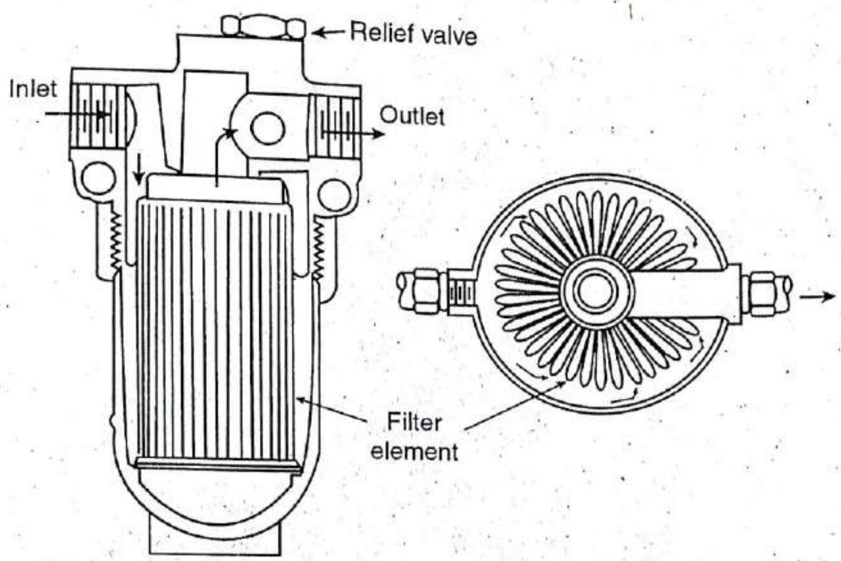


Figure 7.10 Surface Filter

Hydraulic fluid passes through the paper, leaving behind dirt and other solids in a layer on the outer surfaces. Particles down to 1 micron size are held back.

This type of filter is easy to clean and resists media migration, but it has a comparatively low dirt holding capacity.

Advantages

- Greater strength and resistance to fatigue, temperature and corrosion.
- Low initial clean pressure differential.
- Exhibit a large contaminant containment area.
- Surface elements can be cleaned and reused.

Disadvantages

- As the amount of contamination removal from fluid increases, surface filtration becomes much less effective.
- Usually expensive.

Depth filter The depth filter operates throughout the volume of the filter material by having many passages through which the fluid must flow.

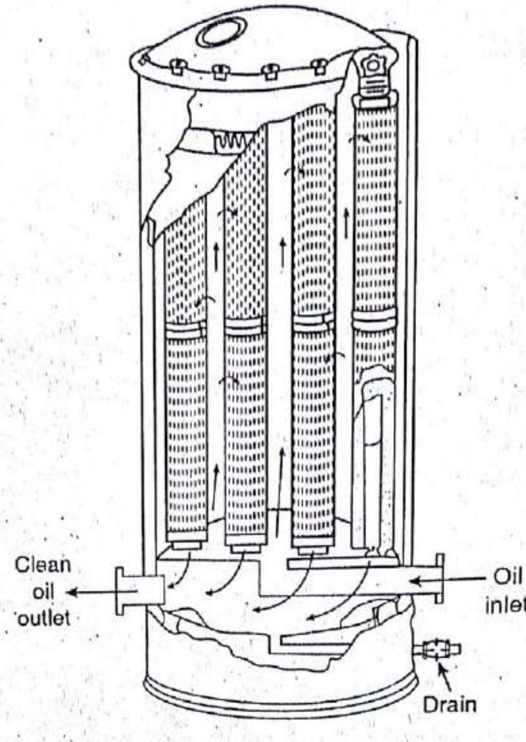


Figure 7.11 Depth Filter

Dirty oil surrounds the renewable filter cartridge and flows radially inward through a considerable depth of filter material such as cellulose. Clean oil flows downward and out at the left. The pores or passages are not of uniform size, and the entrapment depends on the depth and nature of the fluid passage. Depth filters operate successfully at a lower flow rate and at relatively low pressure drops.

Advantages

- Compared to surface filtration,captures a larger percentage of contaminants.
- Removes free water from hydraulic oil.
- Can provide finer filtration to achieve higher degree of cleanliness.
- Usually inexpensive.

Disadvantages

- Impractical to clean.
- Limited compatibility with fluids.
- High initial clean pressure differential.

Edge type filter The filter element consists of wheel-shaped metal discs, each separated from the next by a thin metal spacer. The fineness of filtration is determined by the thickness of these spacers. The stack is closed at the bottom and opened to the outlet at the top.

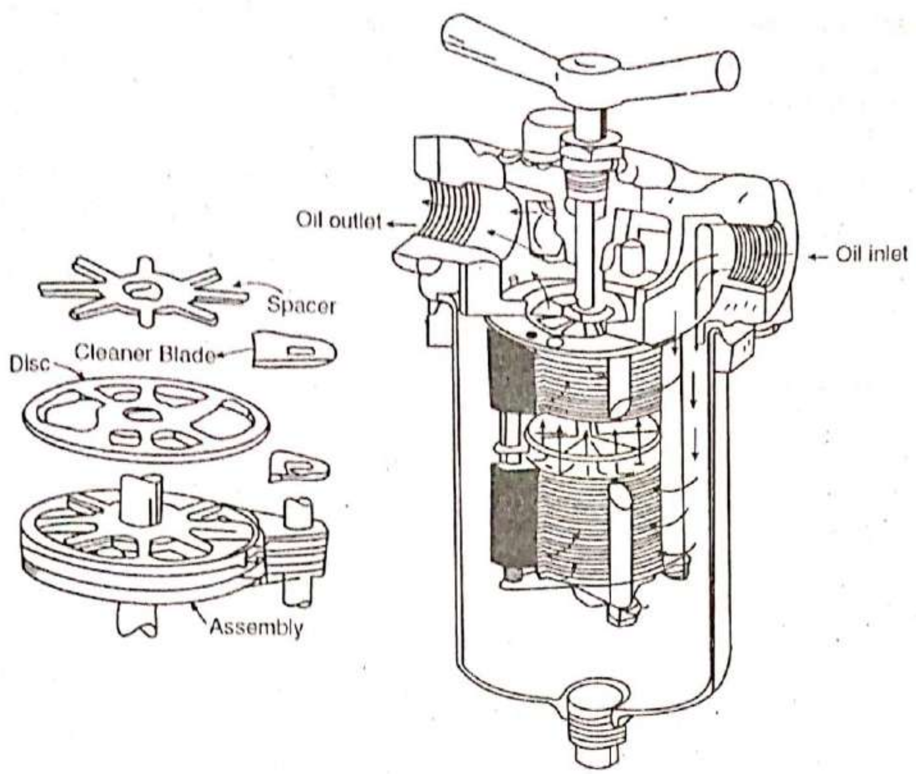


Figure 7.12 Edge Type Filter

The dirty inlet oil flows into the space around the element and is forced through the small openings between the discs. All solids larger than the openings are held back. Clean oil flows upward through the stack to the outlet. Stationary cleaner blades extend into the space between the discs, and the filter element can be rotated against these for cleaning using the handle. Solids fall to the bottom of the housing and should be removed at regular intervals.

7.3.5 Filter Location

As dirt is generated at all parts of hydraulic system, the only way to ensure 100% component protection is to place a filter immediately upstream of a component. But this is not possible always. So this is done in the case of a component which is particularly susceptible to contamination damage. Otherwise the filters can be inserted at various positions according to the purpose. Moreover filtration is a compromise because finer filtration causes a larger pressure drop.

Suction line filter The filter is located between the reservoir and the pump. The pressure drop across a suction filter has to be very low to avoid pump cavitation and a low pressure bypass valve is essential. The element is often woven wire and can be cleaned.

Pressure line filter The filter is located after the pump. If it is placed before relief valve, it filters the total pump delivery and gives protection to the relief valve, rest of the components but will be subjected to pressure surges.

The filter located after the relief valve will filter only a portion of fluid used by the system but will not be subjected to flow variations or surges. Elements are generally depth filter types and are disposable.

Return line filter The filter is located in the main return line receiving flow from all the major components in the circuit. Eventhough the major part of fluid passes through this filter, any dirt introduced in the tank or generated by pump has to travel through the entire system before reaching the filter.

Bypass and bleed-off filter On exceptionally large systems, the cost of full filtration is considered high so a partial flow filtration is used. Here a partial flow is allowed through a small filter will eventually clean up the system. The bypass type is a pressure line filter with a built-in venturi device which puts part of the flow through the filter and part directly to the system through bypass. The bleed-off type uses a return line filter. A flow control valve bleeds-off part of the flow through the filter to tank.

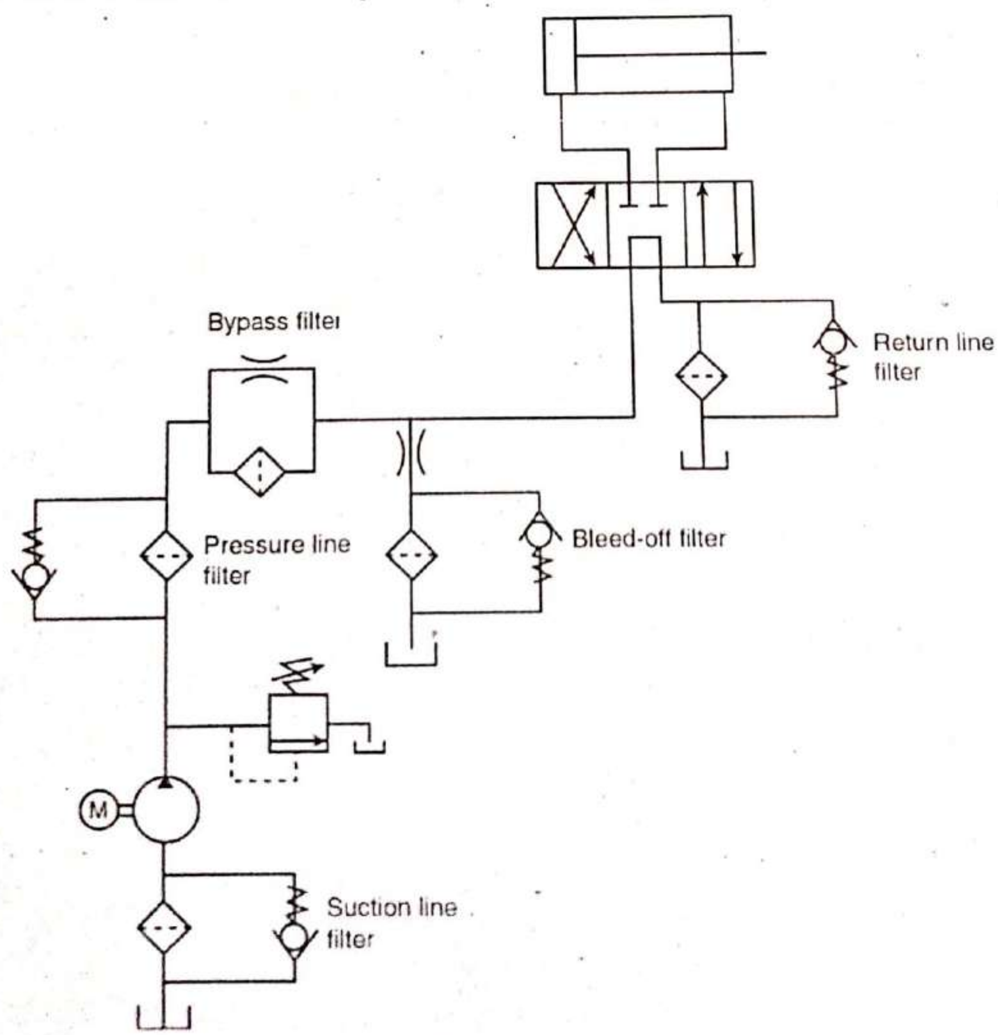


Figure 7.13 Some Possible Filter Locations