Aircraft Maintenance
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Lecture - 03
Aircraft Hydraulic System

So, we have just seen the rules and regulations for civil aviation in India. Now we will start with the Aircraft Systems. The first aircraft system we are going to study is the aircraft hydraulic system. The in this system we will understand what the basic system is, what are the different components, involved in the aircraft hydraulic system? What are the routine checks? We carry out in this system and what how do we troubleshoot if there is any snag in the hydraulic system?

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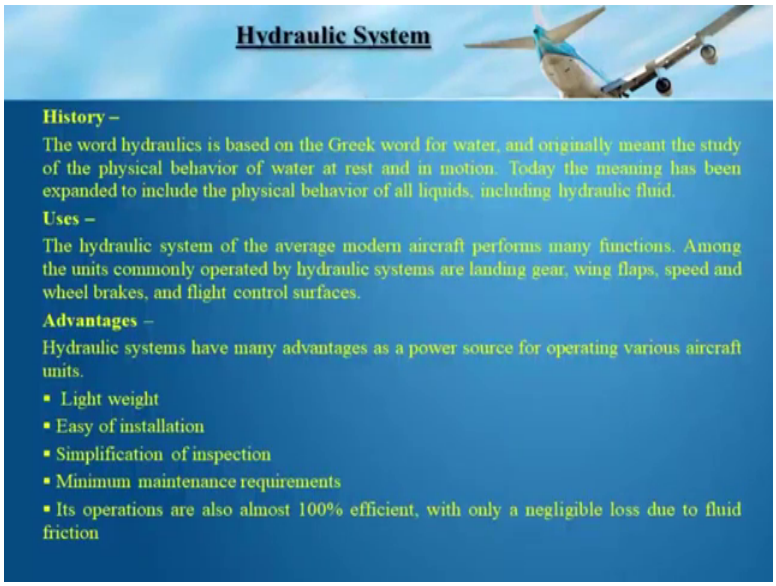

So, aircraft Hydraulic system, the history about the hydraulic system, the word hydraulics is based on the Greek word for water and originally meant the study of the physical behaviour of water at rest and in motion.

Today the meaning has been expanded to include the physical behaviour of all liquids including hydraulic fluid. So, this hydraulics word is basically a Greek word, which meant water and initially it was used to study the behaviour of water at rest or in motion,

but in the present day this meaning has been expanded to include physical behaviour of all liquids including hydraulic fluid.

The uses of the hydraulic system, the hydraulic system of the average modern aircraft performs many functions among the units commonly operated by hydraulic systems are landing gear, wing flaps, speed and wheel breaks and flight control surfaces.

So, this hydraulic system is basically used to operate various things like landing gears, wing flaps, speed and wheel breaks, and flight control surfaces. Depending on the type of aircraft the hydraulics the hydraulic system can be used at various places. What are the advantages of hydraulic system? Hydraulic systems have many advantages as a power source for operating various aircraft units. The advantages are it is light weight, easy of installation, simplification of inspection, minimum maintenance requirements and it is operation are almost 100 percent efficient with only a negligible loss due to fluid friction.

So, you can see very less weight is involved in using your hydraulic system the installation is easy, the inspections are simple and very minimum maintenance requirements are there and the operation is almost 100 percent efficient at very minimum very negligible loss of fluid fric of fluid is there due to fluid friction.

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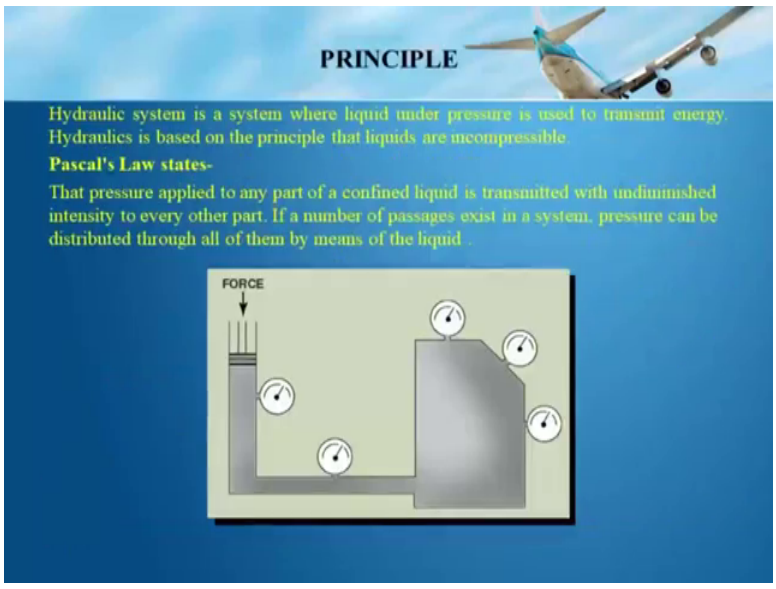

Now, what is the basic principle on which the system operates? Hydraulic system is a system where liquid under pressure is used to transmit energy? So, in the hydraulic

system we are using liquid under pressure. So, that the energy can be transmitted hydraulics is based on the principle that liquids are incompressible.

So, the basic principle that the liquids are incompressible is being used in hydraulics, we all know about the Pascal's law, the Pascal's law states that pressure applied to any part of a confined liquid is transmitted with undiminished intensity to every other part.

If a number of passages exist in a system pressure can be distributed through all of them by means of the liquid. So, this is the basic principle which is being used in the hydraulic system, that pressure can be applied to any part of a confined liquid, which is transmitted with undiminished intensity to every other part. And if there are number of passages in the system pressure can be distributed through all of them by means of the liquid.

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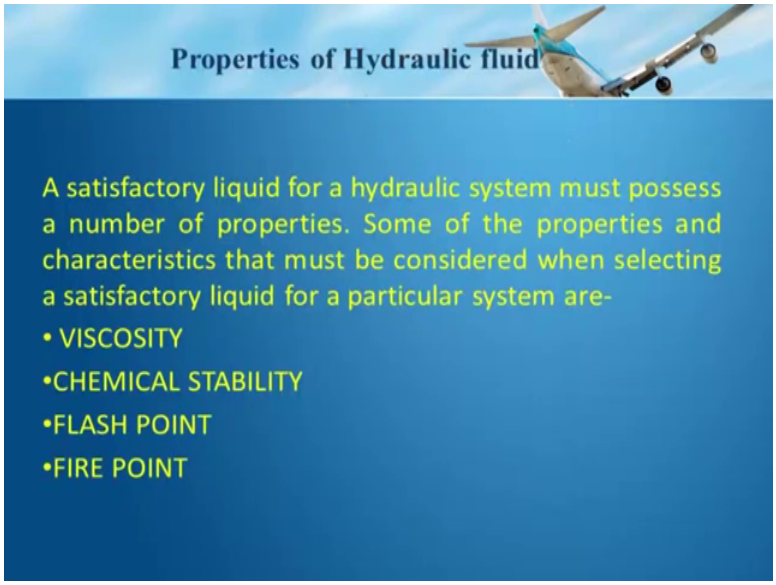

The properties of hydraulic fluid a satisfactory liquid for a hydraulic system must possess a number of properties. So, the hydraulic fluid which is being used in the hydraulic system must possess a number of properties. Some of the properties and characteristics that must be considered when selecting a satisfactory liquid for a particular system are viscosity, chemical stability, flash point, fire point. So, these are some of the properties which we need to consider while selecting a hydraulic fluid, for the hydraulic system, viscosity, chemical stability, flash point, fire point.

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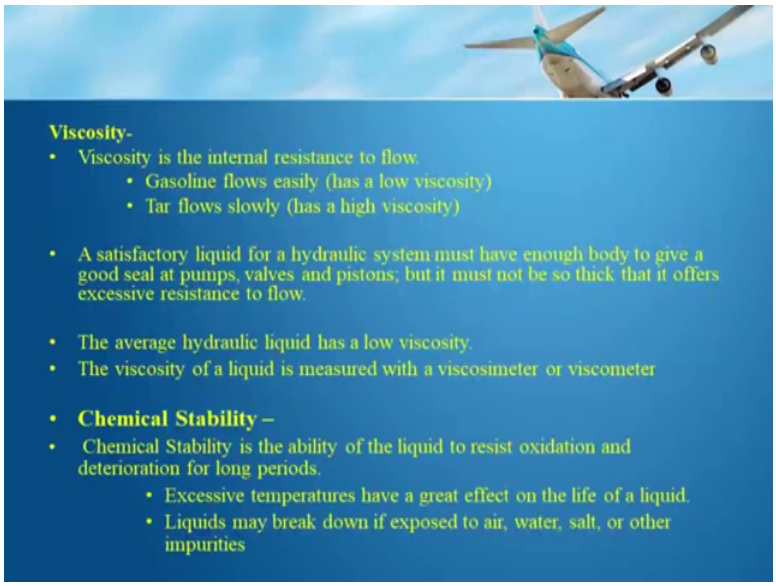

First is viscosity. Viscosity is the internal resistance to flow gasoline a sort of fuel it flows easily, because it has a low viscosity tar flows slowly because it has a high viscosity.

So, a satisfactory liquid for a hydraulic system must have enough body to give a good seal at pumps valves and pistons, but it must not be. So, thick that it offers excessive resistance to flow. So, we need to be careful about the viscosity of the fluid being used it should neither be too viscous, nor should it have it has low viscosity.

The average hydraulic liquid has a low viscosity the first property viscosity; viscosity is the internal resistance to flow, gasoline flows easily because it has a low viscosity, tar flows slowly because it has a high viscosity. A satisfactory liquid for a hydraulic system must have enough body to give a good seal at pumps valves and pistons, but it must not be. So, thick that it offers excessive resistance to flow.

The average hydraulic liquid has a low viscosity. So, the average hydraulic liquid which is being used in the system should have a low viscosity, it should provide enough seal at pumps valves and pistons, but it must not be. So, thick that it offers excessive resistance to flow, the viscosity of a liquid is measured with the viscosimeter or viscometer.

Second property is chemical stability; chemical stability is the ability of the liquid to resist, oxidation, and deterioration for long periods. So, it is the liquids ability it is the

liquids property to resist oxidation and deterioration for long periods, because this hydraulic liquid this hydraulic fluid is there in the system for long periods.

So, it should be able to withstand temperatures, it should be able to with stand deterioration for long periods. Excessive temperatures have a great effect on the life of a liquid. Liquids may bay break down if exposed to air water salt or other impurities. So, chemical stability of a liquid is very important it should be able to resist oxidation and deterioration for long periods. It should be able to withstand temperatures, because excessive temperatures have a great effect on the life of a liquid and if the liquids are exposed to air, water, salt or other impurities they may break down; another property fire point

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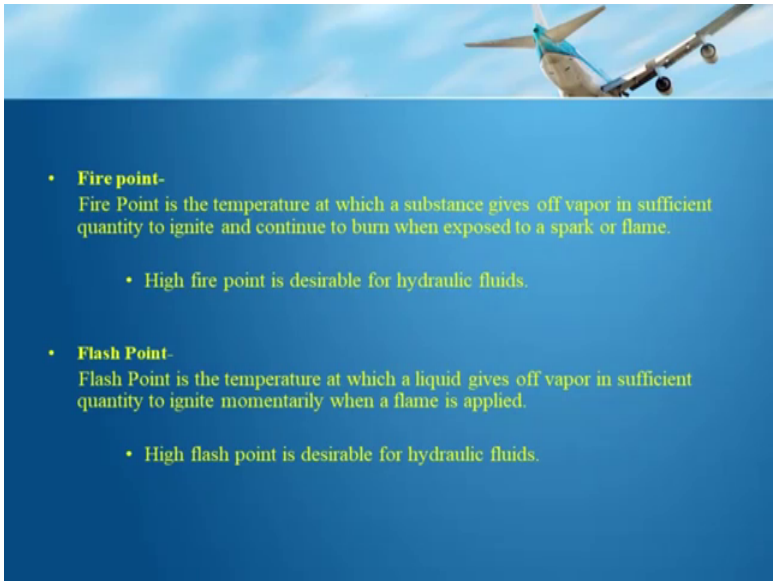

Fire point is a temperature at which a substance gives off vapour in sufficient quantity to ignite and continue to burn when exposed to spark to a spark or flame. So, it is fire point it is the temperature at which a substance gives of vapour in sufficient quantity. So, that it ignites and continues to burn when exposed to a spark or flame in hydraulic fluids high fire point is desirable another property flash point.

It is the temperature at which a liquid gives a vapour in sufficient quantity to ignite momentarily, when a flame is applied you can see in flashpoint the liquid gives a vapour in sufficient quantity, but it ignites momentarily when a flame is applied in fire point thus

liquid gives a vapour in sufficient quantity to ignite and continue to burn when exposed to spark or flame.

In the fire point it continues to burn and in flash point it ignites momentarily same as with fire point a high flash point is desirable for hydraulic fluids.

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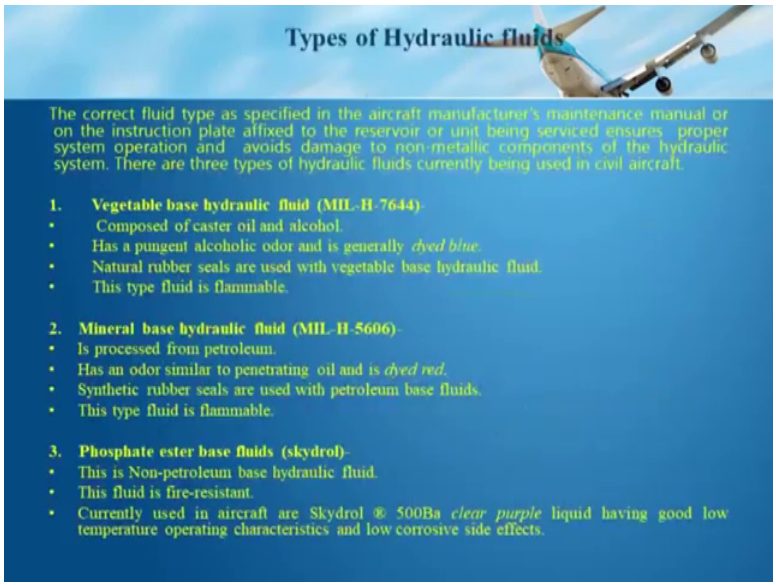

Now, we come to the types of hydraulic fluids it is very important that a correct fluid type, which is as specified in the manufacturers maintenance manual or on an instruction plate fixed on the reservoir or unit being serviced is used proper use of the hydraulic fluid will ensure proper system operation, avoid damage to non-metallic components of the hydraulic system.

There are in general 3 types of hydraulic fluids currently being used in the aircrafts. Number one is the vegetable base hydraulic fluid used in the aircrafts the specification is MIL dash H dash 7644. This vegetable base hydraulic fluid is composed of castor oil and alcohol it has a pungent alcoholic odour and is generally dyed blue.

Natural rubber seals are used with vegetable base hydraulic fluid this type of fluid is flammable. Second is the mineral base hydraulic fluid the specification is MIL dash H dash 5606. This mineral base hydraulic fluid is processed from petroleum; it has an odour similar to penetrating oil and is dyed red. Synthetic rubber seals are used with petroleum base fluids this type of fluid is flammable too.

Next is phosphate ester based fluids or Skydrol, this is a non-petroleum base hydraulic fluid. This fluid is fire resistant and currently being used in aircraft are skydrol 500 b a clear purple liquid, which has good low temperature operating characteristics and low corrosive side effects. So, we have seen 3 types of hydraulic fluids vegetable base hydraulic fluid that is MIL H 7644 mineral base hydraulic fluid that is MIL H 5606 and phosphate ester based a fluid that is skydrol.

We have seen the different properties of these types of fluids vegetable base is composed of castor oil and alcohol mineral base hydraulic fluid is processed from petroleum, phosphate ester base fluid is a non-petroleum base hydraulic fluid, vegetable base has a pungent alcoholic odour and is generally blue in colour, mineral base is red in colour and it has an odour similar to penetrating oil and phosphate ester base fluid you can see it has clear purple fluid.

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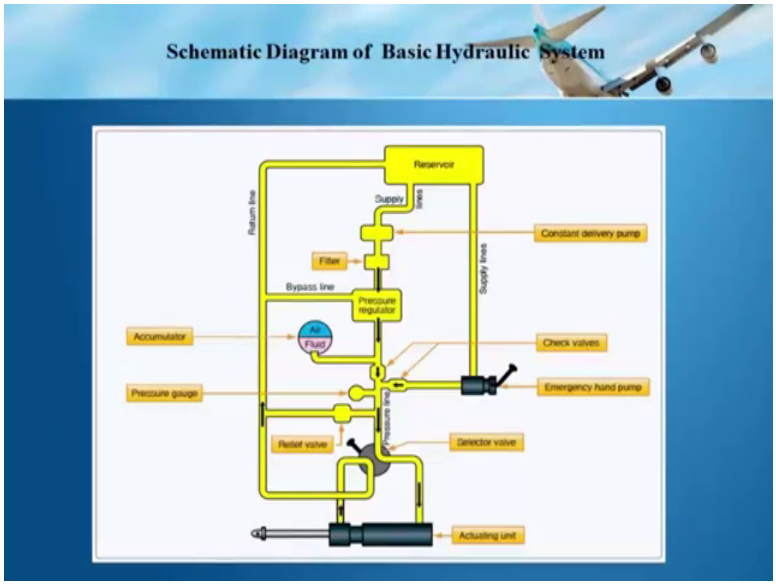

Now, coming to a basic hydraulic system. So, you can see a basic diagram of the hydraulic system, there are various components fitted in this system this is the reservoir here you have the pump, this is the filter, pressure regulator, accumulator, these are the check valves, this is the hand pump, here is the pressure gauge, this is the relief valve, this is the selector valve and this is the actuating unit.

These are the supply lines, this is the supply line and this is your return line. So, the fluid is filled in the reservoir from the reservoir it is coming to the pump from the pump, it is

coming to the filtering unit via the pressure regulator through the check valves it is coming to the actuator unit.

We will study about the different components from the actuator unit the fluid is going back to the reservoir via the return line. In case if your constant delivery pump or the pressure pump is malfunctioning, then there is an emergency pump called the hand pump, which can be operated and this pump is also getting the supply from the reservoir from this pump the fluid is flowing via the check valve through this line to the actuator unit.

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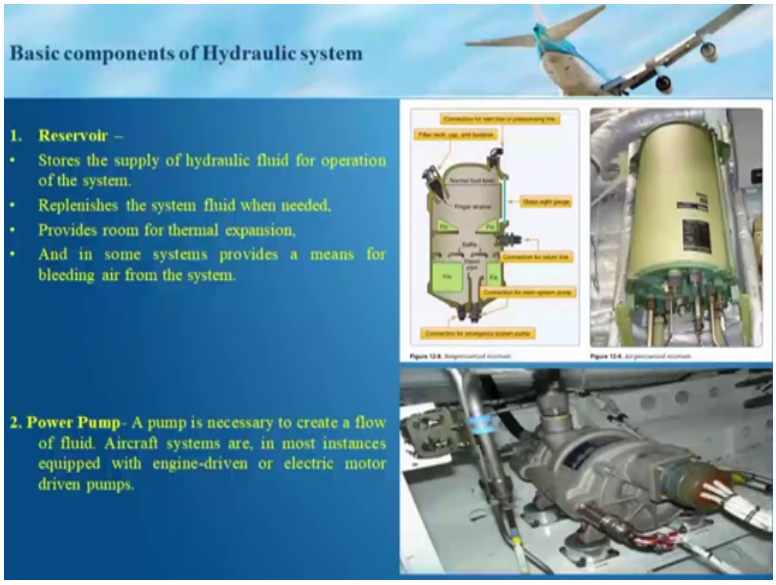

So, this was the schematic diagram of a basic hydraulic system. Now coming to the basic components of the hydraulic system first is the reservoir it stores the supply of hydraulic fluid for operation of the system, it replenishes the system fluid when needed, provides room for thermal expansion and in some systems provides a means for bleeding air from the system. So, we have seen the reservoir, you can see in the diagrams there are 2 types of reservoirs, one is the non-pressurized reservoirs then you have the pressurized reservoir.

So, reservoir it stores the supply of hydraulic fluid for the system, it replenishes the system fluid when required, it provides room for thermal expansion and in some systems it provides a means for bleeding air from the system. So, you can see the 2 types of reservoirs one is the non-pressurized reservoir, one is the pressurized reservoir,

depending on the complexity of the system, the sophistication of the aircraft, the type of reservoir is used, in the non-pressurized reservoir you can see there is a filler neck through, which the hydraulic fluid is filled.

Then you can see the connection lines, then fins and baffles are there inside the reservoir there is a side gauge through, which you can see the level of the reser level of the fluid in the reservoir there is a return line and connection to the emergency pump and connection to the main pump.

So, this is one type of a non-pressurized reservoir, the fence and baffles are provided inside the reservoir. So, that foaming and slashing is avoided. The second component is the power pump; this pump is required to create a flow of fluid. Generally the aircraft systems in most cases are equipped with engine driven or electric driven motor driven pumps, you can see in the diagram there is a pump. These pumps may also be of a different type there are gear type pump, gerotor type pump, vein type pumps, piston type pumps.

So, there are a variety of pumps depending on the complexity of the system and the aircraft type the pump type is chosen so, but in general the pump is required to create a flow of fluid through the system.

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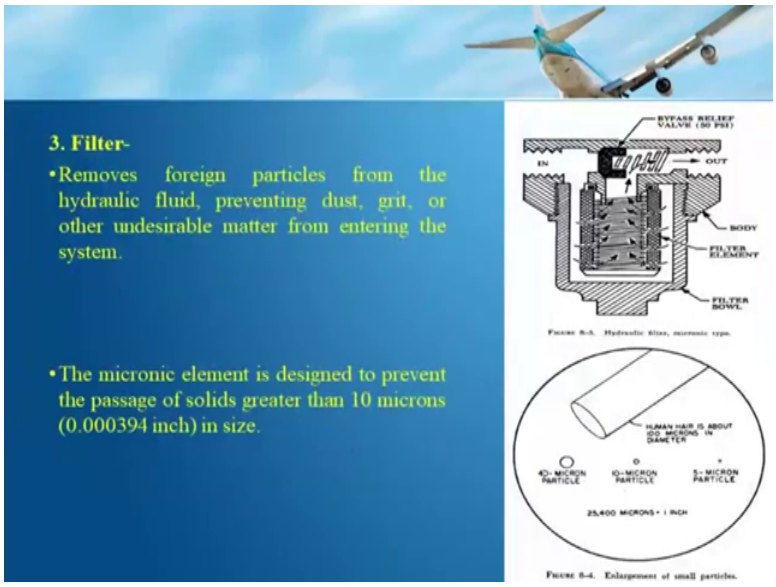

Next comes the filter the filtering unit the basic purpose of the filter is to remove foreign particles from the hydraulic fluid, to prevent dust grit or other undesirable matter from entering the system.

So, in the diagram you can see there is a typical hydraulic filter, which is a micronic type filter and it has a bowl in which a filtering element is there and on the top you can see there is the head in which there is a bypass relief valve fitted.

So, in case if the filter element gets clogged the hydraulic fluid bypasses the filter filtering element and goes straight, the micronic type element is designed to prevent the passage of solids greater than 10 microns. So, in the diagram in the lower diagram you can see that a human hair is about 100 microns in dia. And this micronic element being used in the system it restricts passage of solids greater than 10 microns. So, you can imagine the level of filtering that is required in the system.

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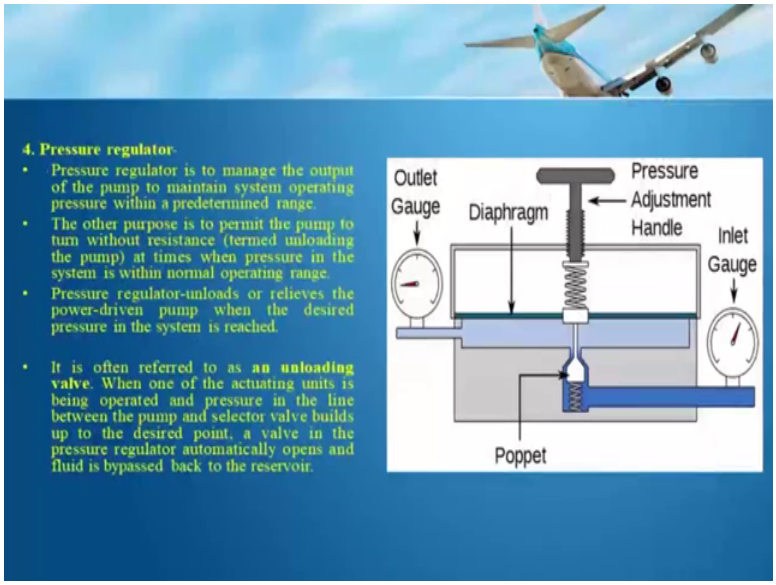

Next comes the pressure regulator pressure regulator is to manage the output of the pump to maintain system operating pressure within a pre-determined range. The other purpose is to permit the pump to turn without resistance. It us also termed as the un as unloading the pump at times, when pressure in the system is within normal operating range. Pressure regulator unloads or relieves the power driven pump, when the desired pressure in the system is reached.

It is often referred to as an unloading valve. Where one of the actuating units is being operated and pressure in the line between the pump and the selector valve builds up to the desired point, a valve in the pressure regulator automatically opens and the fluid is by passed back to the reservoir. So, you can see the pressure regulator it is also referred as an unloading valve, when one of the actuating units is being operated and pressure in the line between the pump and selector valve builds up to the desired point.

So, coming back to the basic hydraulic system you can see when the pressure builds up, you can see there is a pressure regulator, when the pressure builds up between the pump and the actuating unit, you can see there is a bypass line in the pressure regulator, when the required pressure is built up this extra hydraulic fluid this extra pressure is by passed to from the return line to the reservoir.

So, when one of the actuating unit is being operated and pressure in the line between the pump and selector valve builds up to the pressure point a valve on the pressure regulator automatically opens and fluid is by passed back to the reservoir. You can see there is one type of pressure regulator shown in the figure this is a basic type of pressure regulator there is a pressure adjustment handle also provided a diaphragm is there and inlet gauge outlet gauge is provided.

So, you can see this is a basic type of a pressure regulator.

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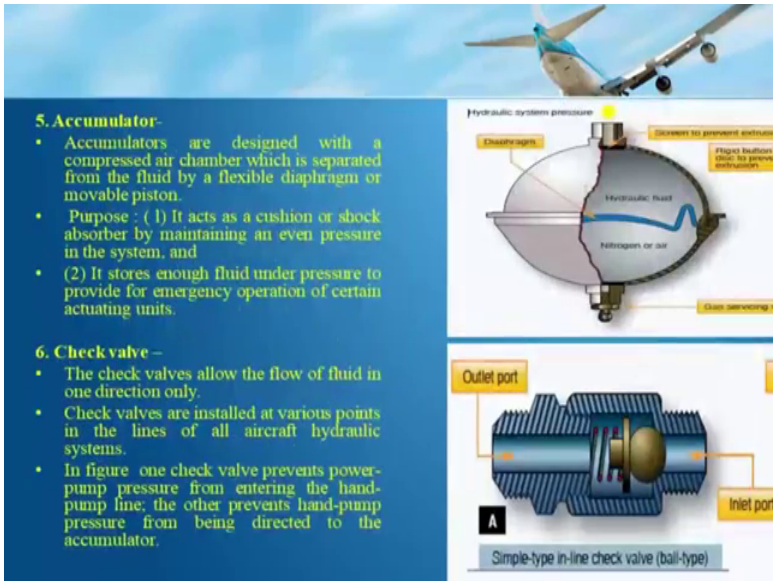

Coming to accumulator accumulators are designed with a compressed air chamber, which is separated from the fluid by a flexible diaphragm or movable piston. It is purpose is to act as a cushion or shock absorber by maintaining an even pressure in the system.

So, accumulator maintains an even pressure in the system it absorbs the shock or cushion it stores enough fluid under pressure to provide for emergency operation of certain actuating units. So, it is also storing fluid. So, that in case of an emergency this fluid can be used can be provided to the actuating units from the accumulator.

So, the basic purpose, but the basic purpose of the accumulator is to act as a cushion or shock absorber and maintain an even pressure even hydraulic pressure in the system. You can see in the figure there is a an accumulator in the bottom chamber, you can see nitrogen or air is there upper chamber you have the hydraulic fluid separated by a diaphragm.

So, the accumulators are designed with a compressed air chamber which is separated from the fluid by a flexible diaphragm or in case of a diaphragm there can be a piston also in place of a diaphragm. Next is the check valve the check valves allow the flow of fluid in one direction only. So, the basic purpose of the check valve is to allow fluid flow in one direction only; check valves are installed at various points in the lines of all aircraft hydraulic systems.

Coming back to the basic system basic hydraulic system what we had seen in the diagram. So, the these are 2 check valves you can see the check valves as we have just seen the basic purpose of the check valve is to provide fluid flow in one direction only.

So, this check valve is permitting fluid to flow in this direction only it will not allow fluid to flow from this direction to this direction; it will only allow the fluid to flow in this direction.

Similarly this check valve will allow the fluid to flow in this direction not in this direction. So, the 2 check valves provided in the system the purpose of this check valve is to prevent the fluid flow of this pump to this line this place. So, this check valve will prevent the fluid flow from this emergency pump to the pressure regulator or to this place.

The purpose of this check valve is to prevent fluid flow this straight fluid flow to enter the emergency pump. So, this check valve is preventing fluid flow which is coming from here to go there and this check valve is preventing this fluid flow to enter this place.

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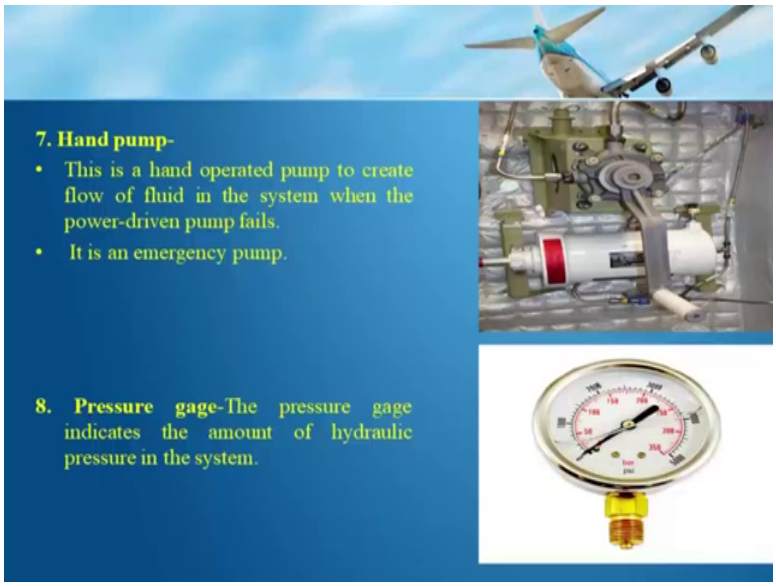

Now, next is the hand pump, we have seen in case of an emergency this is an emergency pump. This is a hand operated pump which is used to create flow of fluid in the system when the power driven pump fails.

So, this you can see in a picture a sort of a type of a hand pump is shown. So, this is used in case of an emergency. Next is the pressure gauge a type of pressure gauge is shown in the figure it indicates the amount of hydraulic pressure in the system.

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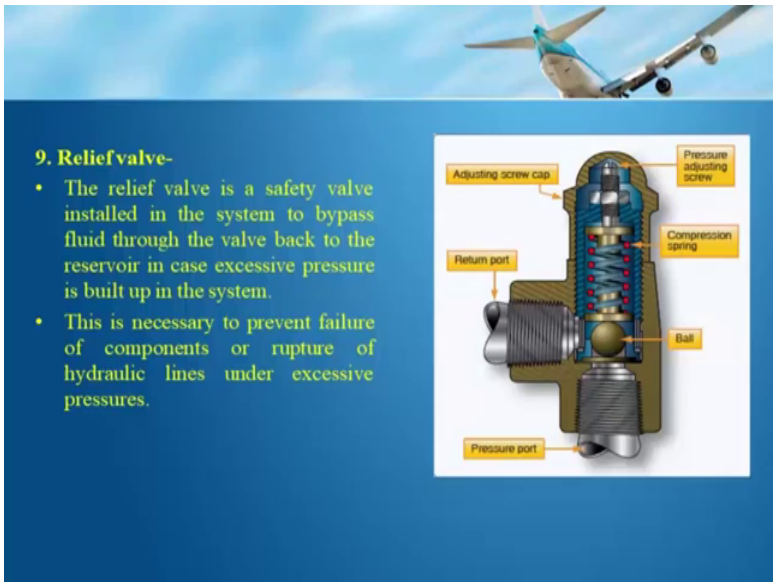

Then we come to the relief valve the relief valve it is called as a safety valve, which is installed in the system to bypass fluid through the valve back to the reservoir in case excessive pressure is built up in the system.

So, in the case of extra pressure excessive pressure being built in the system this valve will allow the fluid to be by passed back to the reservoir. This valve is necessary to prevent failure of components or rupture of hydraulic lines under excessive pressure.

So, in this diagram you can see the relieve valve is here the purpose of this relief valve is to bypass excessive pressure in case, if there is an excessive pressure in this line this relief valve will bypass the excessive pressure from this line via the return line back to the reservoir. In case if this valve is not there then there is extra pressure excessive pressure, that pressure may damage different components may damage the hydraulic lines. So, this valve this relief valve is also called as a safety valve.

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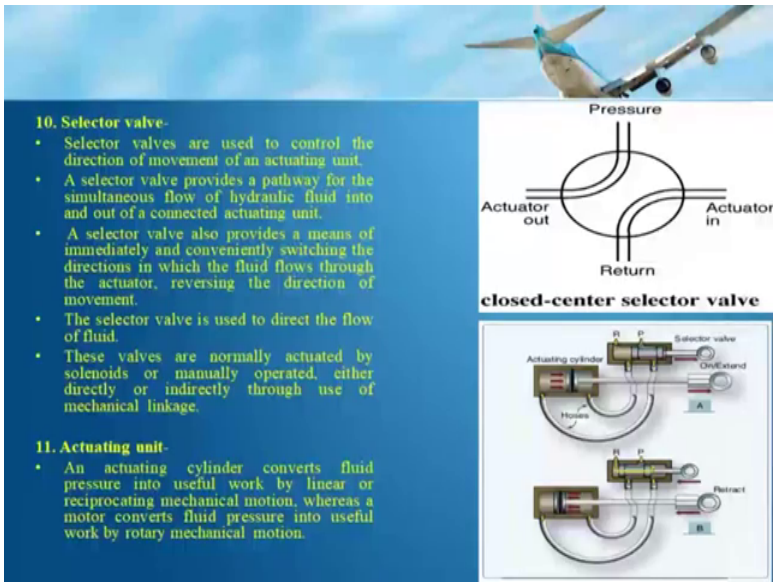

Next is selector valve selector valve are used to control the direction of movement of an actuating unit. A selector valve provides a pathway for the simultaneous flow of hydraulic fluid into an out of a connected actuating unit. A selector valve also provides a means of immediately and conveniently switching the directions, in which the fluid flows through the actuator reversing the direction of movement. The selector valve is used to direct the flow of fluid these valves are normally actuated by solenoids or manually operated by either directly or indirectly through the use of mechanical linkage.

So, in the diagram on the right side you can see a basic selector valve is shown. So, this selector valve is used to control the direction of movement of the actuating unit this can control the direction of flow of fluid into the actuating unit. So, this can provide a means of immediately and conveniently switching the directions, in which the fluid flows through the actuator it can reverse the direction of movement.

Next is on the bottom side you can see we have the actuating units, the actuating cylinder, it converts the fluid pressure into useful work by linear or reciprocating motion whereas, a motor converts fluid pressure into useful work by rotary mechanical motion.

So, here in the diagram you can see this is the selector valve this is your actuating unit these are the lines from the selector valves to the actuating unit. Now this is the pressure pressure coming through the selector valve, through this line and coming to the actuating cylinder.

This hydraulic pressure forces the piston on the right side the piston moves and now the fluid pressure and is converted into the mechanical motion. Similarly here you can see the passage of the hydraulic fluid is reversed this when this selector valve is moved on the other side, this path, this path is now blocked by this piston here this path is blocked.

Now the pressure the hydraulic pressure is moving from the other port on the other side of the actuating cylinder. So, now, the hydraulic pressure has come through this line on the other side of the piston. And now this hydraulic pressure moves the piston to the other side and the direction of this actuating unit is reversed earlier this was moving this hydraulic pressure made this actuating unit move in this direction. Now the in this diagram you can see the motion of the actuating unit is reversed.

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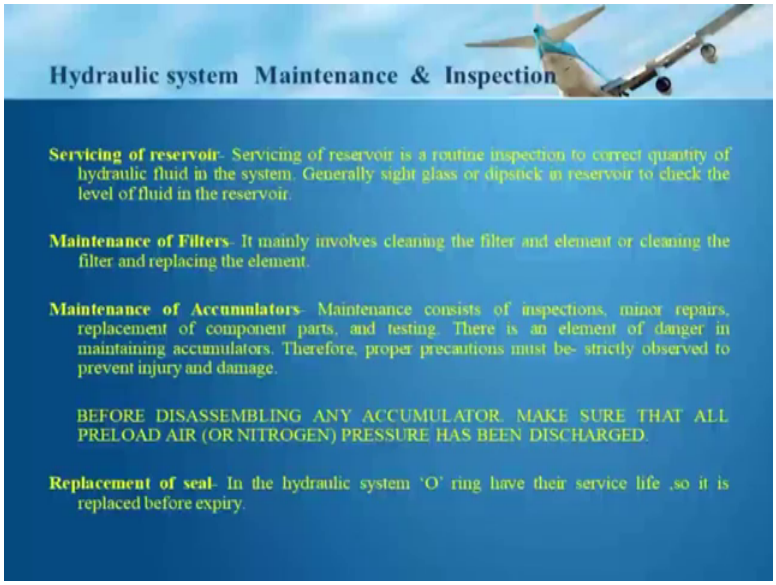

Now, coming to hydraulic system maintenance and inspection, servicing of reservoir; servicing of reservoir is a routine inspection to correct quantity of hydraulic fluid in the system.

Generally sight glass or dipstick in the reservoir is provided to check the level of fluid in the reservoir. So, basic servicing of the reservoir it is a routine inspection, we check the quantity of hydraulic fluid in the system, by means of dipstick or the sight glass. Next is maintenance of filters it mainly involves cleaning of the filter and element or cleaning of filter and replacing the element.

So, it depends on the type of filter, whether the element is of paper type or metal type it all depends on that in case it is of the paper type filter element then it has to be replaced if it is of the metal type it has to be cleaned.

So, basic maintenance on filters is either replacement or cleaning. Maintenance of accumulators consists of inspections, minor repairs replacement of component parts and testing. While maintaining accumulators we need to be very careful as you we have seen earlier it has a pressurized chamber. air chamber.

So, we need to be careful while maintaining accumulator's proper precautions must be observed to prevent injury and damage. Special care to be should be taken that before disassembling any accumulator please make sure that all the preloaded air or nitrogen pressure has been discharged. Very important point another thing in the hydraulic system is replacement of seal the hydraulic system o rings they have their service life. So, they have to be replaced before the their service life expires.

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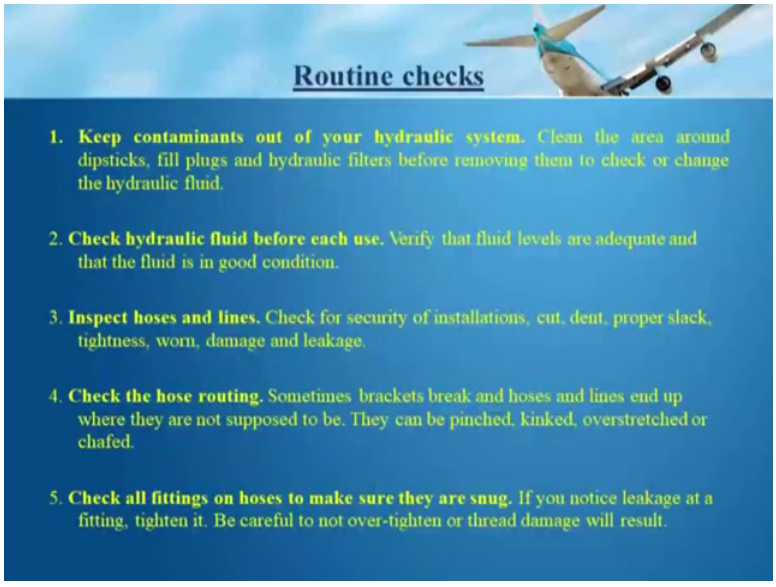

Now, routine checks what w do keep contaminants out of your hydraulic system, clean the area around dipsticks fill plugs and hydraulic filters before removing them to check or change the hydraulic fluid.

So, the area around the dipsticks the filler plugs the filters that should be clean before you check or change the hydraulic fluid. So, as to avoid contaminants entering into your

hydraulic fluid into the hydraulic system; check hydraulic fluid before each use verify that fluid levels are adequate and the fluid is in good condition. Inspect hoses and lines. Check for security of installations, cut, dent, proper slack, tightness, worned worn, damage and leakage.

So, all the hoses and lines should be checked for security of installations cuts, dents, slackness, tightness, damage, leakage, the hose routine should be checked properly sometimes the brackets, brake and hoses and lines end up where they are not supposed to be, they can be pinched kinked overstretched or chafed.

So, we should be careful about the hydraulic hose routings. Next is check all fittings on hoses to make sure they are snug. If you noticed leakage at a fitting, tighten, it be careful to not over tighten or thread damage will result.

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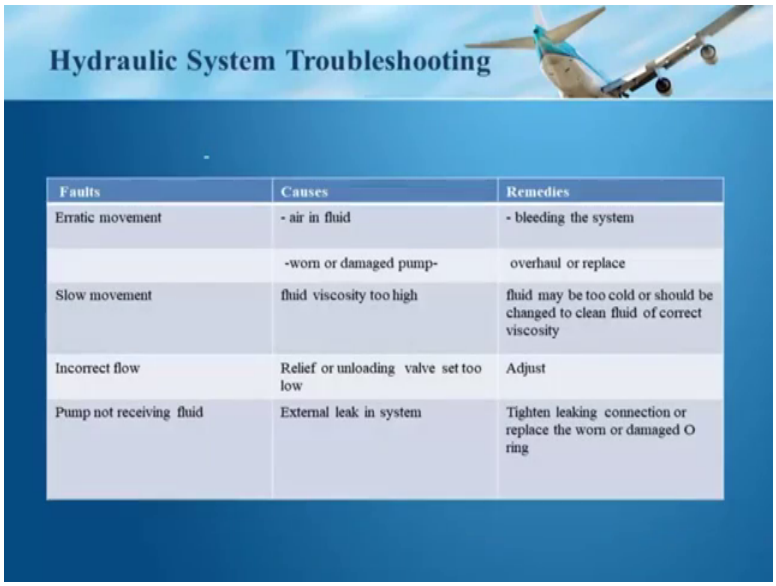

During maintenance or during operation you may observe, some snugs, some problems in your hydraulic system, in this here we are showing some basic problems all though they are there may be n number of problems, but some basic problems we have basic faults we have mentioned their causes and their remedies. The hydraulic in there may be an erratic movement of the actuating unit what are the causes.

One cause may be that there is air in the fluid. In case if there is air in the fluid then you need to bleed the system you need to remove air from the system. Another cause may be

that your pump is worn or damaged; in that case you need to overhaul your pump or replace your pump.

Another problem you may encounter is slow movement your actuating unit is moving very slowly not as it should move. In that case the probable cause may be that your fluid viscosity is too high the fluid the hydraulic fluid being used in the system, it is viscosity is too high in that case fluid may be too cold or should be changed to clean fluid of correct viscosity.

In case the fluid viscosity is too high it may be, because of too cold conditions in that case you may need to replace your hydraulic fluid. In correct flow another problem you may encounter is of incorrect flow, in that case the probable cause is relief or unloading valve set too low, your relief valve maybe the setting of the relief valve may be too low. So, you need to adjust the setting of relief valve.

Another problem that may be encountered is that your pump is not receiving fluid, the probable causes may be one probable cause, there may be number of causes, but one main causes may be that there is a leak in the system you need to check the leakage in the system in case if there is any leak you find, then you tighten the leaking connection or replace the valve or damaged o ring. So, there may be number of problems, but these are some of the problems that may be encountered in the hydraulic fluid hydraulic system sorry. So, we have seen the probable causes and the remedies.

Thank you.