Fundamentals of Industrial Oil Hydraulics and Pneumatics
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Lecture40
Premier and Guide to Oil hydraulic fluids and introduction to Fluid Power Symbols

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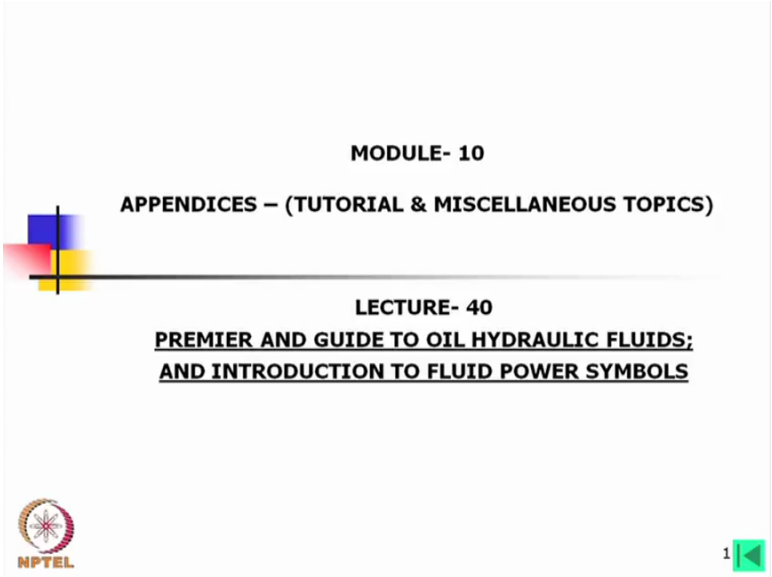

Welcome to today's lecture on industrial oil hydraulics and pneumatics. Today's topic will be practically it will be in two parts, one is that premier and guide to oil hydraulic fluids. This is in addition to our earlier lecture, I think it is second lecture we have given some idea about the hydraulic fluids, we have discussed about some properties, but here this will be additional. Now second one is introduction to fluid power symbols.

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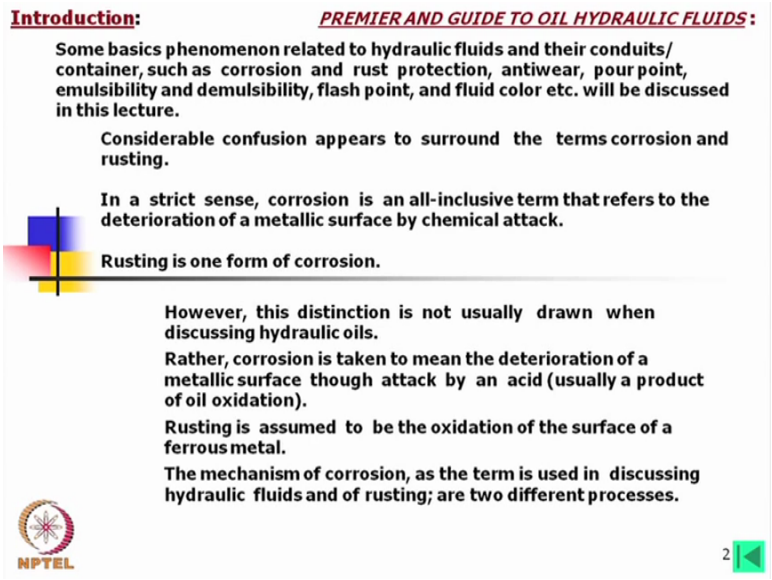

Now as I have told this is what the idea I have given. I have given some, I have discussed about some chemical properties as well as physical properties of the fluids. In this case, this is rather we should say that the preliminary consideration, but some useful considerations which we should take care while we are selecting the hydraulic oil. Now some a basics phenomenon related to hydraulic fluids and their conduits container such as corrosion and rust protection, antiwear, pourpoint, emulsibility and demulsibility, flash point, fluid color etcetera will be discussed in this lecture. Considerable confusion appears to surround the terms corrosion and rusting.

In a strict sense, corrosion is an all-inclusive term that refers to the deterioration of metallic surface by chemical attack. Rusting is one form of corrosion. Therefore, in that sense although the corrosion normally what we use that is a particular phenomenon of total corrosion. However, this distinction is not usually drawn when discussing hydraulic oils. So to say even other oils or water. Rather corrosion is taken to mean the deterioration of a metallic surface through attack by an acid mainly acid usually a product of oil oxidation. Rusting is assumed to be the oxidation of the surface of a ferrous metal. The mechanism of corrosion as the term is used in discussing hydraulic fluids and of rusting are two different processes that we should remember while we shall discuss.

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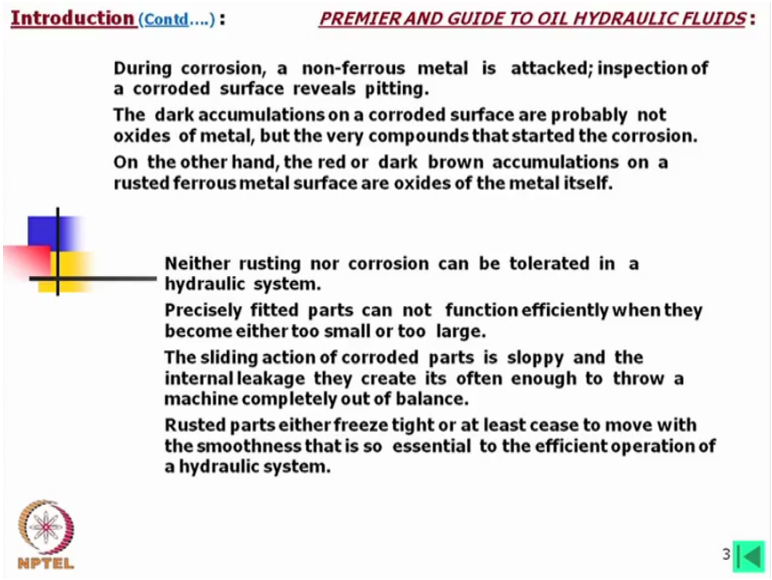

During corrosion a non-ferrous metal is also attacked, inspection of a corroded surface revels also pitting. Pitting is a separate phenomenon that is usually say removal of material due to the contact stress a stress and distress that is fatigue, but in this case also due to corrosion what we observe on the surface that is pitting. The dark accumulations of corroded surface are probably not oxides of metal, but the very compounds that started the corrosion, sometimes we on the pitted surface corroded surface you may find there is some torque (()) (4:24) there. We may think that is this is oxides of metals, but it may not be may be some portion, but it is a normally the compounds.

On the other hand, the red or dark brown accumulations on a rusted ferrous metal surface or oxides of the metal itself. This is of course ferrous material. Neither rusting nor corrosion can be tolerated in a hydraulic system. Precisely fitted parts cannot function efficiently when they are become either too small or too large. This means exactly I think this in this language this we wanted to mean that due to the corrosion if some wear out then it will become small and if it is rusted then it is becoming large. This too either too small or too large in that sense, okay not very big or not very large.

The sliding action of corroded parts is sloppy and the internal leakage that create it is often enough to throw a machine completely out of balance. This means that in corroded parts when be it becomes lousy it may causes the leakage etcetera then we may consider the performance deteriorates very rapidly and it comes the question of rejecting that components also. Rusted parts either freeze tight or at least cease to move with the smoothness that is so essential to the efficient operation of a hydraulic system. So rusting on the other hand it

becomes due to this rust may be if there is a leakage path that may be closed, but on the other hand if there is a moving part due this asked you will find that it is preventing the motion as well this rust particles if it is mixed with the oil that also deteriorate the quality of oil both physically and chemically.

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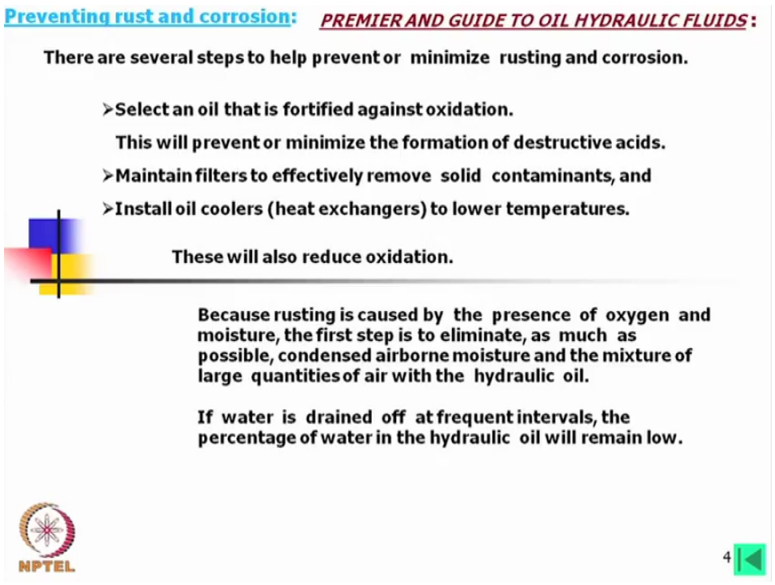

There are several steps to help prevent or minimize rusting and corrosion. These are select an oil that is fortified against oxidations. This will prevent or minimize the formation of destructive acids. Maintain filters to effectively remove solid contaminants and thirdly install oil coolers heat exchangers to lower temperatures, this is one important factor that due to the increase in temperature the many chemical processes are excited or may be those started with temperatures.

So if we can keep the oil temperature below certain limit we can prevent some chemical reactions also. This will also reduce oxidations. These what we are doing mainly for corrosion prevention that will also reduce the oxidations and rusting, because rusting is caused by the presence of oxygen and moisture, the first step is to eliminate as much as possible condensed airborne moisture and the mixture of large quantities of air with the oil hydraulics say for example, with the increase in temperature if the not exactly oiling, but there may bubble creates that bubbles again we will capture the air which will not only go for corrosion also it may cause the oxidation. If water is drained of at frequent intervals, the percentage of water in the hydraulics oil will remain low.

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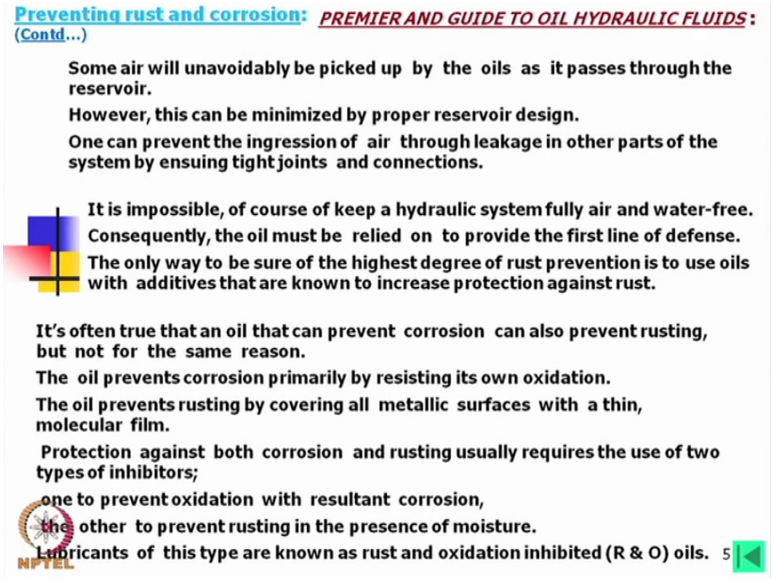

Some air will (unavoidable) unavoidably picked up by the oils as it passes through the reservoir. This happens oil we cannot isolate from the hydraulic oil completely from the air. So when it is going inside the tank, because inside the tank due to the vent out the gases, we provide a venting process through that. That means the top of the oil is filled with air and that air is mixed with the oil while it is going inside the return back to the reservoir. So we cannot avoid the air inside it. However, this can be minimized by proper reservoir designing. There are several methods that by which we can reduce such addition of air. One can prevent the ingression of air through leakage in other parts of the system by ensuring tight joints and connections. It is sometimes what happens due to the leakage path the other side of the components through the joints or something is there the air is also get mixed up. So we have to make such joints leak proof as much as possible.

It is impossible of course of keep a hydraulic system fully aired and water-free. Consequently, the oil must be relied on to provide the first line of defense. Now say water how the water get mixed (())(11:30), you see this oil sorry, hydraulic components are exposed to the atmospheres, say for example the rod end of the open cylinder, it is exposed to the air, then with that some moisture go inside that with that some moisture go inside and with that moisture there will be some water particles which will be mixed with the oil as well in air which is present in the reservoir that we have water particles and that will be mixed up with the oil.

The only way to be sure of the highest degree of rust prevention is to use oils with additives that are known to increase protection against rust. It is often true that an oil that can prevent

corrosion can also prevent rusting, but not for the same reason. The oil prevents corrosion primarily by resisting its own oxidation. The oil prevents rusting by covering all metallic surface with a thin molecular film. Protections against both corrosion and rusting usually requires the use of two types of inhibitors. One to prevent oxidation with resultant corrosion, the other to prevent rusting in the presence of moisture. Lubricants of this type are known as rust and oxidation inhibited which is called propornaly called as R and O oils. So R and O oil means rust and oxidation inhibitor.

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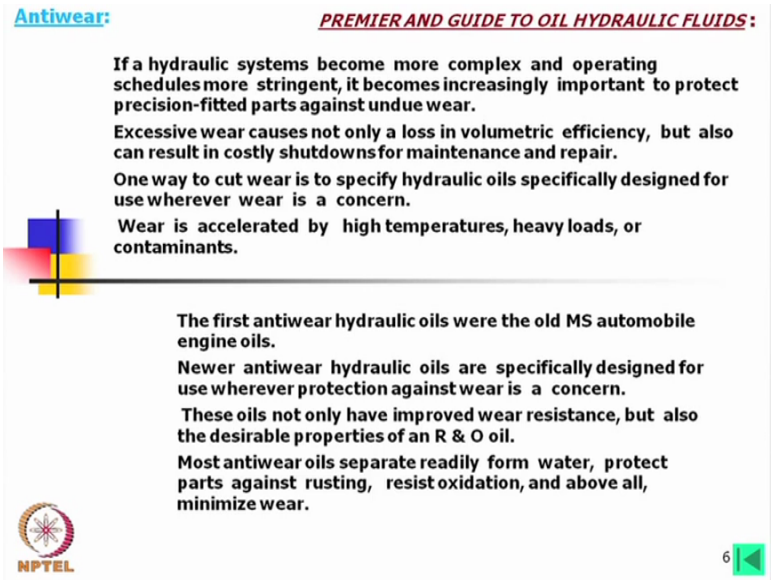

If a hydraulic system become more complex and operating schedules more stringent, it becomes increasingly important to protect precision fitted parts against under wear. Excessive wear causes not only a loss in volumetric efficiency, but also can result in costly shutdowns for maintenance and repair. One way to cut wear is to specify hydraulic oils specifically designed for use whether wear is a concern. Now I would say depending on the operations and the machines hydraulic oil, there are different grades of hydraulic oil which can be selected. Wear is accelerated by high temperatures heavy loads or contaminants.

The first antiwear hydraulic oils where the old MS automobile engine oils. MS stands for some terms which I do not know, but MS automobile engine oil that was the first antiwear may be some additives were added with mineral oils. Newer antiwear hydraulic oils are specifically designed for use wherever protection against wear is a concern. This means depending on type of wear and type of applications, there are different additives that is added with hydraulic wear and we say for this material antiwear hydraulic oil it will be this one. It is like that and this specification is available with the manufacturers of oil. These oils not only

have improved wear resistance but also the desirable properties of an R and O oil. Most antiwear oils separate readily from water protects parts against rusting, resist oxidation and above all, minimize wear.

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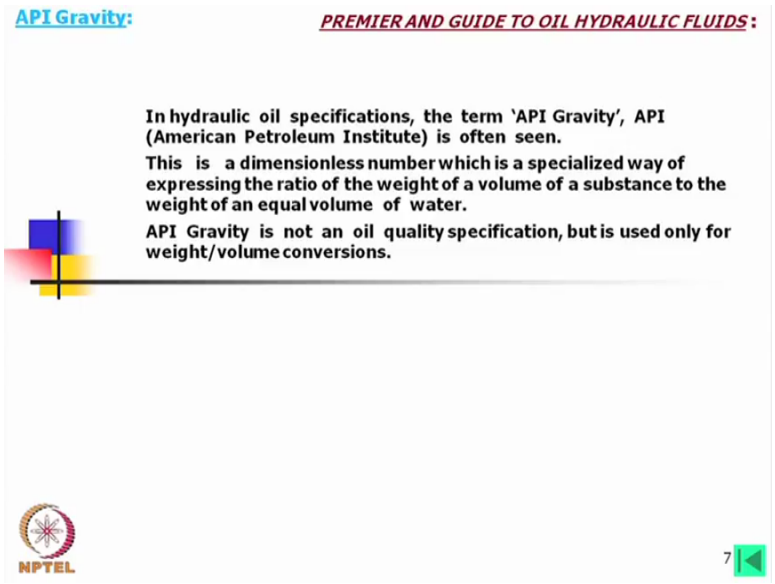

In hydraulic oil specifications the term API gravity, API stands for American petroleum institute is often seen. This is a dimensionless number which is specialized way of expressing the ratio of the weight of a volume of a substance to the weight of an equal volume of water. So this gravity of oil is called a API gravity and this API gravity of oil is specified and it requires for different calculations practically API gravity is not an oil quality specification, but is used only for weight and volume conversions.

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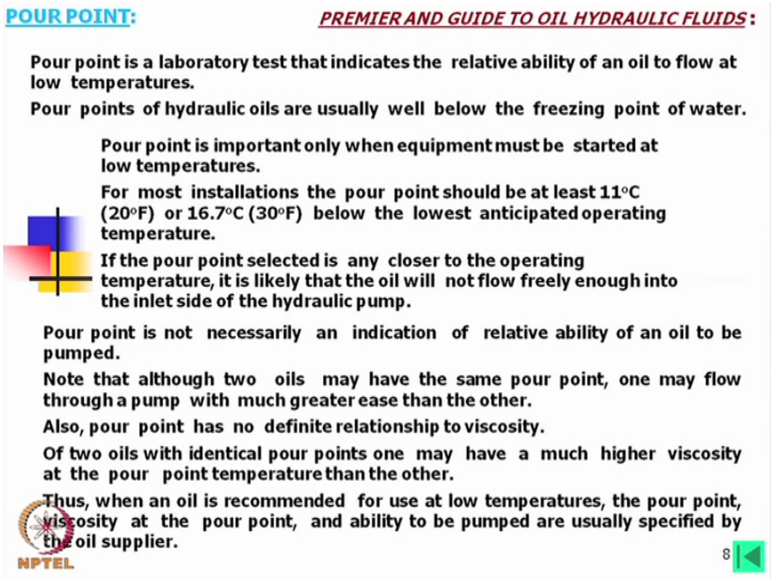

Now we will come to pour point. Pour point is a is a laboratory test that indicates the relative ability of an oil to flow at low temperatures. So it is determined in this way you take some oil in a beaker and cool down it and then you try to pour that oil into another container, you will find one point oil is not being pour from this beaker. That temperature definitely it is low temperature you will find you can mention that is the pour point. So this is important mainly where the operation is being a held at very cold temperature say during this season may be some European countries on the northern countries will find the pour point is very important. So we have to take the oil of higher pour point those applications. On the other hand if we look into this hot countries like India and another places, you may find that we do not we need not take care of such thing this pour point so much.

Pour points of hydraulic oils are usually well below the freezing point of water. See this point say freezing point of water the 0 degree centigrade. So this might be below that. Pour point is important only when equipment must be started at low temperatures. Usually when machine starts even if cold countries then automatically due to generation of heat we need not uh much look into this pour point of this oil. For most installations the pour point should be at least 11 degree centigrade or it is 20 degree Fahrenheit or 16.7 degree centigrade to 30 degree Fahrenheit below the lowest anticipated operating temperatures, I mean this is the knot or it might be the range within this range usually from 20 degree Fahrenheit to 30 degree Fahrenheit.

If the pour point selected is any closer to the operating temperature it is likely that the oil will not flow freely enough into the inlet side of the hydraulic pump. Pour point is not necessarily

an indication of relative ability of an oil to be pumped. This is not important in that way, once as I told once it machine starts operating then automatically the temperature increases the such problems does not arise. Note that although two oils may have the same pour point, one may flow through a pump with much greater ease than the other, you see for same pour point, but you may find one oil might be better for the flow through the pump.

Also pour point has no definite relationship to viscosity that is another important factor. Viscosity is very important. Factor in all necessary calculations or of I mean performance of hydraulic machines, but pour point of that oil may not be that important. Of two oils with identical pour points one may have a much higher viscosity at the pour point temperature than the other. Thus when an oil is recommend for use at low temperatures the pour point viscosity at the pour point and ability to be pumped are usually specify by the oil supplier or rather we should call oil manufacturer.

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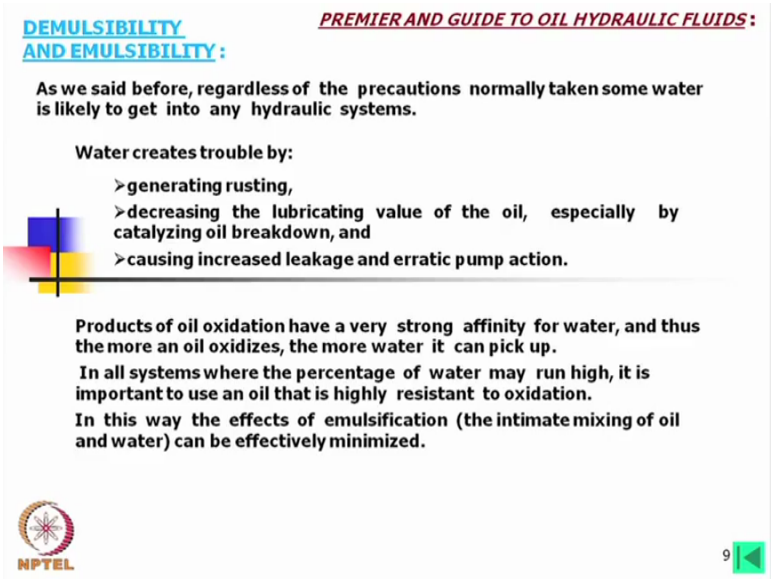

Now demulsibility and emulsibility that we have to look into while we are selecting the hydraulic oil. As we said before, regardless of the precautions normally taken some water is likely to get into any hydraulic system. Water creates trouble by; generating rusting, second decreasing the lubricating value of the oil especially by catalyzing oil breakdown and causing increase leakage and erratic pump action. This is you know this cavitation is one big factor sorry in this case for water there is no cavitation, but this it will change in the oils specification like API gravity and in the viscosity and then pump action may be erratic. Products of oil oxidation have a very strong affinity for water and thus the more an oil oxidizes the more water it can pick up you see, this is another point it can easily take water

due to the oxidation. In all systems where the percentage of the water may run high. It is important to use an oil that is highly resistant to oxidation. In this way, the effects of emulsification that is a intimate mixing of oil and water can be effectively minimized.

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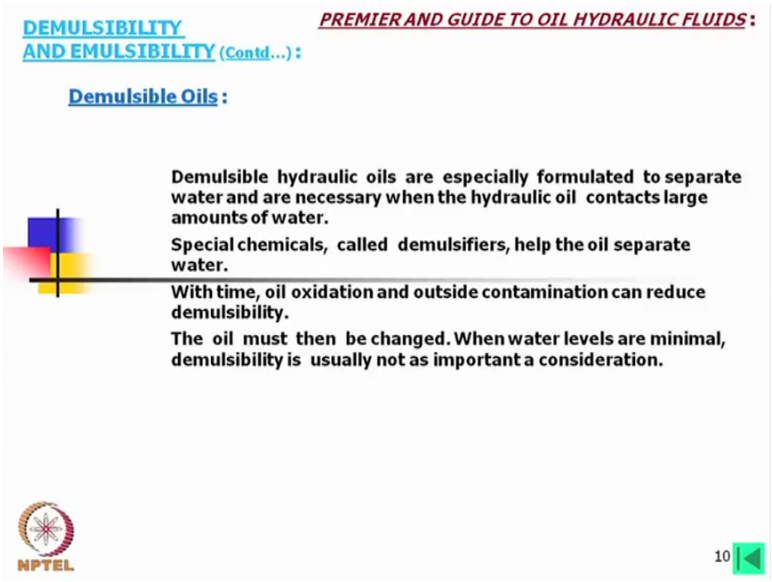

Now demulsible hydraulic oils are especially formulated to separate water and are necessary when the hydraulic oil contacts large amount of water. Special chemicals called emulsifiers help the oil to separate water. With time oil oxidation and outside contamination can reduce demulsibility. The oil must then be changed when water levels are minimal, demulsibility is usually not an important a consideration.

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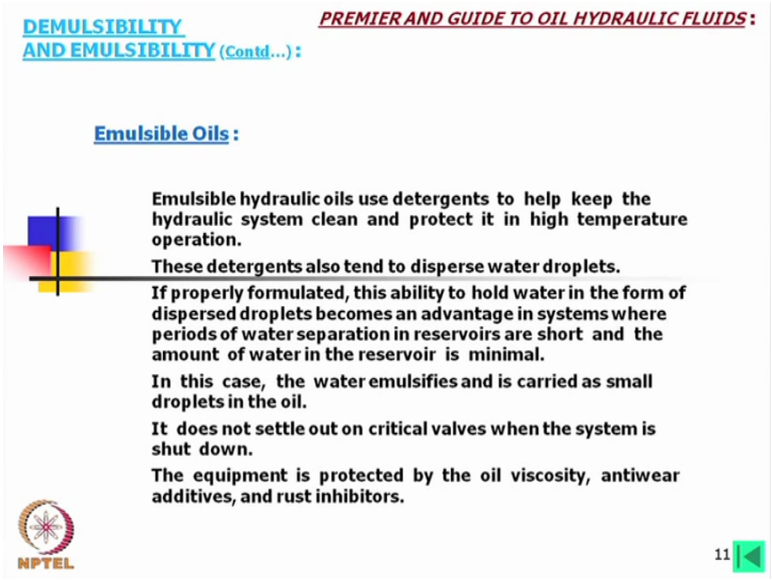

Now emulsible hydraulic oils use detergents to help keep the hydraulic system clean and protect it in high temperature operations. These detergents also tend to disperse water droplets. If properly formulated this ability to hold water in the form of dispersed droplets becomes an advantage in system where periods of water separation in reservoirs are short and the amount of water in the reservoir is minimal. In this case the water emulsifies and is carried as small droplets in the oil. It does not settle out on critical values when the system is shut down sorry, critical valves it does not settle out on critical valves when the system is shut down. The equipment is protected by the oil viscosity, antiwear additives and rust inhibitors.

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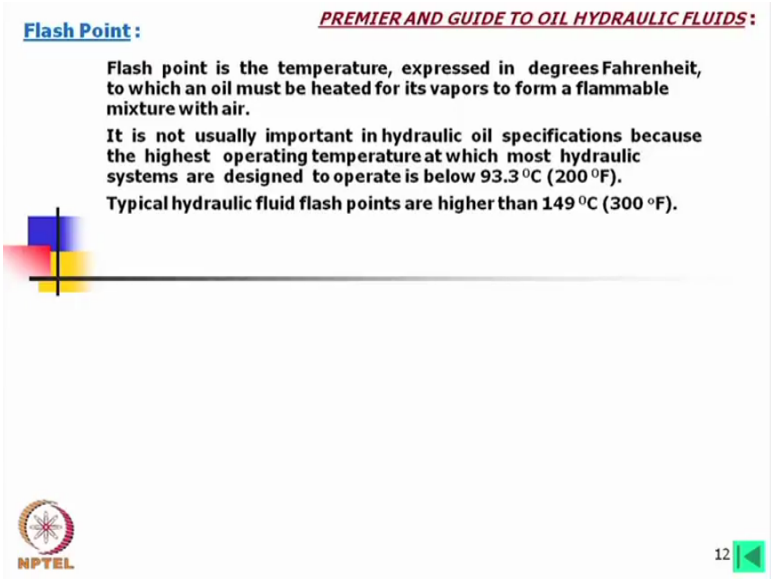

Now another point we should consider the flash point. This is flash point is the temperature expressed in degrees fahrenheit or centigrade to which an oil must be heated for its vapors to form a flammable mixture with air. In presence of air if you go on heating then you will find that it just flame will start in presence of air of course that temperature is called flash point. So that is very important and we should not allow the oil the temperature to be raised above that point, say it happens like this when we are started operating the machines, the temperature may be below the ambient temperature inside the factory or whatever may be even if outside, but when the machine start operates the heat is generated, oil is heated up and the temperature increases, it increases beyond the ambient temperatures, but that temperature never exceeds flash point, it should be below flash point.

It is not usually important in hydraulic oil specifications, because the highest operating temperature at which most hydraulic systems are designed to operate is below 93.3 degree centigrades. Typical hydraulic fluid flash point are higher than 149 degree centigrade usually and normally the temperature of the oil may not increase 200 degree fahrenheit which comes to 93.3 degree Celsius, actually I would say from the practical experience that usually you will find that oil temperature may be 65 to 70 degree centigrades only where the ambient temperature is around 45 degree or Celsius also. This means that on-off pulling (())(29:16) to be provided to the hydraulic oil.

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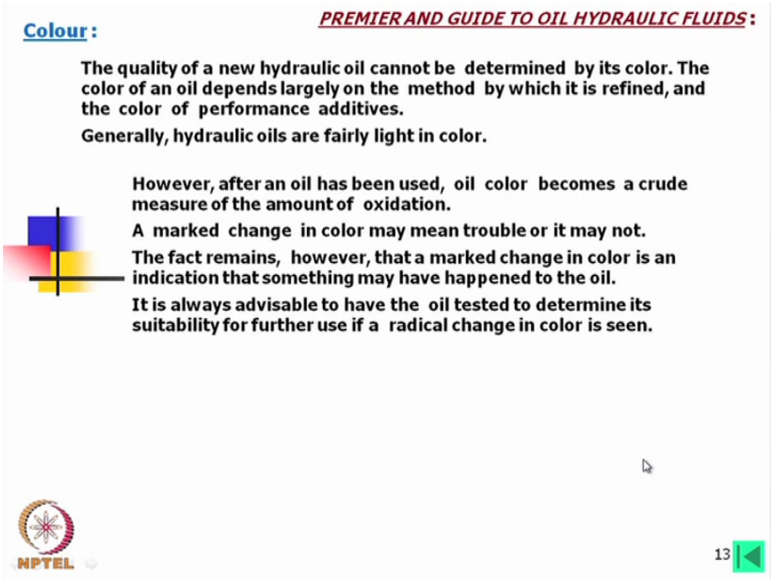

Now the color, the quality of a new hydraulic oil cannot be determined by its color. The color of oil depends largely on the method by which it is refined and the color of performance additives. So oil color actually it is definitely not like waters, I am talking about the mineral oil, but still it is almost colorless, but when some additives are added, it gets a color change, okay. However, it is difficult to understand which one is refresh oil, which one is used oil looking into the color of the oil. Generally hydraulic oils are fairly light in color, okay. However, after an oil has been used, oil color becomes a crude measure of the amount of oxidations. This is like that suppose you have a system and you know particular type of oil is being used. So you know what is the color of the oil, then oil you are inspecting say after 1 months looking into the color of the oil, you can understand whether the oxidation has occur or not, the experienced person he can say this is so much oxidation has occurred, we should reject this oil looking into the color.

If you have not seen the color at the new condition I mean when just you have pour the new oil, it is very difficult to understand then that what is the condition or the present condition of the oil used oil. A marked change in color may mean trouble or it may not. The fact remains, however, that a marked change in color is in indication that something may have happened to the oil. Actually life of the oil is there among the hydraulic components the first I mean any hydraulic system the first thing perhaps the oil has to be changed periodically and that period is short than any other. So next might be the seal you have to change the seal, it is like that.

So in that way we have to contiguously inspect the oil condition. This is health of the oil for the specification of the oil we should check time to time. The one important thing in that way

is that looking into the color of the oil used oil. So perhaps you will not go for any other test if there is no change in color, if there is change in color then maybe you can say okay. This oil to be tested now that is why the color is important. It is always advisable to have the oil tested to determine its suitability for further in radical change if a radical change in color is same.

Now this radical change we should say in that way say suppose you have inspected the oil and suddenly after few days you find that oil has become too much jerk (())(33:07) then that due to failure of the oil at that due to that somewhere some components is being own or may be the oil is being burned at some points, too much friction is there something is there. So looking into that, that gives an indication that there is something wrong in the system not only the oil in the system also. So this is to knowing to become expert in knowing the color of the oil to guess that what might be the problem is a good experience.

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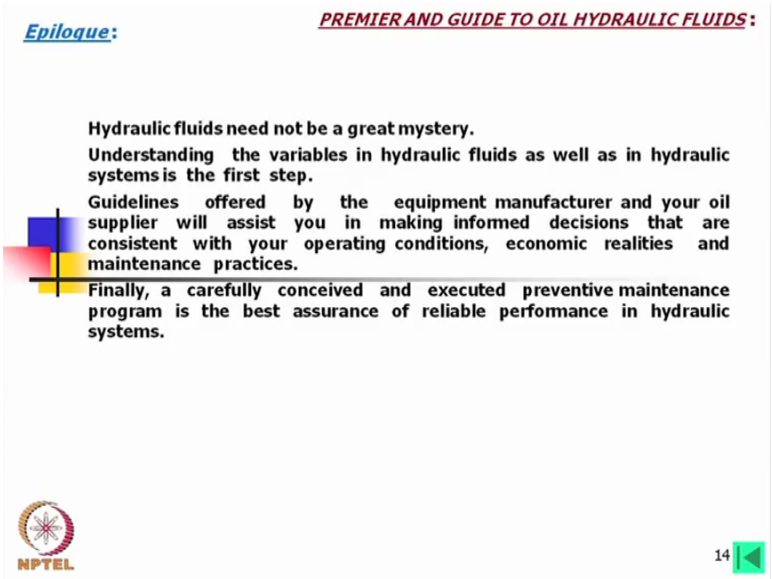

Now lastly I would say this what we have discussed that is only a part of that oil selections, the other parts viscosity index and then the how to calculate such things that which we have discussed in lecture 2. So along with that this we should also consider for the selecting oil. Anyway lastly I would like to say about this selection of the oil hydraulics. Hydraulic fluids need not be a great mystery, understanding the variables in hydraulic fluids as well as in hydraulic systems is a first step.

Guidelines offered by the equipment manufacturers and your oil suppliers will assist you in making informed decisions that are consistent with your operating conditions, economic

realities and maintenance practices. Finally a carefully concept and executed preventive maintenance program is the best assurance of reliable performance in hydraulic systems. This I would like to mention that knowing the operations of a machines, the performance of a machines, efficiency of machines we can make a scheduled for preventive maintenance. When we should inspect the oil, when we should change the oil. So this depending on the operations, it is not necessary the all the machines has to change the oil at the same time if we are using the same oil.

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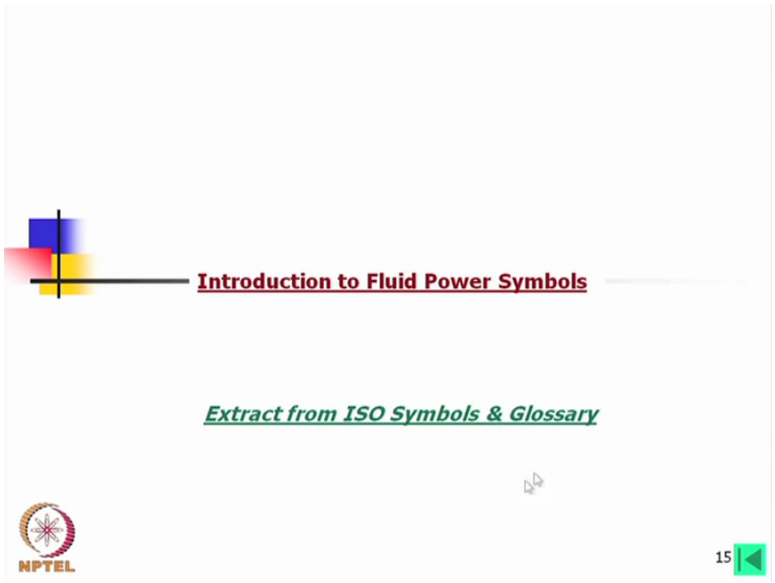

So that was all over the selection of oil and it was a guide line only. Now we will come into a completely new topics you say, this is introduction to fluid power symbols. Here again I would like to mention in lecture second lecture we have mentioned about the symbols. How the symbols are used and how the symbols are built for a particular component, because while we are going to make a circuit the first thing we have to design the circuit and we have to specify the what components we are going to use.

Now if we would like to provide the actual figure of the components, then it will be huge drawing and huge space will be required neither we can draw such things even if icons are available, it will not look nice. So better to use some symbols instead of the actual components drawing when we are making a circuit designing. This is like an electrical engineering. So in electrical engineering, the symbols are perhaps much simpler. In this case, as there are many many components, symbols are also complicated. It is neither possible to remember all such components. However, now the assistance are available you can follow through internet you can follow any symbol guidelines and you can pick up that one and

usually in the industry who are designing such hydraulic circuits and systems, they have their library for all symbols. So you can pick up symbols and you can design the circuits and in this lecture, this is first part, I will show that how the symbols are presented against a component and in the next lecture, I will show you some more symbols. Now first I would like to show you extract from ISO symbols and glossary.

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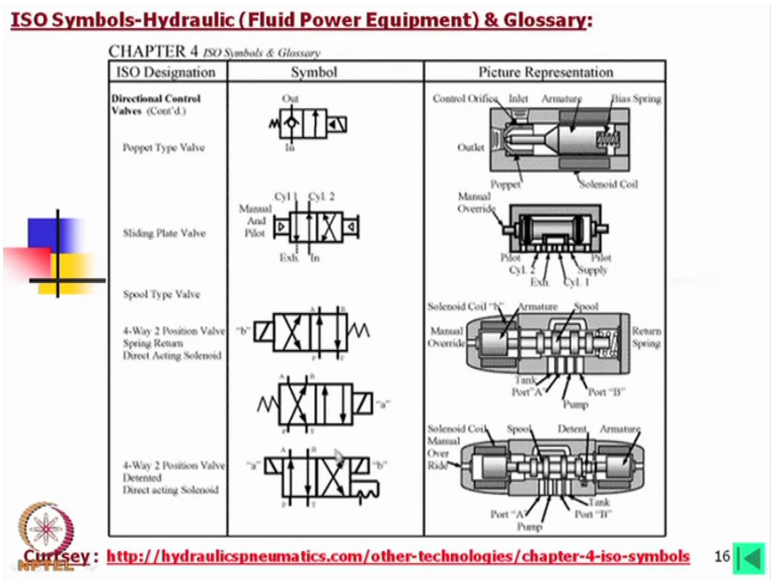

Now if we look into this figure then, this is ISO symbols and glossary. This is chapter 4 of this reference. There is a reference. This is a we have taken from that references, in that case as you see, let us look into this component. This is directional control valves; it is the continuous of direction control valves. In that case this is as you can see that this is flow is going only in one direction we normally call it check valve. That check valve is presented in this way. However, the system is like that we can actuate by an hydraulic system and in that way then this will be direct connected. That means we can push this one through this inlet and then the oil can directly no oil is coming in and going out when we are moving this one. So this symbol is used for this components.

If we come to this another component, here as if we are having a sliding plate. This plate can be move this way or that way then there will be two connections and manual and pilot. These operations are done either manually or pilot, say this symbol means say this extended lines means it is for manual operations and this means that there is a pilot. However, perhaps this is for air, because this triangle is not filled if this triangle is filled then this is for oil, okay. So this is an in, exhaust, cylinder 1 etcetera are given.

Now if we come to the spool types which are very common. In that case as I have told earlier that looking into this we can name this valve say, there are two positions and there are 4 ports. So this we should called 4 by 2 direction control valve. In that case as you see, this details once I have explained you, so I am not going into detail of that if you study you can understand, how the oil is coming in? How the oil is going back and then again this is operated by armature. So this symbols means there is some armature some electric operation is there. So we can present this valve without this operations also, say in circuit designing, preliminary what we can do we can use only the symbol of this portions and we may not use this portion, because this may be hydraulically operated. So this is in the second phase we can select whether it si hydraulic operated and other thing. So this means that when we say 4 by 2 dc valve in that case only we will present this valve.

Now here a spring. Now this springs means it will maintain say this we can move this spool we can move by this armature, but presenting this spring means it is always remain in one position. In that case if we study say if spring is pushing this one, okay in that case pushing this means oil is coming in and it is going to port B that means this one port B. So that means if we do not actuates this one then this valve will be in this position, but if we actuate then it will be in this positions. So that means the normal positions is away from the spring that means by the spring this position is maintained by this one this position is maintained. So in that way we can study the valve looking into a component what is the exact symbols that we can study in that way. So studying such symbols in details will take long time. So I will just show you this and when this lecture is available to you then you can study and you can spend more time to understand such symbols. So in this case, this is just opposite one, so that means in normal condition it is like this, by this actuating this one we will have this position.

Now this is again 4 by 2, in this case we have two actuators that means no spring is there no say neutral positions that opposition your normally called neutral position no neutral position is there. There will be this push to get a position we should actuate one either of this the solenoid or the armature you can say that is drive electric drive and then this is two position and detented direct acting solenoids that means we can use this solenoid, but we can also detent a particular positions. So this means detent positions some detent arrangement is there okay. We can keep in a perhaps we can keep in a intermediate positions also, by using these two armature together.

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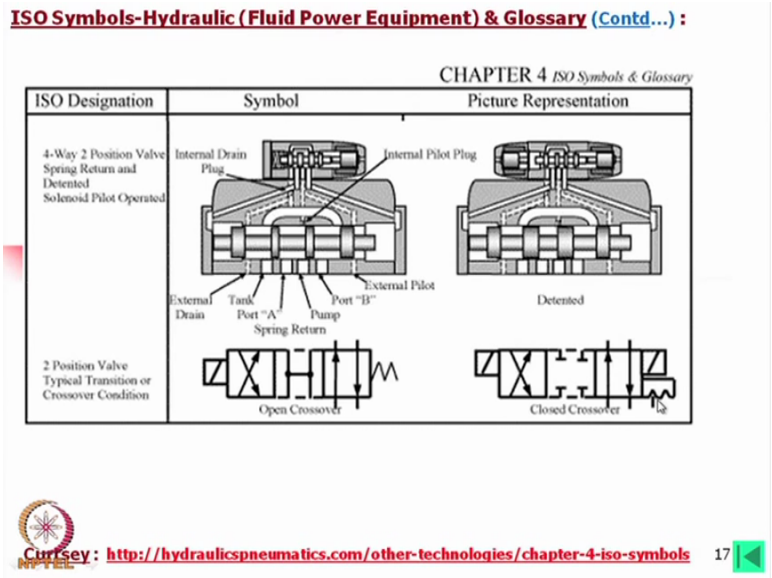

Now another interesting this also 4 by 2 position valve spring return and (())(44:51) solenoid pilot operated. Now this is also again two positions, but completely it is shown the two separate positions are there, that means we can detent in this positions. In this case in detent positions all port are connected in this case in detent positions all are closed. This is a closed centre. This is a complete open centers we can study with this in details open centre and closed centre and in this case, this is there is a spring which is not shown. So spring return is there and other side is driven by the armature. In this case both are driven by this armature and this indicates detent (())(45:52) position.

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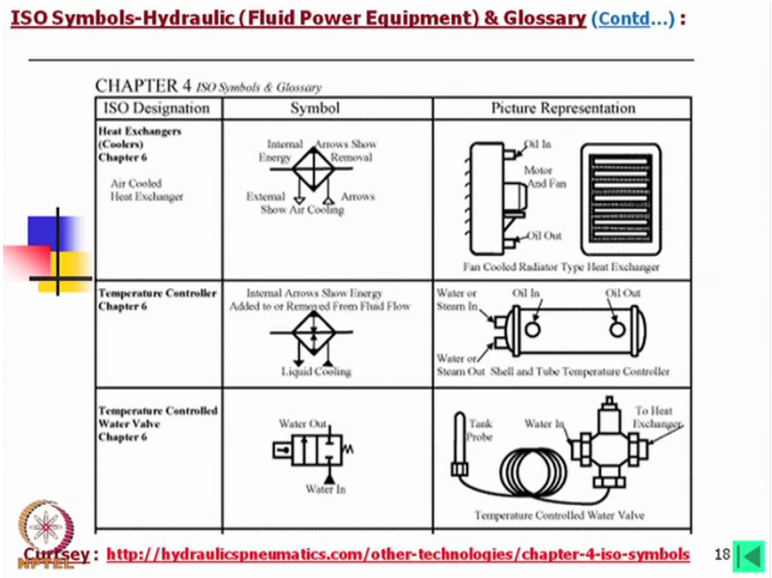

Now if we look into this cooler and heat exchangers then, we will find that this symbol is used. In this case this is not filled means these are by air. So what is their it is some sort of the radiator systems, oil is may be the outside and air is through a coil sort of conduit inside it and the symbol importance in this symbol is that there are two arrows which is in the outside mean heat is going out. Similarly, if we come to this component what we find in that case as if there is this is a tank sort of things inside the oil is going out water or steam inside. So oil is going in oil is going out which we are using the systems and here this is if we would like to cool it then cold water is being going inside and it is going out and if we would like to heat this one then, we are using the steam and in that case what we find this arrow are both direction that means the same component can be used as a cooler as well as heater. So this is a special symbol you can say as well this is operated by some liquid. In that case this is air or gas in this air it will be air no gas normally. In this case, this is usually water.

Now temperature controlled water valve, so this is special water control valve. So here I would like to mentions if we go for ISO standards ISO means international standard organizations. Similarly Indian standard are there usually, you will find such symbols are there against a particular component and there are a logic that itself is a huge things to learn such logics and to develop a proper symbol for a components. However, these symbols are standardize and looking into a component one can easily understands what it is and how it is being operated etcetera , but I would like to say in industries such symbols are followed which may not be strictly ISO standards, but still those are in the usable form.

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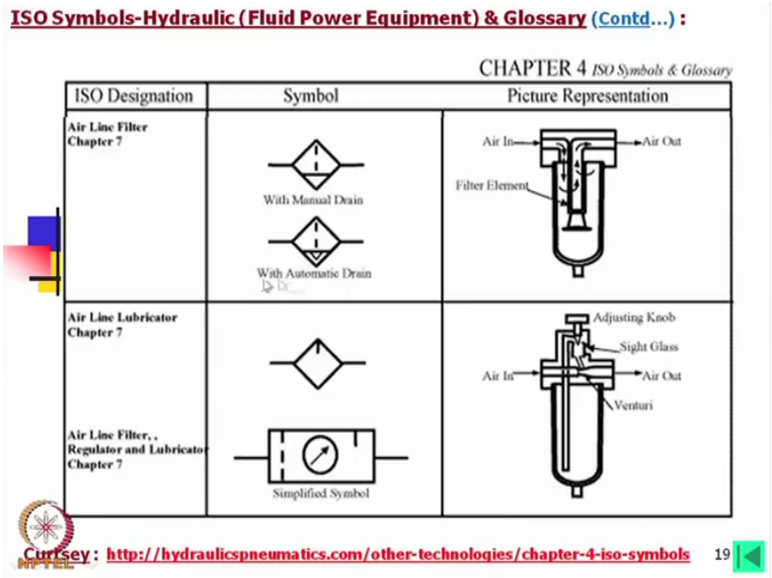

Now these symbols is for filter as you can see, this with manual drain, in this case this sign is (())(49:15) then automatic drain and again airline lubricant, in that case the symbols are like this.

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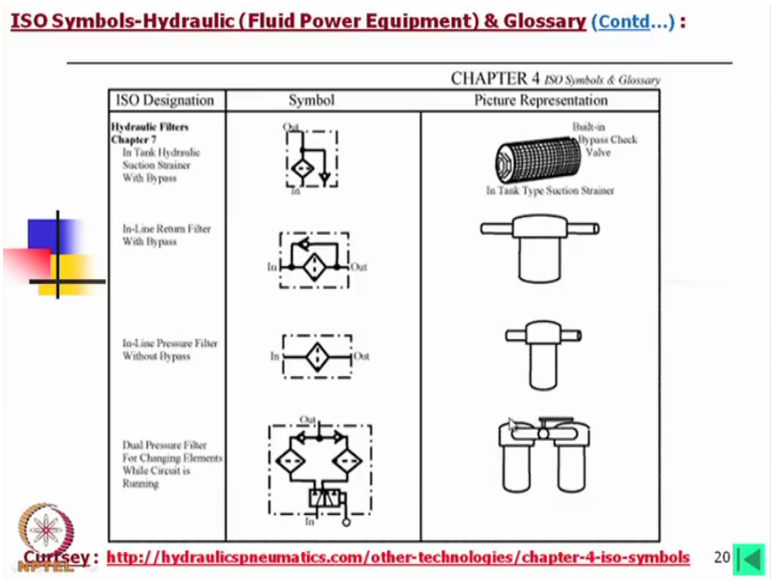

And then there are this is called strainer. Now this strainer with a check valve, it is sometimes without check valve. this one is actually actual component of the strainer and this is in inside the casing the in and out and there is a check valve is there, sometimes it is like that if you use two filters together, of course this also at one time it is going through one filter and other time it is going through other filter which is selected by operating this valve. So this depends on what type of filtration you require, okay.

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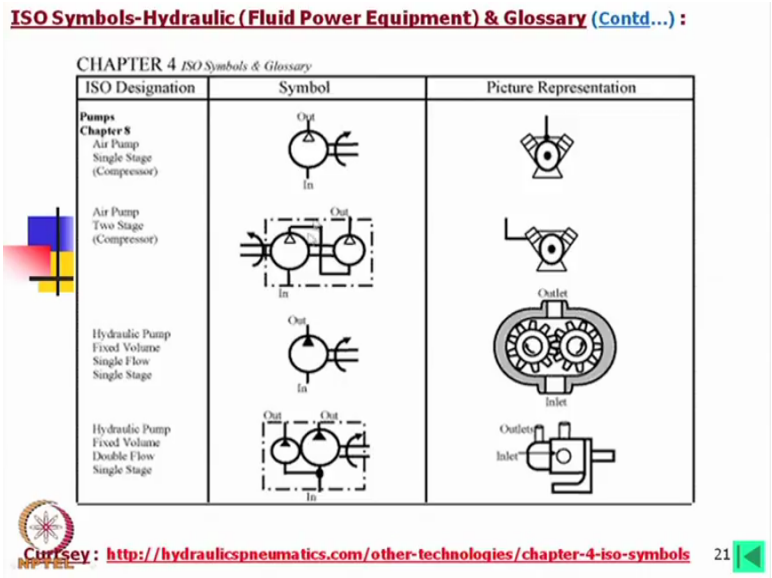

Now next is the rotary actuator. In that case you see this is a pump. Now this pump again this triangle is not filled that means this is air or gas. So this indicates that direction of rotations. So that indicates also rotary actuator. Sometimes you will find the symbols is without the shaft and direction of rotations both are used, because this will be obviously depending on the hot components you are using that will have a shaft and that has to be rotated irrespective whether we present this one or not. This is you can see this double pump that means it is basically compressor not pump you can say this compressor in that case, 2 stage in first stage as it is certain raise of pressure and the second stage it is further raised .

In a single stage if we would like to use a single compressor that will be huge size instead of that in two stage we can get the desired pressure of the air or gas. However, if it is an hydraulic oil or fluid liquid in that case, you will find that triangle is filled and this is the simplest symbol of an pump hydraulic pump. In this case it is gear pump, but instead of gear pump it is a suppose a vane pump the symbol will be same if it is a linear piston pump this symbol will be same. So this symbols means it is hydraulic pump. In that case this hydraulic pump is having an auxiliary pump fitted with that, okay.

So this is hydraulic pump fixed volume double flow single stage that means only single shaft is being rotated both the pump will run together and suppose why suppose in this case, this is a fixed displacement , suppose you are not using this one this pump, in that case you keep this separate. There will be a separate pressure relief valve, you keep this pressure relief valve open all the oil will go to the tank when you find that you have to use this one also, you can set the pressure. In many cases you will find that these two pumps are used when there is a

low flow requirement only this pump is working. When the high flow is required at low pressure then this both the pump are working which we have already learn how the two pumps can be used. In that case, we go for such pump. It reduces the total power consumption, okay.

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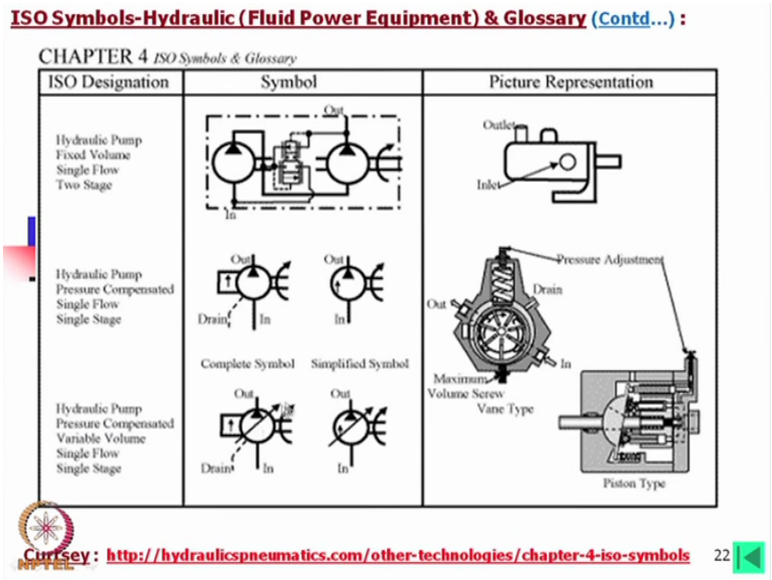

Now next again this one is also as you see the double pump with hydraulic pump fixed volume single flow two stage. Here this is two stage pumps. There two separate pump was running by the same shaft. In this case, this is a two stage pump. This is again to increase the pressure of the hydraulic oil. Now in this case what we find that we have added one drain line here and one arrow. So what it indicates hydraulic pump pressure compensated. This indicates pressure compensated single flow single stage, we have drain flow and pressure compensated sign is present like this. In that case what we find hydraulic pump pressure compensated variable flow. This adding this arrow means it is variable flow single flow single stage.

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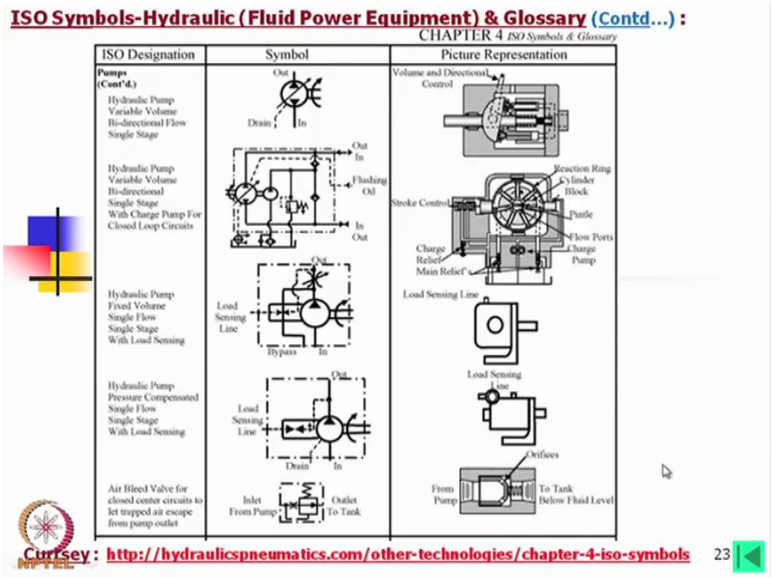

In this case what we find that this is variable displacement, drain is there and it can supply in both directional. So we actually we should call this is a hydraulic pump variable volume bidirectional flow single stage, okay. In that case hydraulic pump variable volume bidirectional single stage with charge pump. This is the charge pump is there for closed loop circuits. These are usually used for closed loop circuits. That means double pump which we have seen that also used for another application is therefore, this is closed circuit, but in case of closed circuit, this pump is very very small just to supply the leakage oil. So and is so it goes on like this and you can study of your own looking into this component and this symbols and these are of course ISO symbols, but in general practice we may not follow such symbols in details some simpler symbols are there also which we will study in next lectures.

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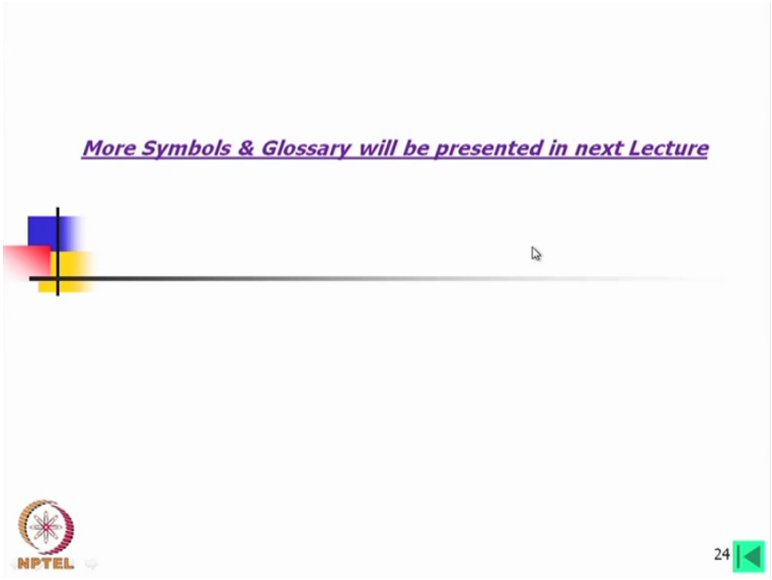

So ya this more symbols and glossary will be presented in next lecture. So thank you for listening.