Fundamentals of Industrial Oil Hydraulics and Pneumatics
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Module03 Lecture07
Different Types of Valves- Features and operations-1

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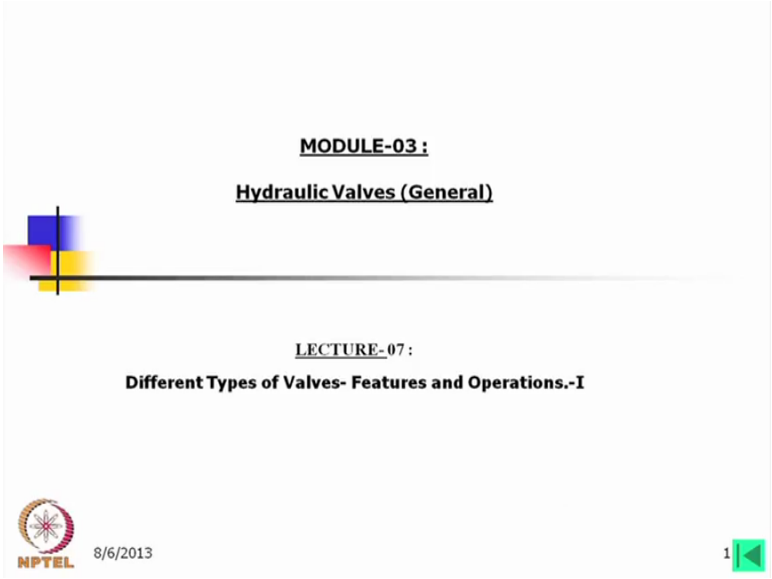

Welcome to lecture 7 on different types of valves- features and operations part one. This is under module 3, hydraulic valves and these valves are of general category.

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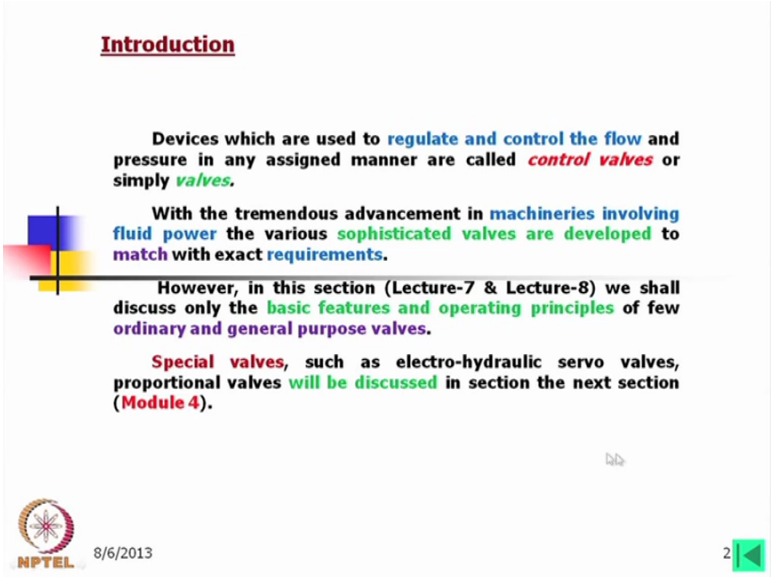

Devices which are used to regulate and control the flow and pressure in any assigned manner are called control valves or simply valves. Actually we should call it control valves, but normally we omit this control part and we call only valve. With the tremendous advancement in machineries involving fluid power, the various sophisticated valves are developed to match with exact requirements. However, in this section we shall discuss only the basic features and operating principles of few ordinary and general purpose valves. In fact if we would like to know the how the valves works and what are their constructional feature, I think this is not possible to learn not only within this scope of class work even, it may take few years and also day by day with the modernization these valve configurations are changing. Manufacturers, they change their valve very often particularly the features engineering features of the valves. Anyway, basic principles are remain same, so we shall look into that. Special valves such as electro-hydraulic servo valves, proportional valves will be discussed in section the next section in module 4.

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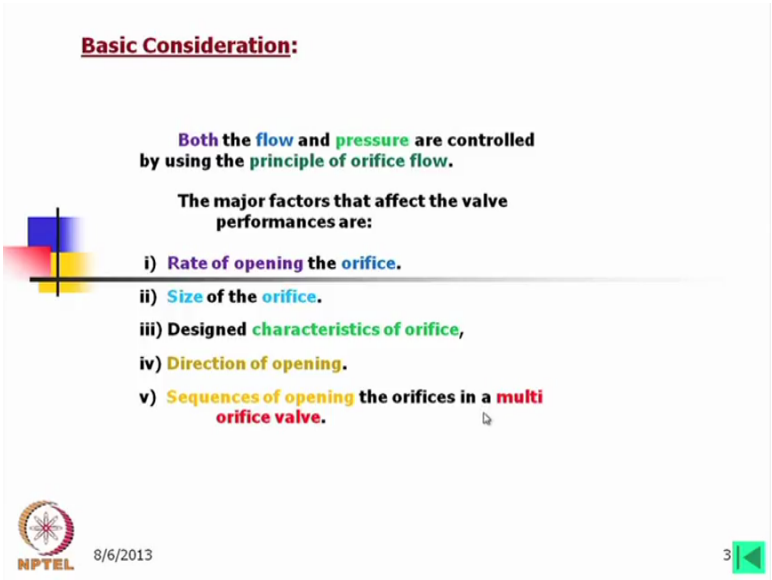

Now what are the basic considerations? First, both the flow and pressure are controlled by using the principle of orifice flow hat which I have discussed in lecture 4. The major factors that affect the valve performances are number one, rate of opening the orifice. Size of the orifice, here size includes the shape also. Third design characteristics orifice that also dependent on the shape of the orifice. Direction of opening. Sequence of opening the orifices in a multi orifice valve.

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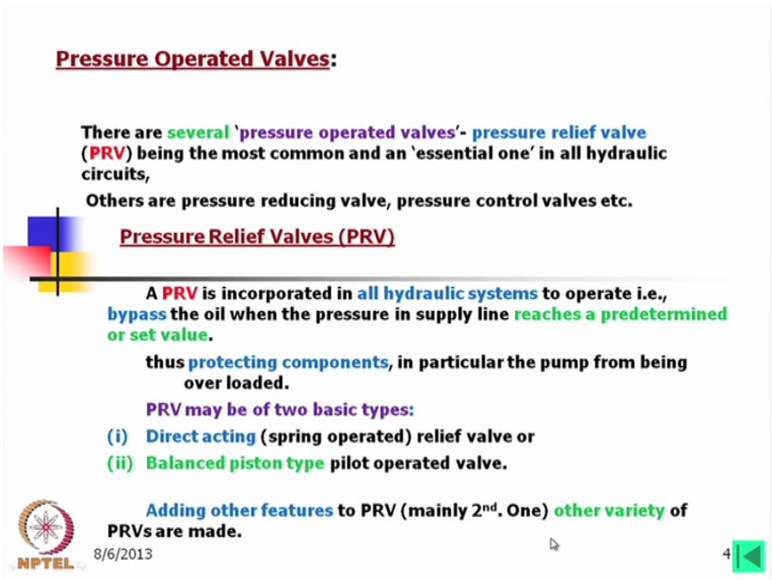

Now first of all we shall consider pressure operated valves. Now in the last slide what I have discussed? What are the orifices that we shall come later about the different shapes of the orifices, but in this lecture we shall only discuss how these valves are working and what are their features? There are several pressure operated valves. Pressure relief valve which is most commonly called as PRV being the most common and an essential one in all hydraulic circuits. Others are pressure reducing valve, pressure control valves etcetera. Now pressure relief valve. A PRV is incorporated in all hydraulic systems to operate by that is bypass the oil when the pressure in supply line reaches a predetermined or set value. Thus, protecting components in particular the pump from being overloaded. PRV may be of two basic types, one direct acting spring operated relief valve or balanced piston type pilot operated valve. Adding other features to PRV mainly on 2nd one other variety of PRVs are made.

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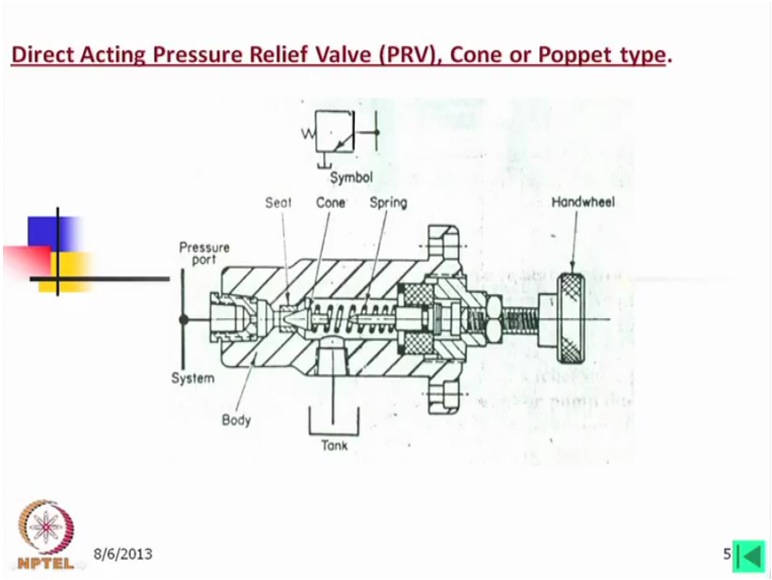

Now we shall consider direct acting pressure relief valve, cone or poppet type. Now look at this, this is the system line if we remember our earlier figure where we developed that how the fluid power circuit is made basic circuit. We connected this pressure relief valve in the supply line from prime (())(7:07) outlet to the valve. Usually, this is put just after the pump and it is connected to the system supply line. Now in this construction, this is the valve body okay. Now here we find a orifice on which a cone or poppet is placed and this poppet is supported by another spring where, this spring can be compressed or expanded by tightening this or loosening this hand wheel and what we find there is a hole through the body connected to the tank.

Now how it operates? When oil pressure increases or so to say this oil pressure creates a thrust on this cone. So this cone will experience a force. Now when this force exceeds the force given by this spring then there will be a opening. So oil will directly come and go to the tank. This means suppose we are having a set pressure of 10 mega pascal. So when this exceeds 10 mega pascal then this will open. This means that the pressure into that area whatever force is giving to this spring that is balanced by tightening this hand wheel.

Now when the pressure will slightly exceed that this will open and flow will begin. So this means that at that pressure flow should go out, but the problem is that of this type of valve that when flow begins, so there will be opening. Now due to this opening if we use these orifice equations we will find that inside the pressure will drop. In this system line pressure will drop, once the flow begins, then what will happen to this, this poppet force on this poppet or cone will reduce and again it will be closed, but once it is closed again the pressure

will rise, again this one will open. This means that if in the system the pressure rises above the set pressure, this poppet will open and close open and close until the pressure is reduce, that means the until the load is reduced.

Now this valve definitely is not suitable for a continuous system. It is only suitable where this is only for a safety valve and this set pressure is rarely least. What will happen due to this cone seating and opening seating and opening a chattering sound will be there and this will be very noisy. However, for the very simple system still we use the direct acting valve, but always we should remember there is a rare case when we reach the set pressure. Usually working pressure will be below that. Now one important thing look at this symbol, what are the symbols we have learned in the second lecture? This is different from that, you see as it is a direct one, there is no pilot line and in that case, if we remember I think in the next slide we will come to that, but there was a straight line and this can come to the line of flow.

In this case apparently say this means that it is drained when the pressure again will be reduced then this will be straight and oil will not be drained. This symbol means that very often we use this some symbol. This may not be ISO symbols, but this is very common for the relief valve even if it is balanced type by mistake we use this type of symbol. If you study a hydraulic circuit industrial hydraulic circuit, very often you will find this symbol is used.

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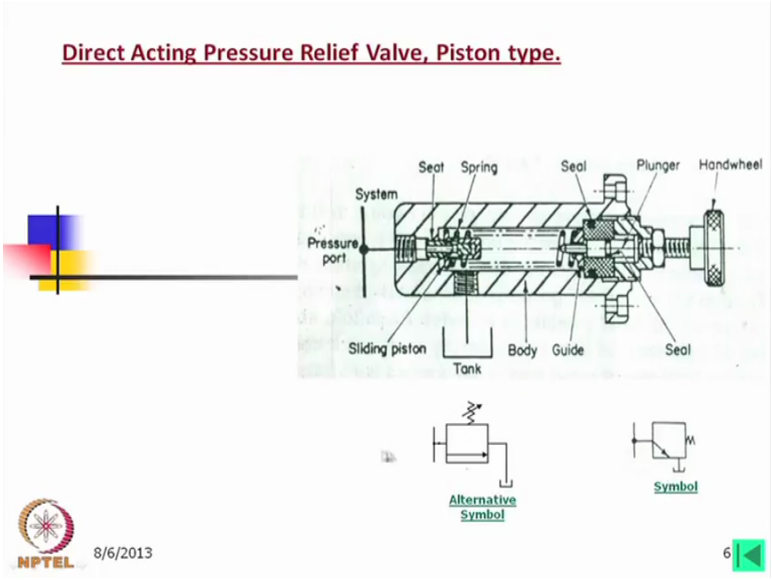

Now next one is the direct acting pressure relief valve, piston type. Again this is also direct acting, but instead of poppet or cone what we have used here a we have used a piston and if you look into this part, there is an orifice and which is giving a pressure to this piston which

is a cap type. That means we may consider this is a piston and this is a cap and then what will happen when the pressure rises, there will be thrust, but this gradually move outside and then the flow through this, there is a hole on this cap and through this hole the oil will come and it will go to the tank. Other mechanism is moved more or less same as in the poppet type valve.

Now what is the advantage of this? This is also direct acting, so the theory is same that when this opens then pressure reduces here and again it will be closed, but due to this piston and a cylinder sort of things what will happen? This will take some time to close and open and it is better from the chattering point of view. In case of the cone that was directly heating the seat cone seat. In this case, this piston is moving. So sound will be less, so it is slightly better than the other one and the symbol is used. They from the symbol you cannot understand whether it is piston type or poppet type, but alternative symbols what we have learned we can use this symbol also. This line this arrow means we can regulate it. Here it is not given, but that does not means we cannot regulate it we can regulate this also.

So this arrow is given to indicate that we can adjust the spring. Although, here it is not given, but still we should say that this can be adjusted. There are only a rare case where fixed type spring is used fixed compressed spring is used and that is a set relief valve usually inside some system a set relief valves is used. It is also possible that we can prefixed and it is a fixed one that means set pressure is always same.

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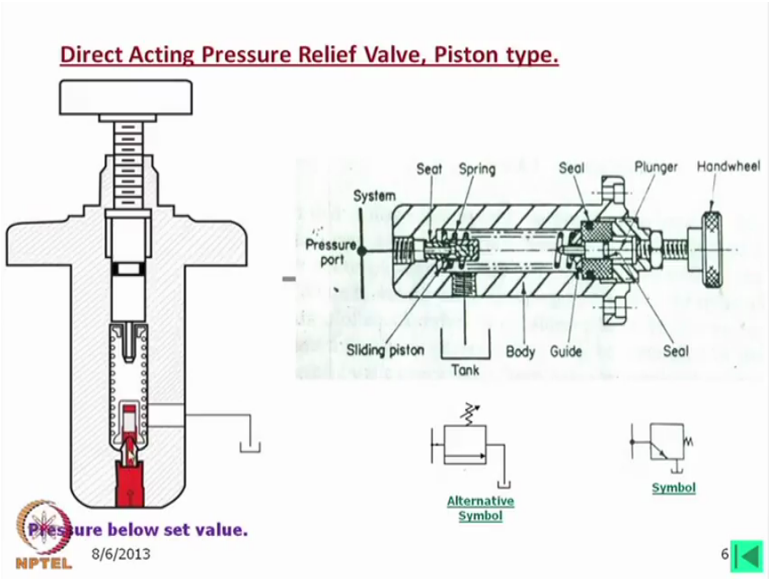

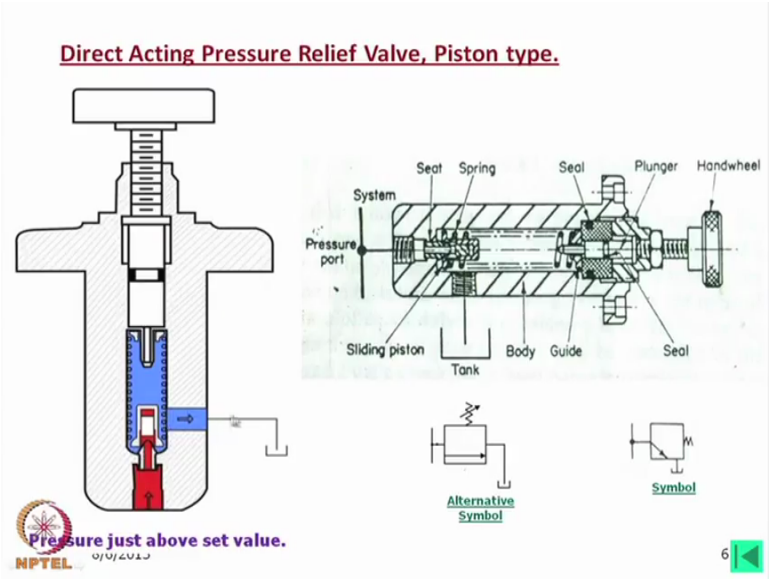

Now if I look into this colored figure. Now when the pressure below the set valve then as you can see that, this is the piston type and this is a another orifice. This orifice is put here, okay and then this is the piston and when there will be rise in pressure then it will open and oil will flow through this and it will go to the tank.

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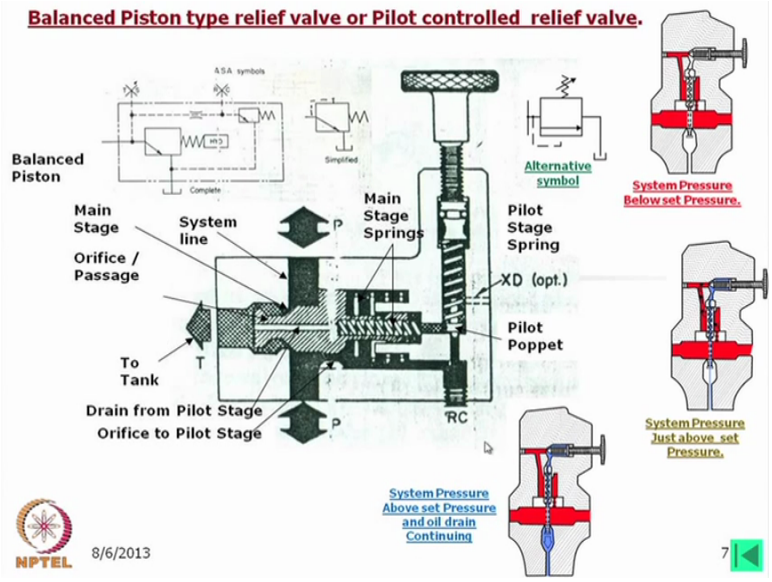

Now we consider balanced piston type relief valve or pilot control relief valve. Now in fact the pilot control relief valve is nothing but one relief valve inside the other or a direct relief valve inside a another bigger relief valve. How it is working? Say this is the flow path, this can be put usually you will find this body of this valve is having one port here another port here, which are normally threaded and you can connect one pipe here another here pipe here, which is directly connected to the system line that means system line is passing through

inside the valve, it is note that we are externally fitting to the system line. It is directly put inside the system line.

Now what is there? This is the main poppet piston main piston type and this is the main stage orifice passage. Now this is imagine, this is a circular and from this diameter, it is a step down here and this is a cone and then this diameter is increase to this and here, on this poppet there is a hole, there is a orifice. Now how it is being operated? The oil is going through this; it might be from this side or from the other side that does not matter. Now when this oil going through this through this orifice, it will come inside. Now this one we may call this is a direct relief valve, but in fact this direct relief valve is called the pilot stage.

Now here as you see, this is a RC that is the external control we can control from externally, but this is normally remain closed unless we would like to operate externally, then oil is coming over here. Now if we consider here is a very small area, so with a small thrust I mean the force is not very high. So this is a finer spring with a small force and when it exceed the set pressure, then it opens then oil come over here. Now if the pressure is below set pressure then, there is no flow remember there is no flow, no flow means the pressure the thrust this side and thrust this side remains same. So this is in a position and it is seating on that. Now when this opens then flow is coming through this. What will happen? There will be pressure drop, due to this pressure drop there will be reduction in the force this side, remember this side force is high, this side force is less. So this one will move inside it.

Now once it moves inside then this will open and oil will go through this. Now here the question is that when the oil is going through this, pressure here will reduce. So if te pressure reduces then there will be again change in flow, but there will be imbalance here again and it will try to close, but the thing is that this now works on a differential pressure that means the reduction of pressure here is not very high or in other words pressure here and pressure this side with a small difference. With that difference this piston remains at it position for much longer time than the direct acting valve.

So if we develop the equations fully from there we can understand how it is working, but at for some valve definitely we will do that, but difference between this balanced type pilot operated pressure relief valve and direct valve is there. There it is direct pressure is opening the poppet. Here the differential pressure is opening the this poppet. Now if I say suppose if I tighten this, then what will happen? The set pressure will change. This means that here the pressure it can it will be able to work at much higher pressure than this, because we have

tighten this one we have change the set pressure, but at that pressure also when this will open, you will find that differential pressure will remain more or less same and for that differential pressure, this poppet will remain open.

Now this is again we are not regulating this much, only thing one is opened and another is closed we will normally you will find this opening is very large, definitely by controlling this size an other we can have the valve of different flow rate, this means that suppose, this flow rate is very small then you will find for that a small area of this orifice will be suitable and for large flow you will find this area is larger, whereas this portion remains more or less same except the spring will be different spring strength will be different, okay.

Now you can see this, it is written here the pilot stage drain, orifice to pilot stage, main stage spring and this is the pilot stage spring sorry, this arrow is not given and this is this one is the external drain port. In many cases, there will be an external drain port through which the oil will go out, it is better if we can take this oil out here separately it is from cooling point of view, but in most of the cases you will find this is closed and this oil is internally going through this one through this single outlet. However, if we would like to control with external signal then we open this one. This means that in that case, if we do not send any signal to this, this will work as it is what I have explained, but with the external signal also we can open this one and then there will be bypass flow drain flow. It is sometimes, it is required that with an external signal we should open this relief valve.

Now looking into the symbols we also use this simplified symbol for this one, only thing here we have shown the pilot lines as you see. There is an alternative also simplified one which you have seen which I will show, but here if you look into the, this is a ASA symbol if you look into this, you will find that this is the main relief valve whereas, this is the direct relief valve. So this is basically combination of one direct relief valve and another is the balanced piston relief valve. Now alternative symbol which is shown here, these are also used and then if we look into this you can see this normal operation is like that. The oil is going through this and this is closed depending on the pressure here. It is below the set pressure, so no flow is there, no different size pressure. So definitely this is being closed, because in this side there is the pressure force which is equal to the pressure force here plus the spring force.

Now when this pressure is above this set pressure. This has open the oil has started flowing through this, there will be imbalance in the force that gradually the force is being reduced here or in other words pressure force is being reduced and pressure force here remain the

same. So difference between these two pressure force at one point will higher than this spring force and this will open. So ultimately this poppet will open and the flow will go through this drain line to the tank.

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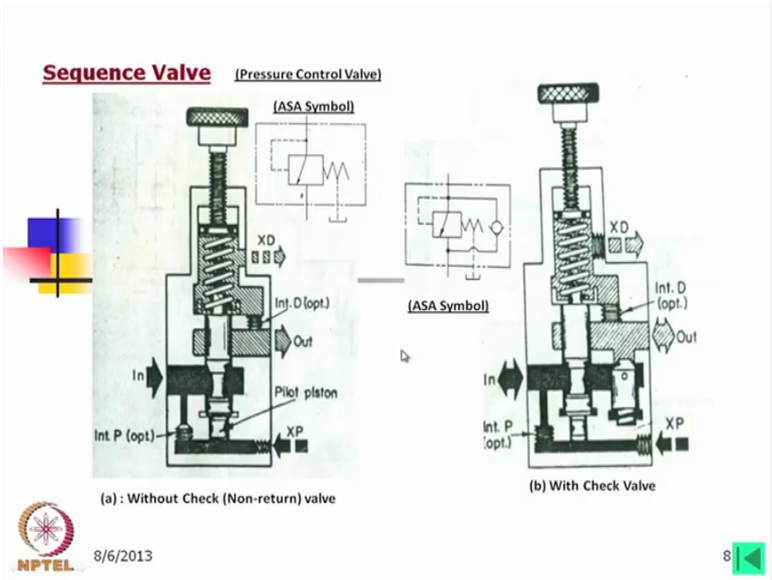

Now we shall consider the sequence valve. The sequence valve is in we can call it is also pressure relief valve, but better we should call pressure control valve. Now this sequential valve sequence valve is having different applications. It ordinarily it looks like in relief valve the only differences we can understand from their function. Now in this case here what we have shown that is without check valve without non-return valve. Now here the flow is going in to this and flow is going out to this one. Now then at that point you can see that one external signal port for external signal and this is internal port, this is optional we can make it we can keep it open or we can keep it closed.

Now this is the pilot pistons okay. Now what happens? This depending on the set pressure, this will have a limited amount of flow, but if the flow wants to come from this side, it will always remain closed. So this valve you can say that it is after controlling the pressure, it is allowing some flow. Now actually the purpose of this valve is not discussed here, we will show that by using these valve which is some sort pressure relief valve, we can conduct a different operations. Now ASA symbol if you look into this you even if I also confuses just to see whether this is a sequence valve or a pressure relief.

Now this variety is having another option to have a check valve. What is the check valve? We have a check valve like this. Now this check valve due to introduction of this check valve this

allows flow from the other side also. In this case, flow is only from one directions may be regulated pressure, may be regulated flow. In this case, if the flow is coming from other side then this will operate this check valve and flow can go out. Now this is again in both cases this is for external drain and this is for internal drain. If we use these external drain then the oil will go out, because this is a more resistive path. In some cases, instead of closing this there is also a check valve is there. So when the pressure inside increases automatically it comes out of that and it go in the direction of flow. In this case it may go this direction or that direction in this case; it will go only in this direction, okay.

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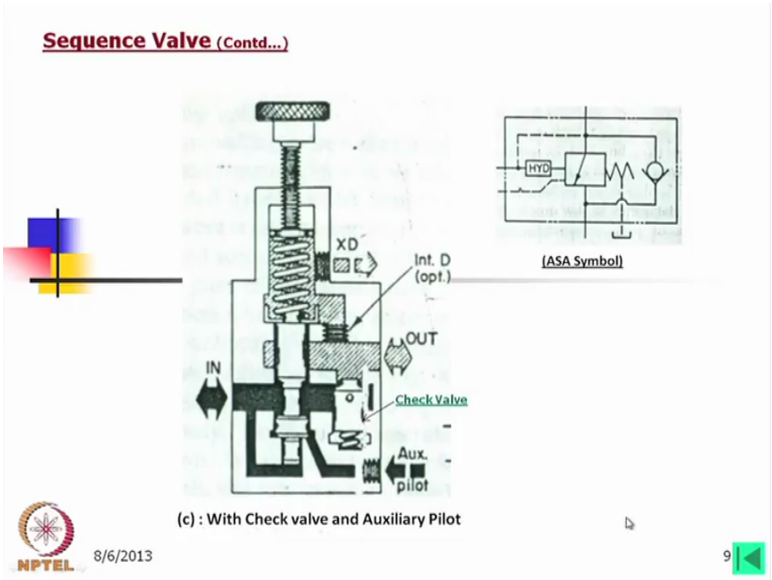

Next sequence valve with check valve and auxiliary pilot. In this case, as you if you look into this, check valve is there which I have described earlier, but instead of this is being closed there it is connected. Now due to this we have an auxiliary pilot wherever, this pilot is there whether it is a pressure relief valve or any pressure regulated valve. This means that this works on the principle of differential pressure. differential pressure means it better balance is possible of this spool main spool and this will remain stable for longer time, but definitely to make this this valve will be expensive and as well as you see, there is an external pilot of course it was there in earlier one also. Now if we would like to operate from the outside we can operate this. Now remember in that case we are forcefully moving this spool. So this may be anything any situations you can see this, if you if possible you can remember this symbol or else just for your knowledge this is the symbol of the sequence valve with check valve and auxiliary pilot.

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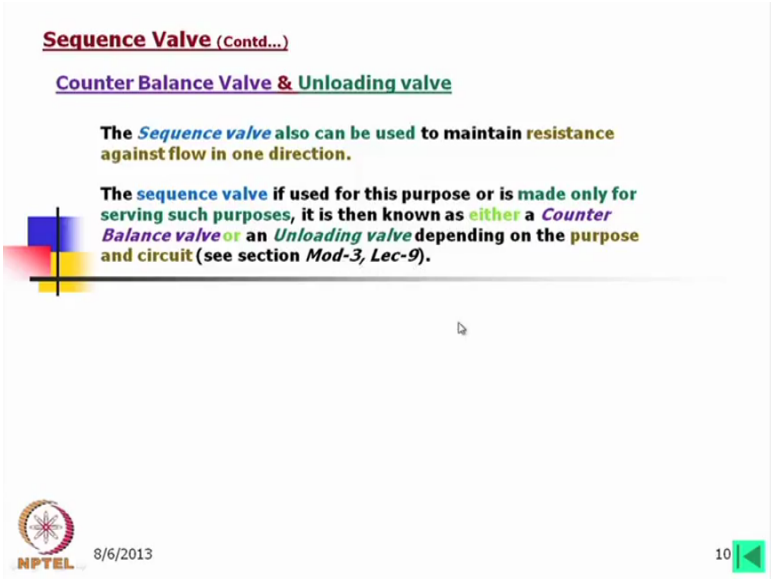

Now counter balance valve and unloading valve. In fact the sequence valve depending on the applications, they are given different name. Normally we do not call that we need a sequence valve for this circuit, rather we call we need a counter balance valve basically which is a sequence valve we call a unloading valve, we call a venting valve etcetera. Now the sequence valve also can be used to maintain a resistance against flow in one direction. The sequence valve if used for this purpose or is made only for serving such purposes, it is then known as either a counter balance valve or an unloading valve depending on the purpose and circuit. Now one if we do not come to the circuit design we will not be able to understand the purpose of counter balance valve and unloading valve which are sequential valve. So that we will learn may be in next lecture it is actually in lecture 9 in module 3.

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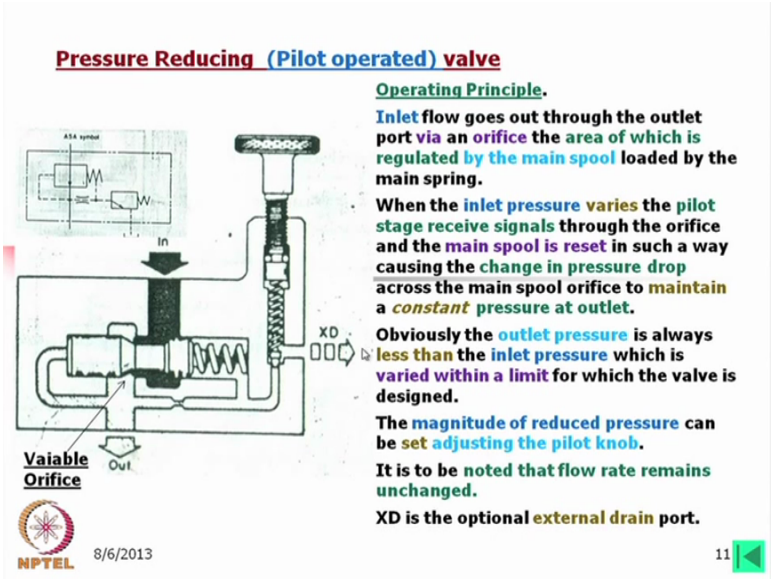

Now we will come to the pressure reducing valve. What is pressure relief valve and what is pressure reducing valve? Pressure relief valve is the valve where we relief the flow if it is above the set pressure whereas, in case of pressure reducing valve, from a system flow we can reduce the pressure we cannot increase we can reduce the pressure to a desired pressure. Of course, depending on the amount we would like to reduce we have to select the spring and other features, size of the poppet and etcetera. Now how it is working?

First let us examine, this the main poppet and flow is coming through this. Now what is there? There is also this orifice, but this orifice on the reduced flow side not on the main flow side. So this is the flow coming in to the valve and here is the main poppet and here is the main orifice. Variable orifice means when this will move this way or that way, this orifice will open. So this is the main orifice. Now the orifice to this pilot stage is on the reduced pressure side the outlet side not in the inlet side. Now what will happen?

Now when the oil is coming in, suppose consider that this is in a closed position, but it is not. Actually, with this spring force and here the top of this poppet, it will remain open. Now so this means that depending on the size automatically there will be some reduction in that. Now let us consider that pressure this side has increased then this flow will come over here and also, this will come to this, okay. Now in that case, if this pressure has increased above the set pressure, then the flow will enter to this passage also flow will begin and there will be a pressure drop. This pressure drop and there is also a thrust from this side. This will move in this direction, this will be closed. This orifice is being closed means less area and through this

less area same flow means we need to have a pressure drop here so that pressure drop will again set to the desired pressure. What it means?

This valve we can control again by using this one, suppose if we open fully then almost this pressure will be equal to this outlet pressure, but gradually if we close this one, always we will get some reduction in pressure and that will be utilized in the circuits, but there is a one question, say if we are reducing the pressure from this side to this side, suppose here we have set at a 10 mega pascal's by using this one, then this side definitely there is a pressure on the system line, pressure is more than the system pressure set pressure is there 10 mega pascal's.

Now what will happen that if this total flow is not utilized in this side? This will increase this pressure increase to the set pressure here. In fact in most of the time, the pressure here will be just above the system pressure supplied by the system line. That means in this line there is a pressure relief valve you will find the whatever flow is not being utilized it is going through this relief valve. This means that we can regulate this pressure, but in this side the pressure will remain the set pressure of the main system relief valve that you should remember. in our laboratory we have this type of valve and when the experiment will be there or some other time, I can show you.

Now operating principle which I have already described, but quickly we will go through this. Inlet flow goes out through the outlet port via an orifice, the area of which is regulated by the main spool loaded by the main spring. Then when the inlet pressure varies, the pilot stage receive signal through the orifice and the main spool is reset in such a way causing the change in pressure drop across the main spool orifice to maintain a constant pressure at outlet. This means when here this opens then this will reset to the controlled pressure.

Obviously, the outlet pressure is always less than the inlet pressure which is varied within a limit for which the valve is designed. Depending of amount of flow and the pressure drop, this orifice size, spool sizes, spring etcetera all are determined. That means these valves will have a range only, you will find say suppose if you want to control very small level, say 1 mega pascal pressure probably you have to go for a smaller work (())(42:37), okay. Now the magnitude of reduced pressure can be set adjusting the pilot knob, we can adjust this one. It is to be noted that flow rate remains unchanged. The flow rate normally will remain unchanged within this range. If this is in excess flow system that means this flow will always go through the pressure relief valve. XD is the optional external drain port, okay.

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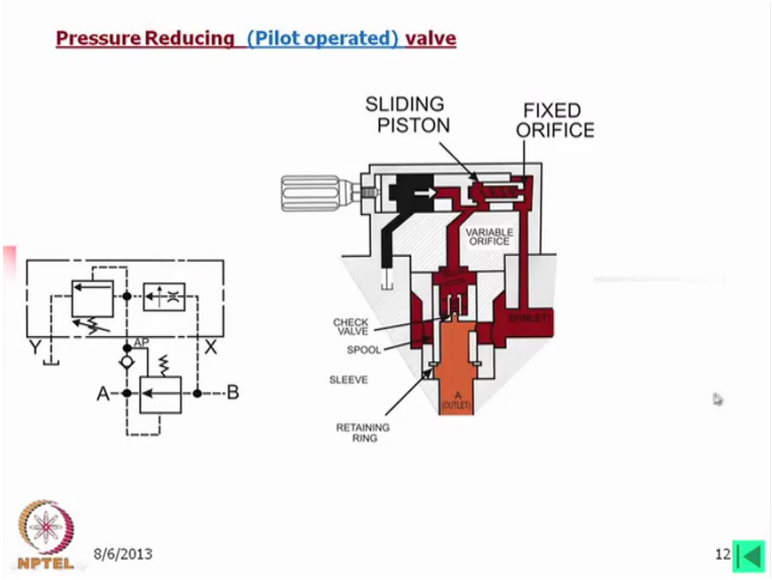

So here I have shown another pressure reducing pilot operated valve. Now look at this, this symbol is very complicate as you see. There is a pressure relief valve. This is the symbol of pressure relief valve, but as well there is a flow control valve added to that and then there is another valve with a check valve which is added to that. Actually, this is you can say the when the flow is going from this side then it can go through this. So this valve is not the symbol of this one. This is some other valve added to this system and this is the pressure reducing valve. Now how it operates? In this case as we see that this is inlet, okay and this is the reduced outlet and this oil is going through this and also from the inlet side going to this pilot stage which is controlled by this knob and then this area here, this area varies to give this outlet flow. This is just to understand, because I shall not ask you to remember this and to produce in the answer script (())(44:55).

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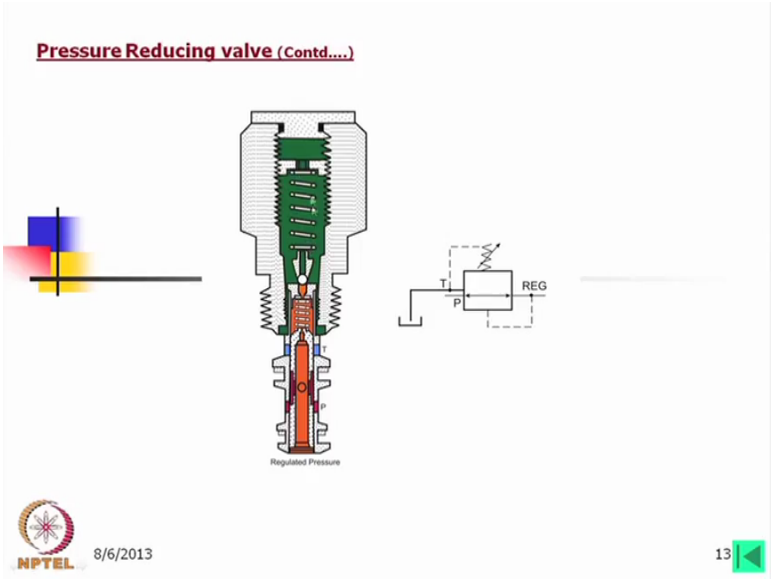

Now this is another pressure reducing valve which is called cut trees type, as you see here you can study this part. This is the pressure line okay. Oil is coming over here and this is the main spool which moves depending on the regulation here and then flow goes to the tank through this part. So this means that it is having one flow in and then regulated pressure flow out and then this is to the tank. Now this whole thing can be mounted on a manifold simply this is threaded to there and there are cavities, as you see this grove, there will be an orifice. So this is one chamber and there will be another chamber where the oil can go to the tank and then this is directly connected to the regulated flow side. So this is a cut trees type, but as you see this is a fixed valve. This cannot be regulated. This is a fixed valve.

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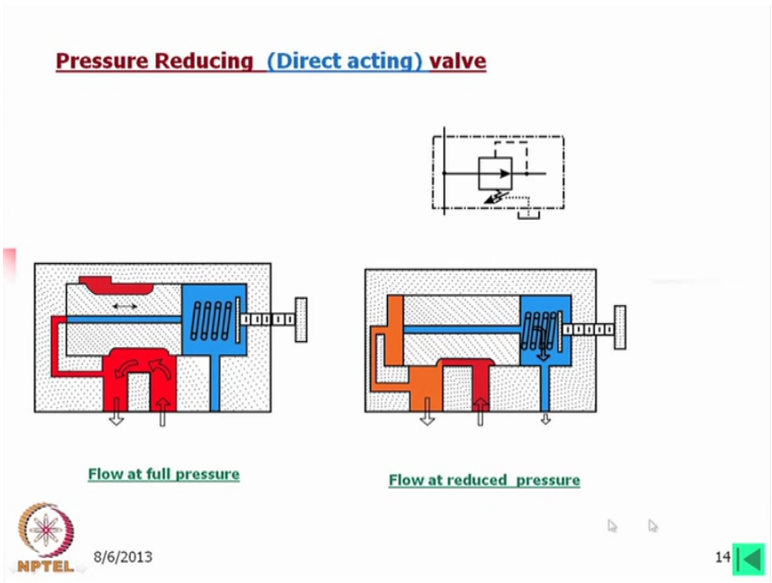

Now again there is a direct acting pressure reducing valve. In that case, what is there? This is a very simple mechanism. This oil is in normal codes, it is going like this, okay. Now we can regulate this one. That means here we can increase the thrust or decrease the thrust. Now what happens if there is? So when this pressure will come then, this will go through this orifice and it will go outside. Now in case this pressure increases then there will be more thrust and when there is a more thrust then this will be closed and there will be a pressure drop.

Now the question is that will it remain in that stable condition? The answer is yes, because of the reason that this pressure reduction will be there only when this pressure exceed the pressure we need here. Suppose this pressure is less than the regulated pressures say for example the regulated pressure is 10 mega pascal's and here the pressure say 12 mega pascal, but we need the pressure here only 7 mega pascal for the operation. In that case, the situation will be like this. Do you understand my point? Say regulated pressure we need 10 mega pascal and utilized pressure is less than 10 mega pascal then this is the situation, but when the utilized pressure is 10 mega pascal and here the pressure is more in the system, only then this will operate and it will work like this. So this is called direct acting.

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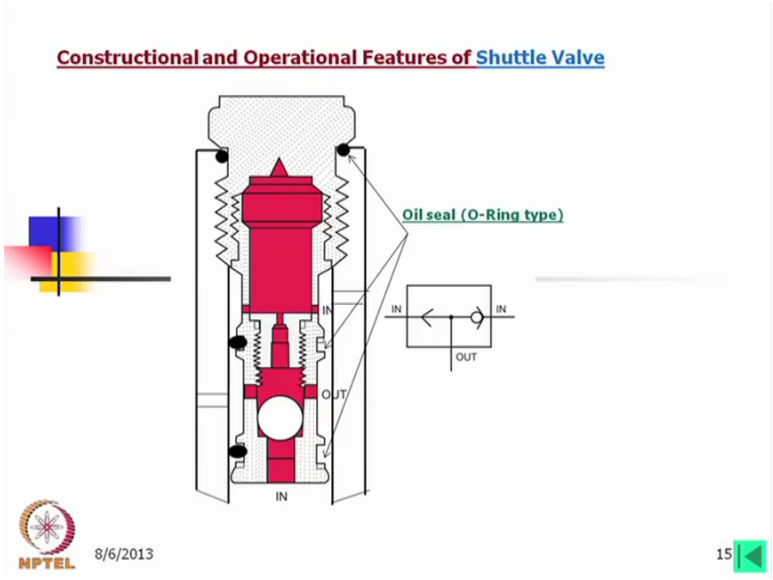

Now here are we are discussing some other valve also. This is constructional and operational feature of shuttle valve. If you remember this is the shuttle valve. What is the shuttle valve? In that case there are 2 inlets, one inlet here and another inlet here. Now whatever may be the inlet outlet is always through this. Now suppose there is a flow then simply this valve will go here and oil will go through this and it will go to the main system or may be to the drain.

Suppose oil is coming through this point then this will be closed and oil will go out through this one. Now question is that if the oil in from the both side then what will happen? Then probably depending on the flow this valve may not seat on any side and all the oil will go out. So depending on the applications this shuttle valve is used in the circuit.

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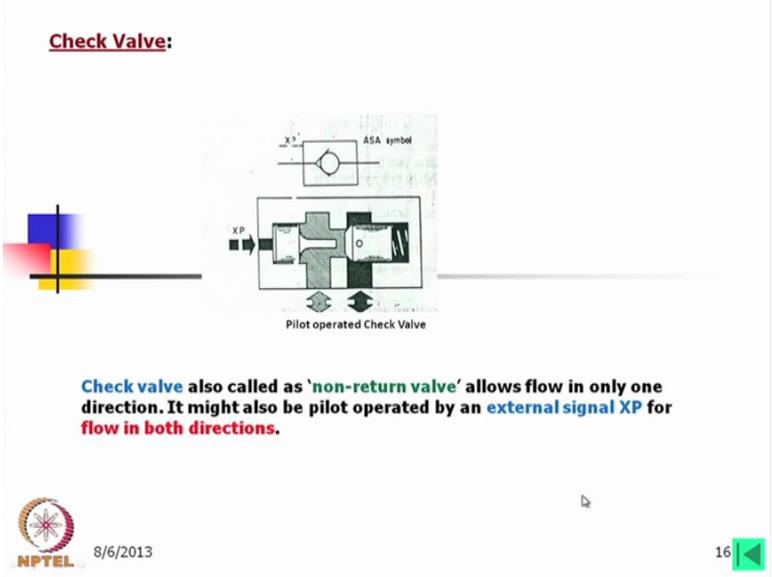

Now check valve. Check valve already I have described. Now here a simple mechanism is there. This is the main poppet of the check valve. So flow can go like this , this means if the flow is going like this then oil will go, it will not be able to go in any directions whereas, if the oil is going from this then it can blow this one and this oil will go out. Now check valve is also called non-return valve allows the flow in only one directions, it might also be pilot operated by an external signal XP for flow in both directions. Now suppose if we use a signal like this then we can allow the flow from this side also. This is completely from external operations. Here the symbol is this one. So if the flow is from this side then this will be operated, then flow can go from either side otherwise flow only can go from this to this side and when the flow is coming from this side, it will remain closed.

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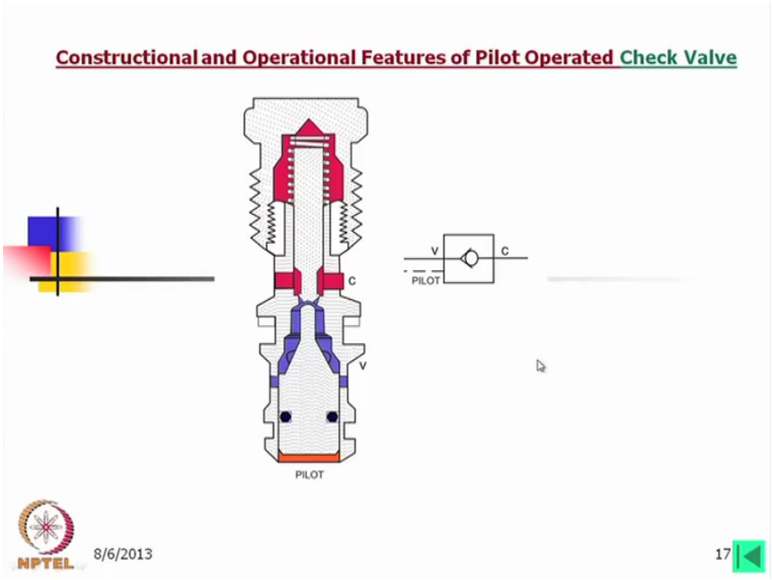

Now this is constructional operational features of a pilot operated check valve. Now in the case this is which I have described. The same thing in a colored figure as you see that oil is going through this and when it is going through, it can blow and it can go to the tank, but if the oil is coming from this side, it cannot go to the other side and the symbol is like this.

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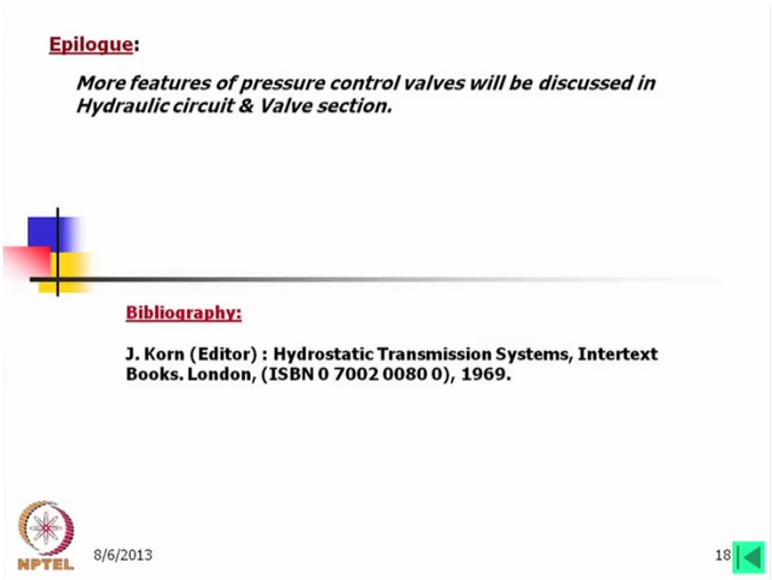

Now more features of pressure control valves will be discuss in hydraulic circuit and valve section. Only with the applications we will be able to understand the working principle of valves and that will be discussed with the different circuit. Now this portion I have taken mainly from a book named hydrostatic transmission systems and this is edited by J. Korn. So thank you.