Automation in Manufacturing
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Week – 10
Control valves and graphical representation
Lecture – 03
Graphical representation of hydraulic system elements

I welcome you all to the lecture 3 of week 10. In week 10 we are studying various control valves and the Graphical representation. In this lecture, we will have a elaborate discussion on the graphical representation of various elements, which are used in a typical hydraulic system.

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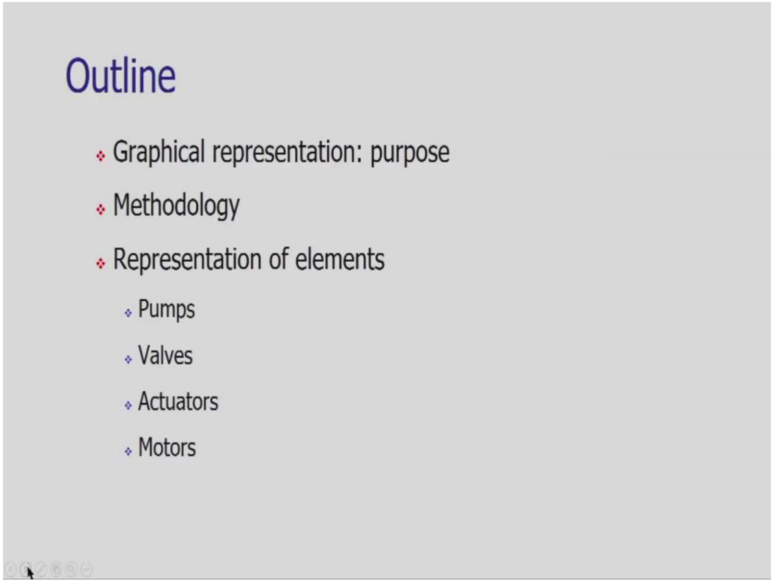

Let us look at the outline of the lecture. At start of the lecture we will have a discussion on the purpose, why it is needed to have the graphical representation? What is the methodology of representing a hydraulic system by using variety of elements? There are lot of elements we have seen till now and we will see how to represent them in a proper way in a standard way. These elements are pumps, valves, actuators and motors. Let us begin the lecture 3 of week 10.

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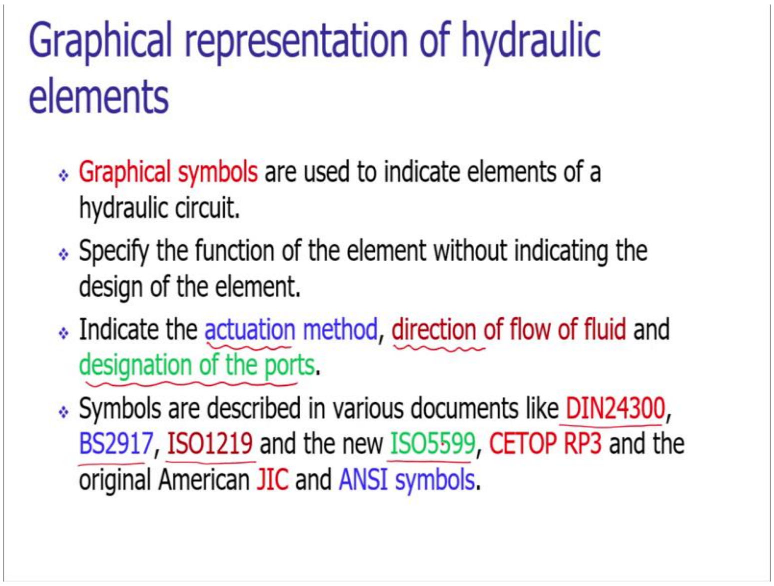

Till now we have seen various elements of hydraulic system. We have seen pumps, we have seen various valves, we have seen the variety of actuators, such as the hydraulic cylinders, piston cylinder arrangements. The valves, the actuators, pumps, and electric motors, they do combine and give us a hydraulic power pack. Such hydraulic power packs are used in the industry for variety of applications.

In a typical automation industry, there may be many applications of hydraulic system and they are integrated to each other. Some of the applications are interdependent. When we design a hydraulic system, we have to first select the appropriate elements for the hydraulic system then we have to assemble them together.

During the process of selection and assembly, we have to communicate the hydraulic circuits, which are designed by the designer to the process planner or the purchase engineer. And it is also to be communicated to the shop floor engineers those who are doing the actual assembly operation.

In this process, there is lot of communication that to be carried out. And as we have seen the construction of the hydraulic elements is very complex. The valves are complicated and some of the valves they do have the similar construction. There may be chances of having the ambiguity, there may be chances of having the confusion during the communication based on the actual figure, the real picture of the drawing. It is very tedious; it is very cumbersome for communication with this.

Therefore, the graphical representation of these elements have been developed for the simplification, for the ease in communication of the complicated hydraulic circuits. The graphical representation is also very much helpful for the comprehension of the hydraulic circuit, for the better understanding of the hydraulic circuit.

Based upon the graphical representation various drawings can be created various circuits can be created, which are very similar to the electrical circuits or the mechanical circuits, or mechanical systems.

The graphical symbols are thus used to indicate the various elements that are used in a hydraulic circuit. The primary function of the graphical symbol is to specify the function of that element. The primary purpose of representing the elements graphically is to specify the function of the element without indicating the design of the element, without indicating the physical appearance or the internal construction of that hydraulic system element.

However, these graphical symbols or graphical representation should indicate the actuation method. What kind of actuation method is being applied? Is it the mechanical actuation, or pneumatic actuation, or pilot actuation, hydraulic actuation, or electromechanical actuation? The graphical symbols should represent the direction of flow of fluid which is very essential. Otherwise, it is meaningless to just put the symbols in the circuitry without giving the direction of the flow of fluid.

The designation of the ports: we have seen various types of external openings are there to the valves and these ports are to be designated. Tthis may be the pressure port or the application port or they may be the tank port or the sub port. To standardize this communication, to standardize the convention of providing the graphical symbols, various guidelines are available.

And, these guidelines can be seen on your screen. These are DIN24300, BS2917, ISO1219, the newer guideline or newer standard is the ISO5599 and many such standards are available. These standards are being employed by these standards are being practiced by the practicing engineers in the industry.

Therefore, it is very much essential for the budding engineers for the students of the automation engineering or the manufacturing engineering should know how to represent properly a typical hydraulic element.

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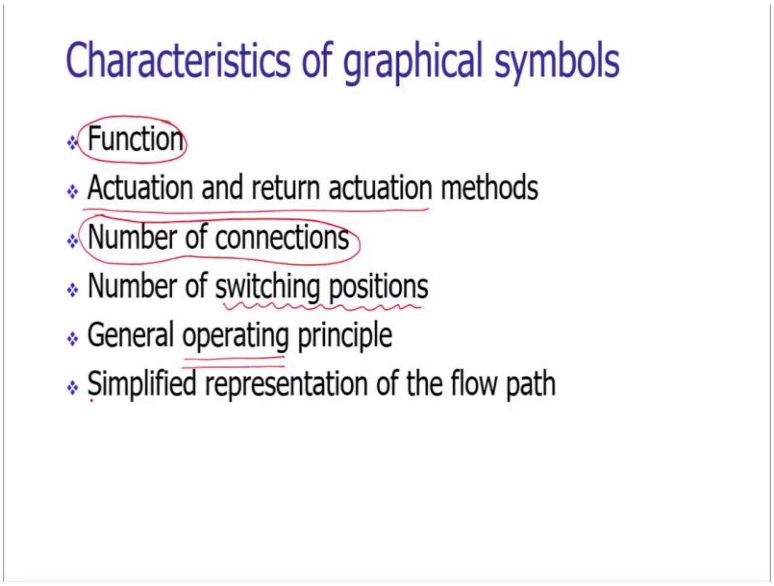

What characteristics of the graphical symbols? The characteristics are as follows. The graphical symbols are designating they are defining the function of the element; they are defining the actuation and the written method. The symbols are providing the information about the number of connections to that to a particular element or to a particular hydraulic system. The symbols are also providing the information about the switching positions. How many positions are there?

It may be a two position valve, or it may be three position or the four position valve, based upon this we can you know communicate in a better way about the operation of the hydraulic system. The graphical symbols are also providing information about the operating principle of that element.

Overall we can say that the graphical symbols are providing the simplified representation of flow of path of the fluid. It may be hydraulic fluid or it may be the compressed air in pneumatic systems.

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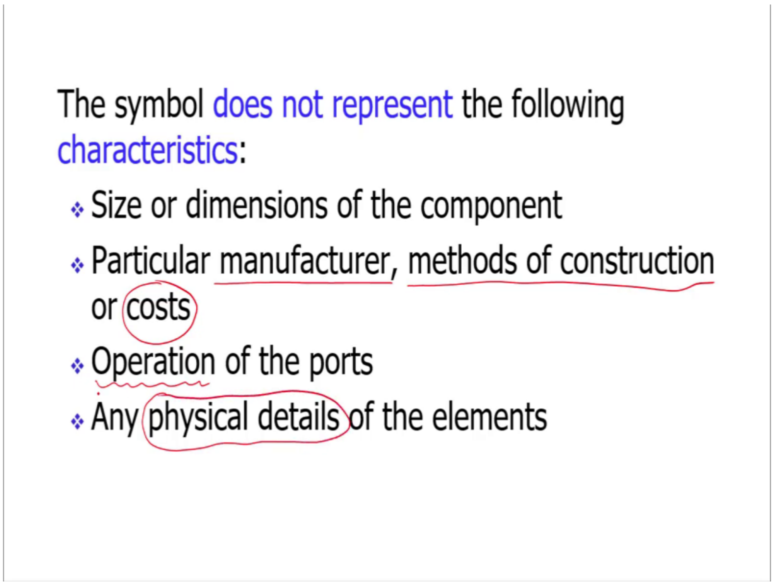

But, what it is not indicating? What the symbols are not representing? These characteristics are the size and dimensions of the component. The sizes may be very large or very small, huge sizes of the components such as the motors, tanks or piston, cylinder, arrangement to draw them on the paper it is very difficult.

The size and the dimensions are not being represented on the paper or in the digital drawings, which we are using commonly nowadays. The graphical representation does not provide the information about the manufacturer or the method of construction of the element.

It also does not indicate the cost of that particular element, it also not representing the operation of the port. The internal construction of the port or the internal operation of the port is also not been communicated by the symbols. Any physical details about the element is not specified in the symbol.

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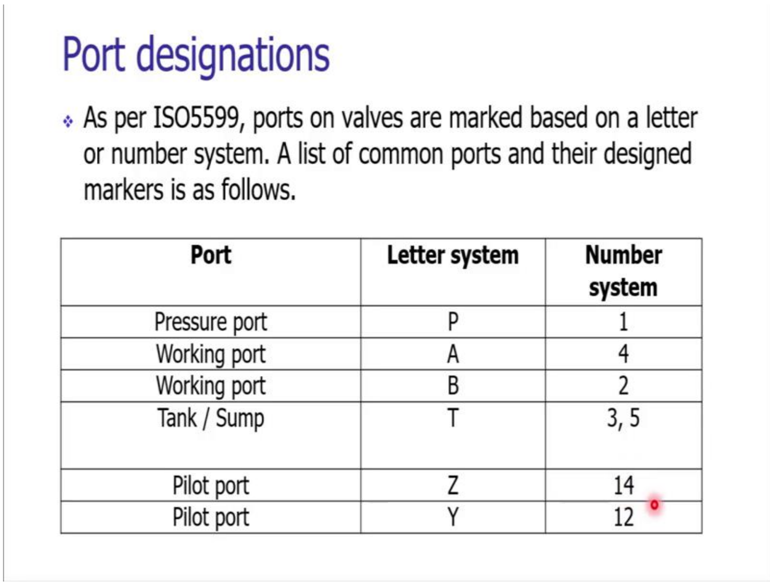

Now, let us look at what are the port designations as per the ISO5599. On our screen we can see the various ports that are used in a typical hydraulic system. As per ISO5599 or as per the various designation systems, we can use a letter or we can use the numbers as well.

Particularly the ISO5599 is providing the facility to designate the ports by using the numbers, or in general we are using the letters such as the letter P for the pressure port or the power port or you can call that as the pump port as well. However, in number system number 1 has been designated to the pressure port, there are various working ports which we have seen.

Working ports are the actuation ports. The port A is connected to the extension requirement of the piston cylinder arrangement and B may be connected for the retraction or the contraction of the piston cylinder arrangement. The number 4 is assigned to port A, number 2 is assigned to port B.

We have seen in our previous slides that the tank or the sump is the integral part of a hydraulic power pack. To designate the tank or the sump the letter T is used and in number system it may be 3 or 5. We are using the external fluid; we are using external air, compressed air, to actuate the valves, to operate the valves. These are called as the pilot ports. Pilot ports are designated by using the letters Z or Y or X and the numbers can be seen on our screen.

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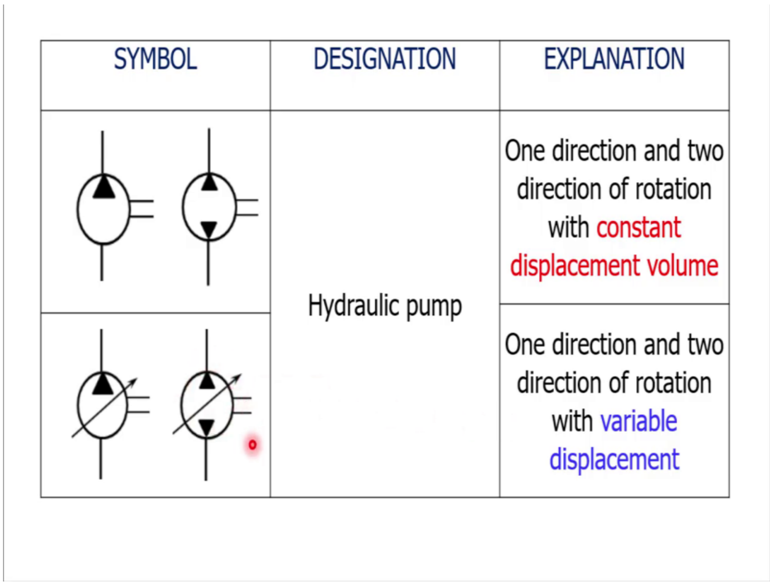

The hydraulic pump is basically designated by using a circle and that circle is having a filled in triangle. The triangle in this format which is filled in that is designating the hydraulic pump.

When only one triangle is provided the meaning is that, this is the one direction pump, when 2 triangles are provided in opposite direction that is the meaning is that it is a 2 direction of the pump. With two parallel lines is designating that the displacement volume is constant, with constant displacement volume the pump is working.

But, many pumps are having the variable displacement. The displacement is changing as per the requirement. To represent that variable displacement, we are using an arrow, the arrow is placed in this format as the arrow is there we can easily say that the pump which is represented is having the variable displacement.

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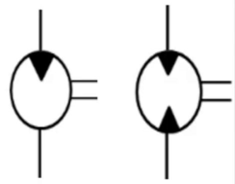
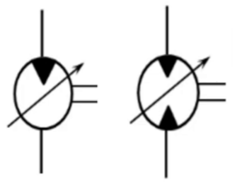
Rotary actuators

SYMBOL	DESIGNATION	EXPLANATION
	Hydraulic motor	One direction and two direction of rotation with constant displacement volume
		One direction and two direction of rotation with variable displacement

We can use the representation for the actuators as well and the hydraulic motor is a rotary actuator. The hydraulic motor is working on the principle that we are using the hydraulic energy and that hydraulic energy will be converted into the rotational energy. And that rotational energy or rotational moment will be utilized for our intended application.

The hydraulic motor is also represented by circle, it is also having a triangle, but the, but the orientation of the triangle is exactly opposite to the orientation of triangle that we have seen for the hydraulic pump, the triangle is filled in triangle. When only one triangle is represented the meaning is that the motor is allowing to have only one direction of the rotation.

The two parallel lines are designating the constant displacement volume. If we are using two filled in triangles for the hydraulic motor; that means, it is providing us the two way direction or the rotation. And, the two parallel lines for the second schematic representation is giving us the information that, it is also the constant displacement volume hydraulic motor.

Similar to hydraulic pump, if we want to have the variable displacement that to be accommodated a variable displacement that to be provided, then we are, then we are putting an arrow as you can see on your screen. The meaning of the arrow is that the motor is working with the variable displacement.

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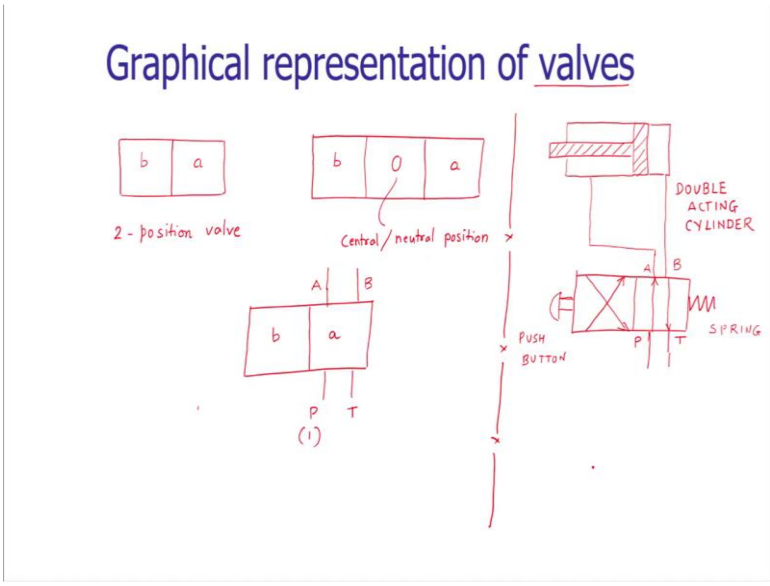

Now, let us study how to represent a typical valve. A valve is represented by a square for each of its switching positions. A typical two position valve can be represented by using 2 squares, now let us draw the 2 squares. This is position b and position a. This is 2-position valve. We can have a 3-position valve as well for that purpose we may need to utilize 3 squares.

So, this is position b, position a, and the O position. O is basically used to designate the central or the neutral position. O is the central or we can call this as the neutral position. Now to these positions, we are adding the ports, we are adding the actuation information.

Let us see, if we are having a typical now here we are designating the ports. Consider these two position valve is having the 4 ports. The port P is designated the pressure port, the port T is designated the tank port and it is having two application ports A and B.

The vertical lines outside the square are representing the ports and the letters or the numbers, which are designated here are representing the ports. The P is 1. Now, if these positions are also to be added the information about the actuation. Now, let us understand how to represent, how to designate the valves.

Now to understand the graphical representation of valves, let us take an example how to control the moments of a double acting cylinder. Let us consider a double acting cylinder and we have to control its operation by using a valve. To communicate this information to the shop floor how we will carry out the representation.

The double acting cylinder is represented by using a simple T that is the piston, which is located inside a cylinder. Now to actuate this, we are applying the fluid energy at the top center, the there would be extension of the cylinder the piston will come out. And, the pressurized fluid which is at the rod side that to be moved to the tank.

Now, in the next position we need to have an arrangement, which is making us possible for the retraction of the cylinder. For that purpose, we have to have the pressurized fluid flow at the rod side and so that the cylinder will get retracted, but the pressurized fluid which is there at the top side that to be taken to the tank side. For that purpose, we need a valve, so we need the 2-position that is the extension position and the retraction position.

Let us draw a 2-position valve, we need to have a 2-position valve. Now, the normal position we are considering here is the contraction or the retraction of the cylinder. The retraction of the cylinder as mentioned, that we have to have the pressurized fluid a at the rod side.

Let us connect this to the rod side. The valve should have a application port A, which is connected to the rod side. Let us draw this as port A which is connected to the rod side and we are having, another purpose that is the discharge of the pressurized fluid at the top of the piston, that to be taken out to the tank.

For that purpose, we need to have another port, this is another port, that is needed and this is the port B. Port A for application of the pressurized fluid at the rod side and port B is to take the fluid back to the tank. To provide the pressurized fluid we need a pressure port that is P and to take the pressurized fluid from the piston cylinder arrangement back to the tank we need a port T.

Now, for this position we have to designate the direction of fluid flow as well. Here we are representing as per the convention, the number of positions are shown, the number of ports are shown the connections are drawn, but we have to show the direction of fluid flow.

For this position the direction of fluid flow is from P to A. Let us draw P to A, and the fluid is getting to the tank from B to T, but the valve is operating on what actuation? This particular position has been maintained by a spring. Spring is designated by using a zigzag line.

These zigzag lines are representing the spring. The spring is controlling this particular position. This is the normal position of this particular valve. Now, as mentioned I have to now extend the piston cylinder arrangement, I have to extend the cylinder. For that purpose, we need to provide the pressurized fluid from P to B and I have to get back pressurized fluid from the rod side to the tank.

The connection are now to be from P to B and A to T. Thus the initial position will now be changed to the next position. In the next position P is to be connected to B and the A is to be connected to P. In this case we are not rewriting the A B, P T for the next position, it is understood that this point is P, this point is T, this port is A, this port is B. Only, we are providing the direction of movement of the fluid for the next position.

But, we need to provide how this position is getting achieved? How this position is getting actuated? For that purpose, consider if we are using a push button. When we apply the energy, when we apply the force at the push button, the position from the spring operated port connection to the opposite connections will be achieved.

When somebody will look at and will try to comprehend this particular circuitry simple circuitry, then it is very easy to understand that the valve is having 2-positions, it is having 4 number of ports. The default position is P to A and B to T that is the contraction of the double acting cylinder and that is controlled by using a spring.

To change the position or to change the connections of the ports we are using a push button arrangement as we actuate, as we push the button here the connections are getting in a opposite direction. The P is getting connected to B and A will get connected to T. In this way by drawing simple graphical representation we can communicate very complex phenomena, very complex operations of the hydraulic systems.

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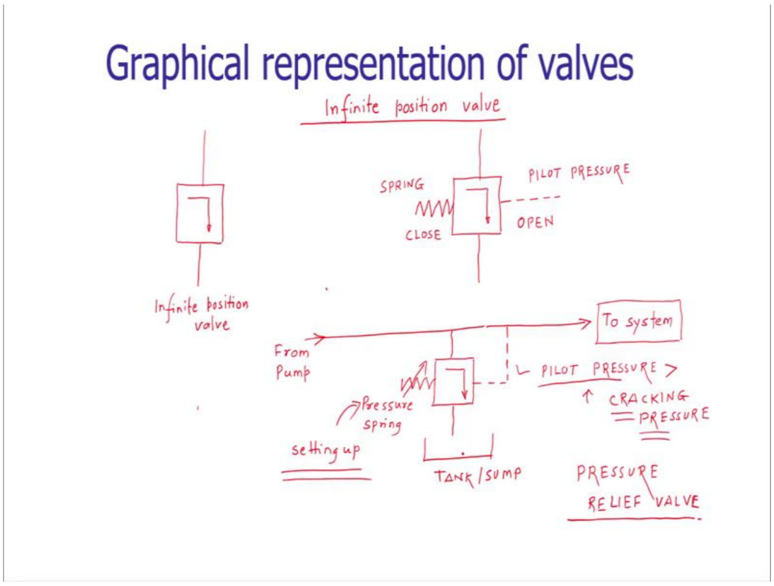

Now, let us see how can we represent the in finite position valve. Infinite position valve is nothing but a valve which is providing a number of position. In general as we have seen that the valves are providing only 2 or 3 the finite number of position, in this case it is providing the infinite number of position so we have to just operate the valve, we have to operate the stem of the valve and we can have a variety of positions.

That infinite number of position valve can be designated by using a simple square and in that square we are using an arrow. This is the arrow which is placed in the square and it is showing the line of application of the fluid. This is the simple designation of the in finite position valve.

Now, if we want to put the actuation symbols with actuating symbols or with actuation symbols, it can be designated as the square with the arrow the line of fluid flow and now we have to put the actuation. Normally, the infinite position valve is closed and that the closed position is being controlled by a spring.

To open this particular valve, we are using a pilot pressure. To designate the actuation by pilot pressure we are using the dotted lines, a pilot pressure is applied and when the pilot pressure or the external pressure is applied, the valve is getting open; opening of the valve due to the pilot pressure. Now, let us see how it is working in the practice to understand that, let us draw a flow line.

Here we are getting the pressurized fluid from pump and it is going to the system to the load or to the application. Inside this line we are using this infinite position valve. We have taken a branch of the fluid and that branch of the fluid is passed through this valve.

As we know that the normal position of the valve is closed due to the spring. The pressure is applied by the spring, but when the system pressure is increased, the load is very high is it is blocked, there is no need of the pressurized fluid from the pump continuously to the system it is not essential.

Already the load, already the pressure at the system is very high. Due to the increase in pressure at the application at the load at the system, we need to now relieve the pressure, we have to reduce the pressure of this particular flow line. To carry out this we are using a pilot pressure which is part of the system pressure itself. We are getting a branch of flow line from the system and that is connected to the valve itself. This dotted line is the pilot pressure and that pilot pressure is part of the system itself.

Now, when this pilot pressure is more than the cracking pressure of the valve? When the pilot pressure is more than the cracking pressure the valve will get open and after opening up that valve, it will pass that excessive pressurized fluid to the tank or the sump.

How to decide the cracking pressure? Now, how to provide the cracking pressures for that purpose we have to use the screw. The screw based arrangement is utilized and that has been shown by using an arrow which is put over the spring.

Meaning of that arrow over the spring is that we are setting the pressure. We can set the pressure here, setting up of the pressure by using the screw arrangement. In this way, a simple in finite position valve is converted into a pressure relief valve. By default it is closed the pressure of the spring has been set up by a screw, when the system pressure is more, when the load pressure is more.

And we have to safeguard the entire system from the damage we are using the pilot pressure, branch of the pressure, branch of the flow line from the system itself, which is operating the valve and as the pilot pressure is more than the cracking pressure of the valve the valve will get open and it will send that fluid to the tank.

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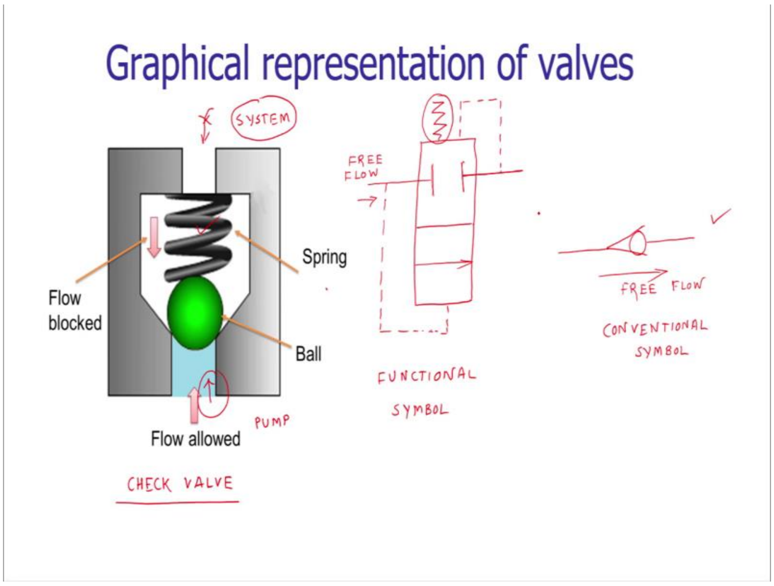

Let us draw the graphical representation of the check valve. Very useful element of hydraulic power pack that is check valve. We have seen the working of the check valve in our previous lecture itself. The check valve is having a ball and a spring arrangement and it is not allowing the fluid in one of the directions, but when the applied pressure is more than the cracking pressure of the spring, then the fluid will be allowed to pass from the other direction.

In this case the fluid is passed or it is allowed to pass from the pump to the application line, but it is not allowed to pass from the application line to the pump. This is the pump port and this is the system now to show the operation of this valve, let us draw 2 squares. At normal position the flow is blocked. Let us consider the flow is there inside the valve, but it is blocked. There is no pressurized fluid passing through the valve at it is default position.

The free flow is from left to right; however, it is blocked. And, then blocking is due to the spring. Due to the spring we are blocking the flow of fluid, it is not only the spring, it is due to the system pressure itself. The system is applying the pressure on this side due to that as well there is blocking. To designate that system pressure we are showing the dotted lines.

This is the default position of the check valve, but when the inlet pressure is more than the cracking pressure. Let us consider a branch of the free flow is used as an actuation element itself. When the inlet pressure which is designated by using a dotted line.

If this inlet pressure is more than the cracking pressure, is more than the spring pressure here, then there is flow of fluid is possible from the direction shown over here. From left to right, the flow of fluid is possible when the inlet pressure is more than the cracking pressure.

In this way the check valve has been represented. Though the construction of the check valve is very simple it is operation is also very simple, but the representation is very complex. In conventional way, we are representing this flow valve by using an arrow and a circle and there is the flow line. In this way, conventionally we are representing the check valve. This is the functional symbol, this is functional symbol and this is the conventional symbol.

It is very tedious every now and then to you use such a complex representation in the hydraulic circuit, it will consume lot of space and it will it may lead to the confusion as well. Therefore, we are using a simplified representation in this way. This arrowed designates that there is a blockage and on left to right side the flow is allowed. This is the free flow is from left to right is allowed. However, from right to left the flow is blocked.

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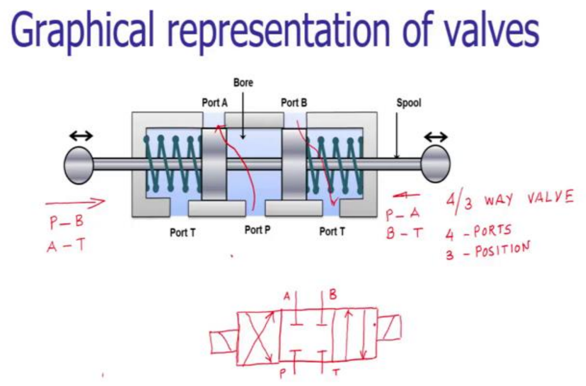

One more example, we will study for the representation of the valves. On our screen, we can see a 4/3 way valve. We have seen the meaning of the 4/3 way valve in our previous class. It is having 4-ports, there are 4-ports and 3-positions.

The default position is seen on our screen that is the blocking i.e. the holding position. The port A is blocked the port B is also blocked and they are at hold position. Port T there is no fluid is coming to the port T the port through port P through pressure port as well no fluid is going to the port T and port A and B.

By default or the center position is the hold position or the neutral position is the hold position. Here we are having the 2 ports. These are the 2 ports which are blocked port A and port B both of them are blocked from port P there is no fluid is going. We can consider this also a block in block position port P and the tank is also in a block position. But let us consider that when we you know give the movement from right towards the left. What will happen?

Say, if we move the spool from right to left, we are changing the position of the spool. Let us add the square. If we change the position of the spool from right to the left, what will happen? When the spool is moving from right to left port P will be connected to port A and port B will connect to tank port T. P is giving the pressurized fluid to port A and the pressurized fluid from B is coming back to T.

Here what is happening? P is connected to A and B will be connected to the T. For the first position, I can draw here the P will be connected to the A. Simply I will just draw an arrow indicating that P is connected to A and B is connected to T. This is consider we are giving spool movement from left to right.

When we are giving the movement from left to right we are having one more position here. Tto draw that we are using one more square. Now, when we are pushing the spool from left to right power port will be connected to B and application port A will connected to port tank T.

Here P will be connected to application port B and A will be connected to the tank port T P to B. P to B just draw right and from A to T, A to T. This is the representation of 4/3 way valve. Now, here we can add the actuation. Now, let us consider that the valve movements are actuated by the solenoid. By using the solenoid, we are actuating the valves.

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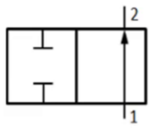
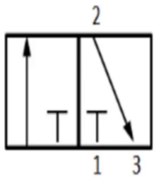
Direction control valves (DCVs)

SYMBOL	DESIGNATION	EXPLANATION
	2/2 way valve	Two closed ports in the closed neutral position and flow during actuated position
	3/2 way valve	In the first position flow takes place to the cylinder In the second position flow takes out of the cylinder to the tank (Single acting cylinder)

I in a similar way we can now represent various DCVs that is the directional control valve, on your screen you can see a 2/2 way valve. It is having 2 positions and there are 2 ports. By default it is blocked. When we are actuating the port 1 is getting connected to the port 2. It is a 2 closed ports in the neutral position and the flow will occur when we are actuating the valve.

Similarly, we can have the representation of 3/2 way valve. Here the 3 means number of ports are 3 so 1 2 3 number of ports and there are 2 positions position number 1 and position number 2. In the first position the flow is taking place to the cylinder now flow is taking place to the cylinder.

From port 1 i.e. pressure port it is giving to the piston cylinder arrangement and the tank port is blocked. In the second position the flow is taking place from the cylinder back to the tank. This is in general the working of a single acting cylinder by using the 3/2 way valve, 3 ports 2 position way valve.

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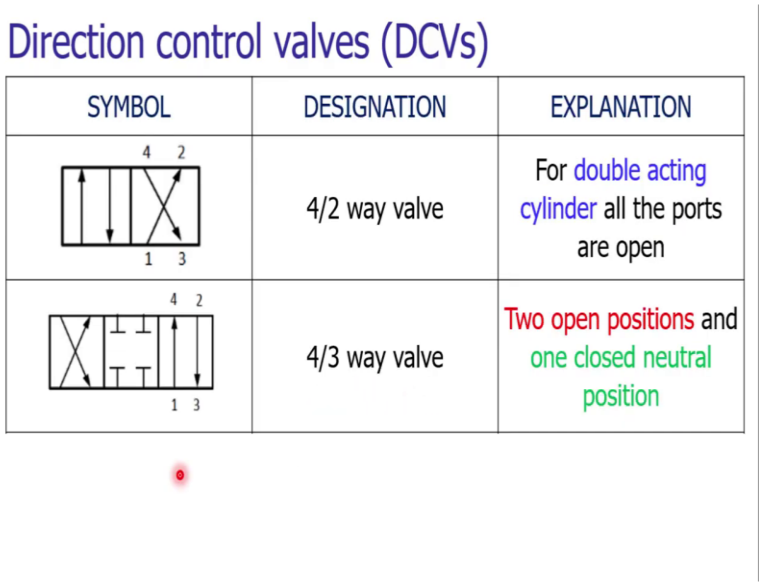

We can have the understanding of the 4/2 way valve, we just observe the 4/ 2 way valve, so the 4 is the number of ports and 2 is number of positions. Port 1, port 2, port 3 and port 4. Port 1 is the pressure port, port 3 is the tank port, 2 and 4 are the application ports. 4/2 way valve is generally used to actuate the double acting cylinder, by default or the neutral position is allowing the ports that are open. 1 is connected to 4 and 2 is connected to 3.

We are allowing the pressurized fluid that to flow inside the double acting cylinder from the rod side end, the fluid is coming back to the tank. When we actuate this valve, the connections are getting reverse. 1 is getting connected to 2 and 4 is connected to 3. In similar way we can also have a 4/3 way valve which we have already seen, in our previous slide so the designation can be seen on your screen. There are two open positions, one closed neutral position.

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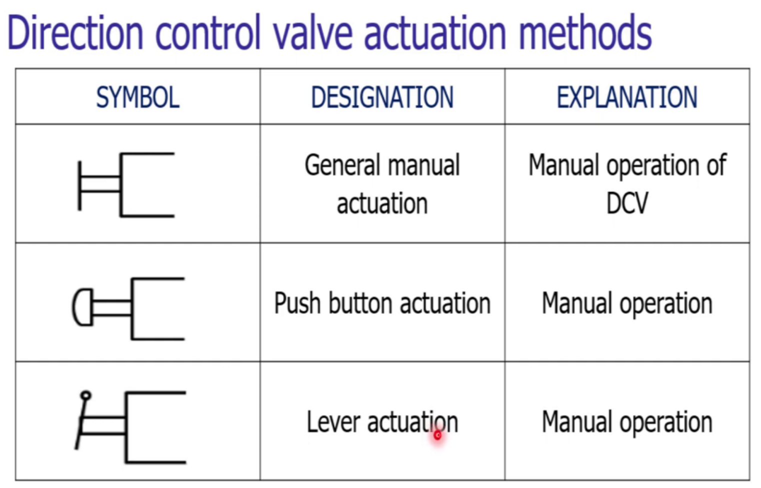

There are various ways to represent the actuation methods. Nnow consider a manual actuation method. If we want to control the valve by using the manual actuation, we are using a simple symbol. The symbol is having 2 parallel lines and a vertical line. That is designating is a manually operated.

If we are using these kind of arrangement, it is called as the push button actuation. When we want to give the push button. We are using a semi-circular representation with 2 parallel lines a bar and a push button, a button which is attached to the bar. When we are trying to represent the lever? Now, we are using a little inclined line with a circle to represent the lever based actuation.

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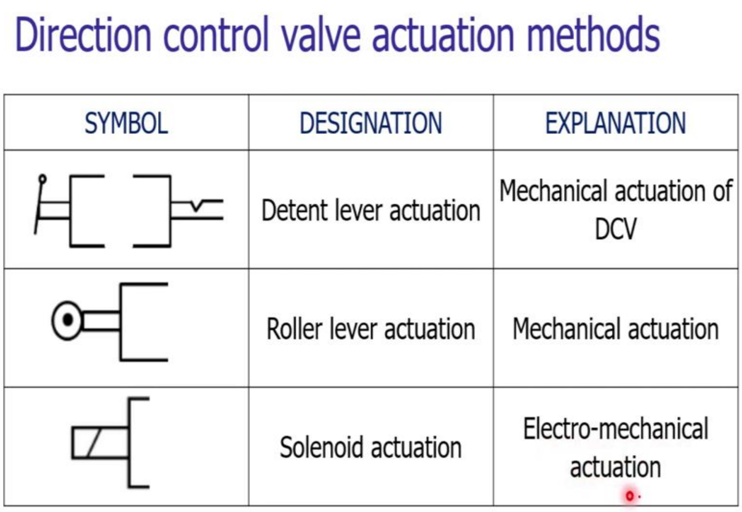

Direction control valve actuation methods

SYMBOL	DESIGNATION	EXPLANATION
	Detent lever actuation	Mechanical actuation of DCV
	Roller lever actuation	Mechanical actuation
	Solenoid actuation	Electro-mechanical actuation

The mechanical actuations can be represented as like the detent lever actuation. Detent is the locking mechanism. By the detent we can have the facility to hold the position of the valve, for that purpose a detent is the mechanical element which is having the various the slots. And, that slots are utilized to lock the valve in its intended position.

We can have the roller lever actuation. The roller lever can be represented by a circle with concentric field in circle, this is representing the solenoid actuation. This solenoid actuation, we are using a rectangle and an inclined line the solenoid actuation as we know that it is the electromechanical actuation.

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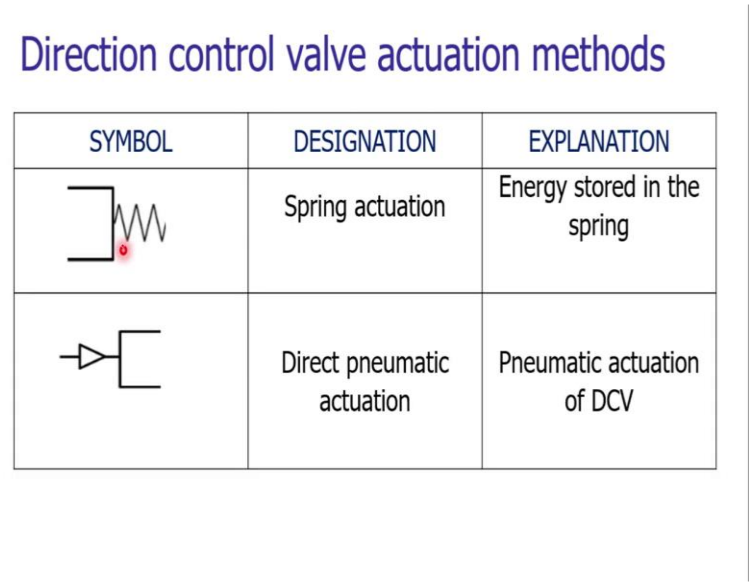

Direction control valve actuation methods

SYMBOL	DESIGNATION	EXPLANATION
	Spring actuation	Energy stored in the spring
	Direct pneumatic actuation	Pneumatic actuation of DCV

The springs are represented by using a zigzag line and we can also utilize the pneumatic based actuation. When we are using now compressed air to operate the valves we are using an arrow which is not filled in arrow. Empty arrow and that is designating the direct pneumatic actuation.

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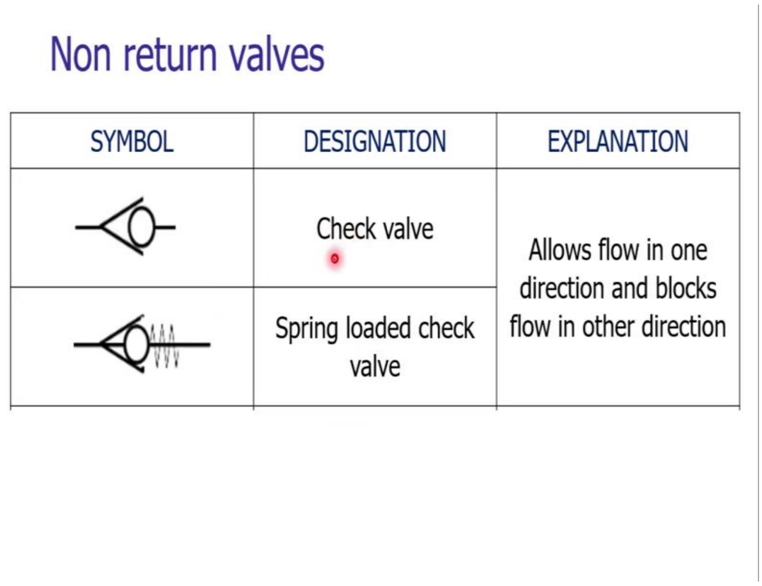

Non return valves

SYMBOL	DESIGNATION	EXPLANATION
	Check valve	Allows flow in one direction and blocks flow in other direction
	Spring loaded check valve	

The check valve is represented by using this symbol, already we have seen the meaning of this symbol and how it has been derived? The check valve is allowing the flow in only one direction and it is blocking the flow in the other direction. We can have the spring loaded check valve as well. When the check valve is spring loaded we are using a zigzag line, as shown on the slide.

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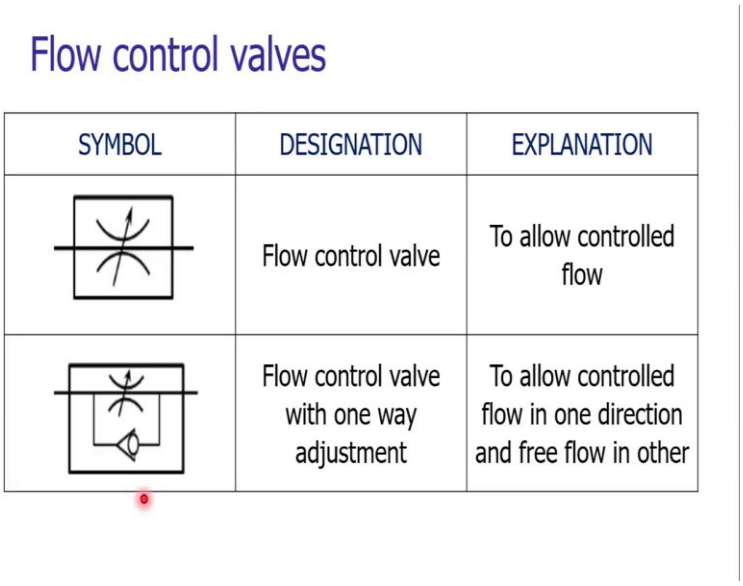

Flow control valves

SYMBOL	DESIGNATION	EXPLANATION
	Flow control valve	To allow controlled flow
	Flow control valve with one way adjustment	To allow controlled flow in one direction and free flow in other

The flow control valve can be represented by using a rectangle and there are two curves, you know these two curves are represented in this way and it is having an arrow. Arrow is representing the variable displacement, the variable flow of the fluid through the flow control valve. The flow control valve with one-way adjustment can be shown by using the diagram on your screen. Here we are having two arcs which are represented in this way and an arrow and there is a check valve.

What is the meaning of with one-way adjustment? It is allowing the controlled flow in one direction and the free flow in other direction. It is allowing the flow of the fluid in a free way from left to right through the check valve, against the spring pressure in this direction and in the reverse way the flow control valve is taking care.

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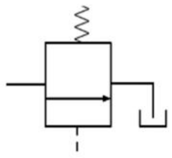
Pressure control valves

SYMBOL	DESIGNATION	EXPLANATION
	Unloading valve	Allows pump to build pressure to an adjustable pressure setting and then allow it to be discharged to tank

The unloading valve which we have seen in our previous lecture can be represented by using a square and a fluid flow line by default the unloading valve is closed. Now the closed valve due to the spring action is represented by a spring a zigzag line over here.

When the external pressure we are applying, external fluid pressure or the pilot pressure is applied to safeguard the system, then the valve will open and it will allow the pressurized fluid the excess pressurized fluid to pass through the valve and that will send to the tank. In this way, the unloading valve is controlling the pressure and that has been designated by using a simple representation.

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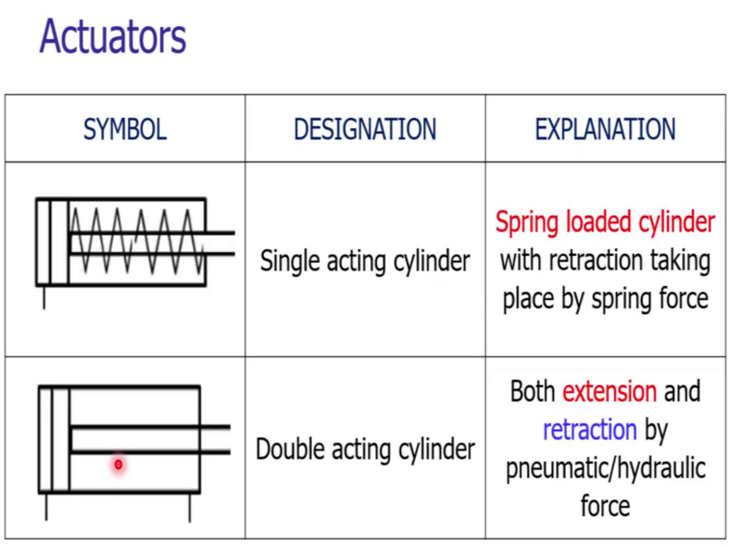

Actuators

SYMBOL	DESIGNATION	EXPLANATION
	Single acting cylinder	Spring loaded cylinder with retraction taking place by spring force
	Double acting cylinder	Both extension and retraction by pneumatic/hydraulic force

The hydraulic actuators such as the single acting cylinder and the double acting cylinder can be seen on your screen. The single acting cylinder can be seen it is having the piston and the rod and the piston are having a spring. When we are applied the hydraulic pressure at the top side of the piston it will be extended, the cylinder will be extended.

However, restoring of the cylinder will be done by the spring force itself. In double acting cylinder we are using 2 ports, in single acting cylinder there is only 1 port. In double acting cylinder as you can notice there is a pressure port at the top side of the piston and there is a 1 more port at the other side of the piston movement.

The double acting cylinder is based upon the extension and retraction both by using the pneumatic or the hydraulic force. However, in the single acting cylinder the retraction by taking place the spring force, but the extension would be carried out by the hydraulic fluid only, the pressurized hydraulic fluid.

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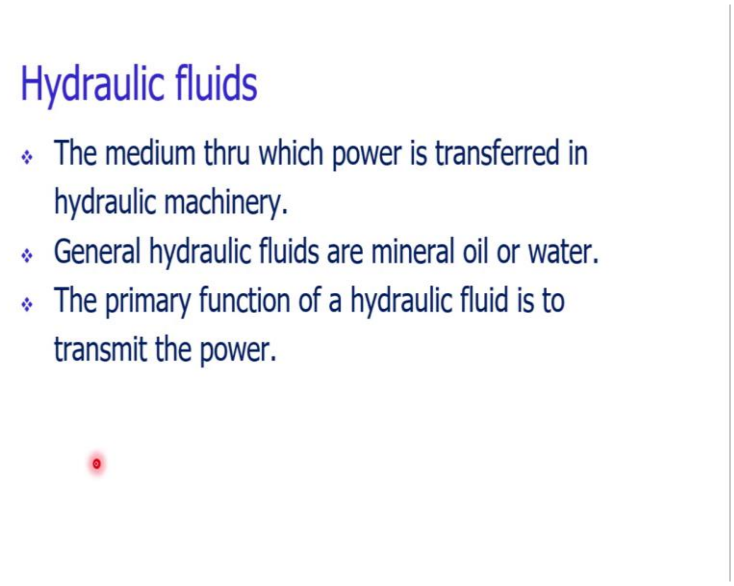

In the industry lot of hydraulic fluids are being utilized. And, as we know that the hydraulic fluid is the medium through which we are transferring the power to the hydraulic machinery. In general water is the best hydraulic fluid, but the flash point of the water is very less. It will get evaporated at a low temperature comparatively low temperature.

Due to the friction inside the system, the system pressure may increase. The temperature will also increase and that may lead to the boiling of the water, which is leading to the cavitation problem and the failure of the device itself. The viscosity of the water is also a concern the viscosity of the water is low so we need a little high viscous fluid.

For that purpose, the mineral oils are the best choice to be used as the hydraulic fluid. The primary function of the hydraulic fluid is to transmit the power; we have to transmit the power from the pump to the designated load or the desired application.

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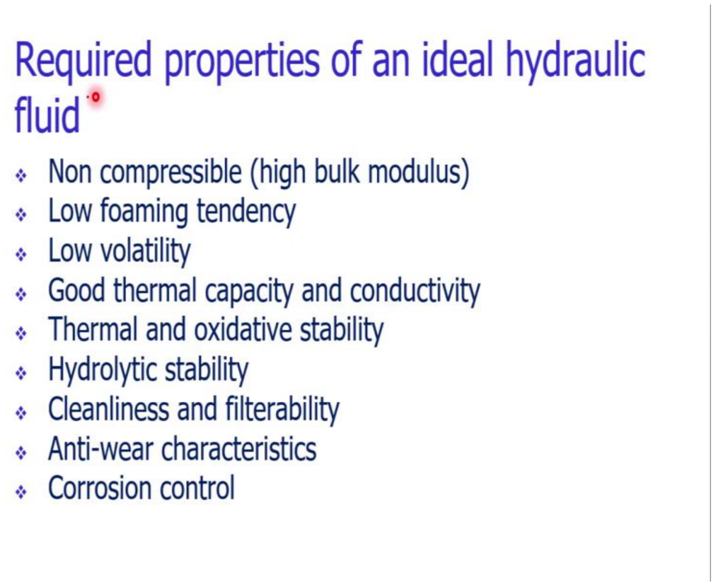

There are certain properties that an ideal hydraulic fluid should have the fundamental properties that, it should be non-compressible it should not compress. That it will intact it will transmit the power efficiently. It should not form any foam during the operation it must be less volatile; the ideal hydraulic fluid should have very good thermal capacity.

The heat capacity should high and it should have good thermal conductivity. If the conductivity is low, it will get heated up and that hot hydraulic fluid will lead to the failure of the system, it will damage the system. The hydraulic fluid should have sufficient thermal and oxidative stability; the fluid should be stable enough. It should have the hydrolytic stability as well the fluid must be clean and it can be easily filtered.

The hydraulic fluid should provide the anti-wear characteristic, it should provide good lubricating characteristic, it should be non-corrosive. Generally, the hydraulic fluids are corroding the mechanical elements the ferrous elements of the system and we need to continuously monitor the condition of the hydraulic elements.

Due to the corrosion the system strength will get reduced and that may lead to the failure of the system. The corrosion is concerned in the hydraulic fluid based stems the hydraulic fluid should provide minimum possible the corrosion inside the system.

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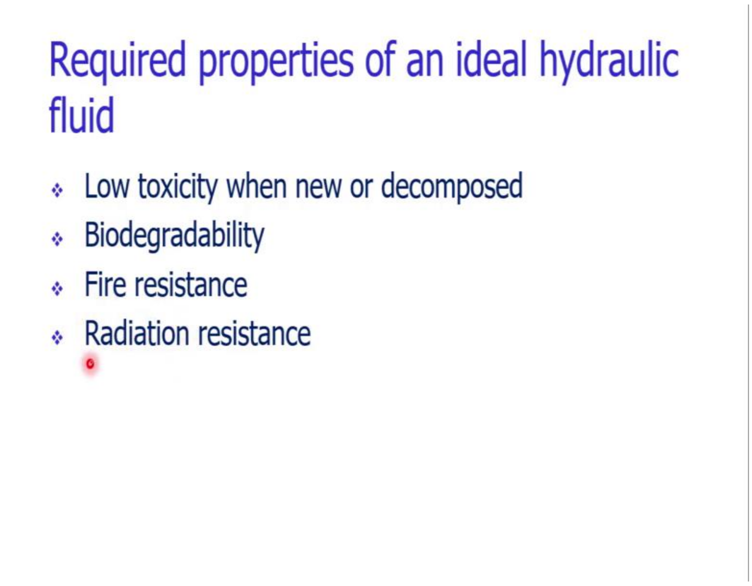

The hydraulic fluid should be low toxic. We are using the hydraulic systems in presence of the human beings, the fluid will be handled by the human beings. It should not harm the health of the human beings it should be less toxic, it can be easily decomposed, if it is a biodegradable that would be the best the hydraulic fluid. It should have the resistance capability to the fire and it should have even the radiation resistance as well.

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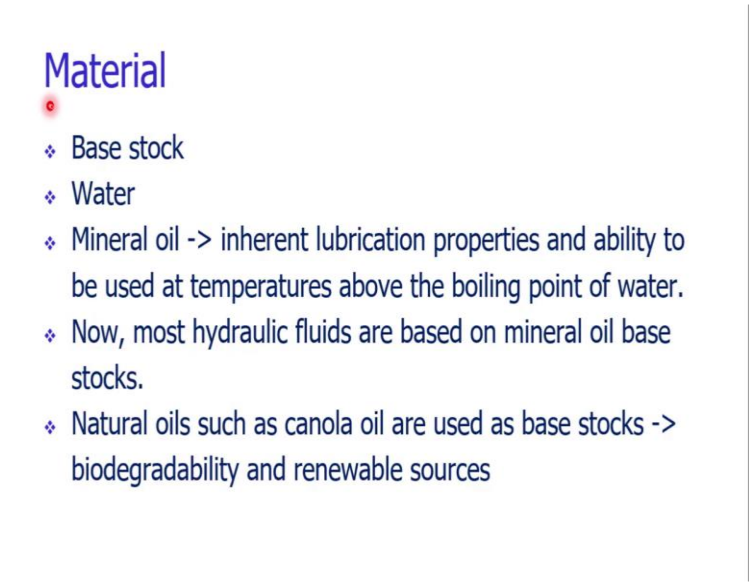

The fluid material, as mentioned, is the water earlier when the hydraulic system started people started using the water, but later they changed the water or they replace the water as base stock to the mineral oil.

The mineral oil is having inherent lubrication properties and we can use the mineral oil at the temperatures above the boiling point of the water. Most of the hydraulic fluids are based on the mineral oil as a base stocks. Natural oils such as the canola oil can also be used as the base stock.

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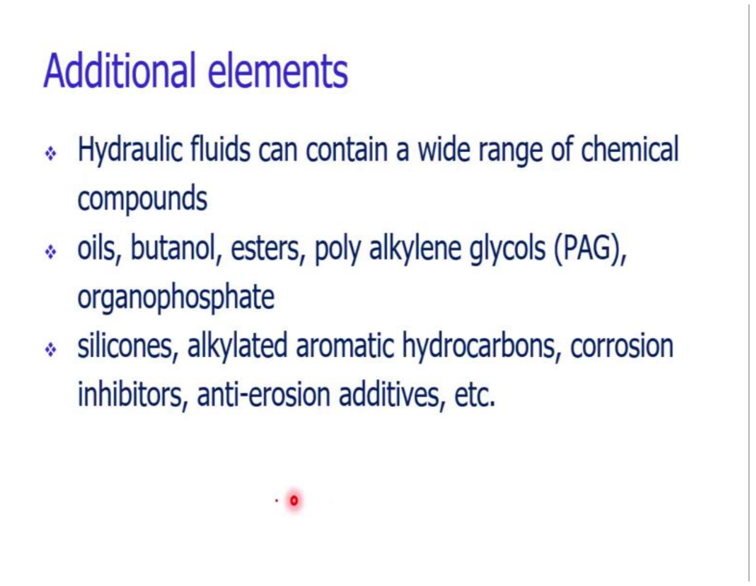

The canola oil or the vegetable oils are having the best characteristics as they are bio degradable to improve the performance of the hydraulic fluids. Certain elements are being added in the hydraulic systems and these contains various chemical compounds.

These are the butanol, esters, poly alkylene glycols and various chemicals are added to get the required properties as I mentioned in the previous slides. Even we are adding the silicones, corrosion inhibitors, anti-erosion additives and many such elements are added to improve the performance of the hydraulic fluid.

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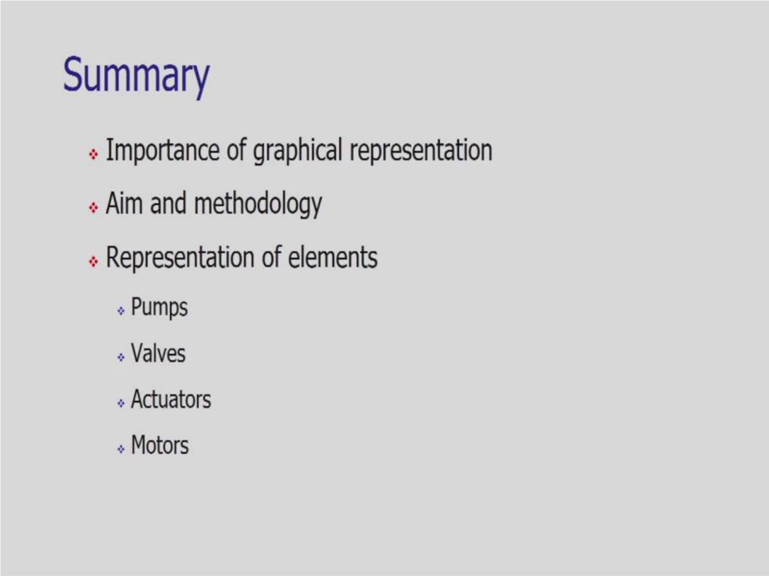

Well let me summarize the lecture 3 of week 10. In this lecture we have seen the graphical representation of variety of elements which are required to build a hydraulic circuitry. We discussed the importance of graphical representation; we have seen what are the aims and methodologies to represent these elements? We have seen typical elements representations such as pumps valves actuators and motors.