

Oil Hydraulics and Pneumatics
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Directional Control Valves

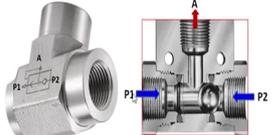
Lecture - 33

Part 2: Construction and Application of Shuttle valves, 2/2 DCV, 3/2 DCV, Quick exhaust valve, Time delay valve

My name is Somashekhar, course faculty for this course.

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Shuttle Valve



- Important Features
- 3 Ports → P₁, P₂ and A
- Ball sliding in a valve body

- Also known as **double check valve** and it is primarily used in a pneumatic device and it is rarely found in hydraulic circuits
- Shuttle valves allow **two alternate flow sources** to be connected to one branch circuit
- So they have **two inlet ports (P₁ and P₂)** and one outlet port (A)
- Outlet A receives the flow either from P₁ or P₂, **whichever inlet is at a higher pressure**
- So it is treated as Logic OR valve (i.e. A will receive the flow either from P₁ or P₂)



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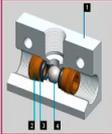
Move on to second category of DCV, shuttle valves. Can you please tell me what are the important features friends here, by seeing the diagram? Can you please, what you have to see in all the valve? You will see in all the valve friend, how many ports are there; how many positions are possible here.

You will see now important features are 3 ports are there. Correct? P 1 port, P 2 port and A port. But the function of P 1 and P 2 is same what you can call the pressure ports. Ball sliding inside the valve body, one ball is there. Based on the pressure, if P 1 is more, it will slide and blocks the P 2. If P 2 is more, ball slides and blocks the P 1 port.

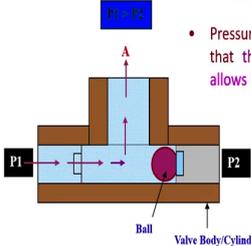
Shuttle valves are also known as double check valve and it is primarily used in pneumatic devices and is rarely found in hydraulic circuit. Shuttle valves allows two alternative flow sources P 1 and P 2 to be connected to one branch circuit A. So, they have two inlet ports P 1 and P 2 and an outlet port A. Outlet A receives the flow either from P 1 or P 2, whichever is at a higher pressure. So, it is treated as a OR valve, Logic OR valve. Because its functionality is similar to logic OR gate; A will receive here, the flow either from P 1 or P 2.

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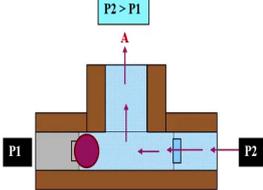
Shuttle Valve



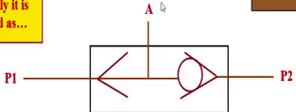
• Pressure P_1 is greater than that of P_2 , so that the ball slides to the right and allows P_1 to send flow to outlet A



• Pressure P_2 is greater than that at $P_1 \rightarrow$ so that the ball slides to the left and allows P_2 to send flow to outlet A



Symbolically it is represented as...



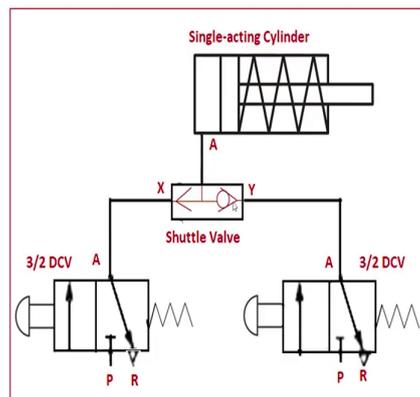



This will be shown here, you will see here friends, in this sketch is a valve body and ball is slide here; meaning, the pressure P 1 is greater than the P 2, so that the ball slides to the right and allows the P 1 to send a flow to actuator and A. When pressure P 2 is greater than the P 1, so that the ball slides to the left side and allows P 2 to be connected to A.

This is graphically represented as see here double check valves. See here, how to represent double check valve. Graphical symbols are very important friends. I am requesting all the students to be concentrate on the symbols. This is a double check valve; P 1, P 2 and A. These numbering is also very important. These are engraved on the valve body.

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Application



Application of this shuttle valve, I am showing you here for the single-acting cylinder operation. It is the single acting cylinder; only one port is there and spring return. This is a piston; this is a piston rod. It is connected to the shuttle valve here and one side of the shuttle

valve is connected to the 3 by 2 DCV and other side of the valve is connected to the another 3 by 2 DCV.

Meaning you will see friends here, always you will connect the circuit in the exhaust mode. You will see here, return line; meaning, always the piston is retracted more. When you will press this button, what happens friends? The P line is connecting here, the ball will slides here, head will receives the flow from the left side 3 by 2 DCV.

If you want to send a flow from the right side, what you will do? Push this button, then flow is coming here moves the ball to this side; then, head will receives the flow from this. Meaning here, the single acting cylinder receives the flow from this power source or this power source using your shuttle valves.

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2/2 DCV

- Generally spool type design
- Spool is a cylindrical body with lands and grooves, moves inside the valve body
- DCV are either of Closed type or Open type based on the customer requirement

Directional Control Valve

2 / 2 DCV

2-position : P-Open /P-Close





Next, move on to 2 by 2 DCV. What is this 2 by 2 DCV? What is 3 by 2; what is 4 by 2; what is 5 by 2? Generally, these are spool type design. Spool is a cylindrical body with the lands and grooves; you see here, bigger one is called a lands these are called a lands and these are called a grooves, these are called a grooves.

It is a cylindrical body with the lands and grooves moved inside the valve body or a sleeve. It is a spool, this is a sleeve. DCVs are either a closed type or a open type based on the customer requirements. Just I will tell you what is this 2 by 2 signifies. This is same convention for 3 by 2, 4 by 2, 5 by 2.

Please understand very carefully friends here, the first two designates 2 way or a 2 flow paths; 2 flow paths are there. Also, two means 2 ports in the valve body; P and A. One port should be there, P port and one port should be receiver, A port should be there. Then, flow paths are P to A open or P to A closed, you send the flow or cut the flow. These are the two ways.

Then, you will see down one here 2, specify the 2-position; meaning, null position whether P is connecting to A or P is blocked, what it is? That will specifies in the P whether it is a closed or a open position, that is why I am telling 2-position. 2 by 2 means 2 ports; this is 2 position or a 2 ways how the flow is taking place. Here, it is a position. Each position is represented by the one square. Then, DCV generally, Directional Control Valves.

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2/2 DCV Normally Closed



- Important features
- 2 Ports → P port and A port
- 2 Position → Null position and Active position
- Normally closed means → At null position P port is blocked



Now, quickly we will move on to some of the constructional features which are essential to understand how the valve will operate and how the portings are there in the valve body. Now, we will quickly move on to the 2 by 2 DCV normally closed. Read carefully friends, normally closed.

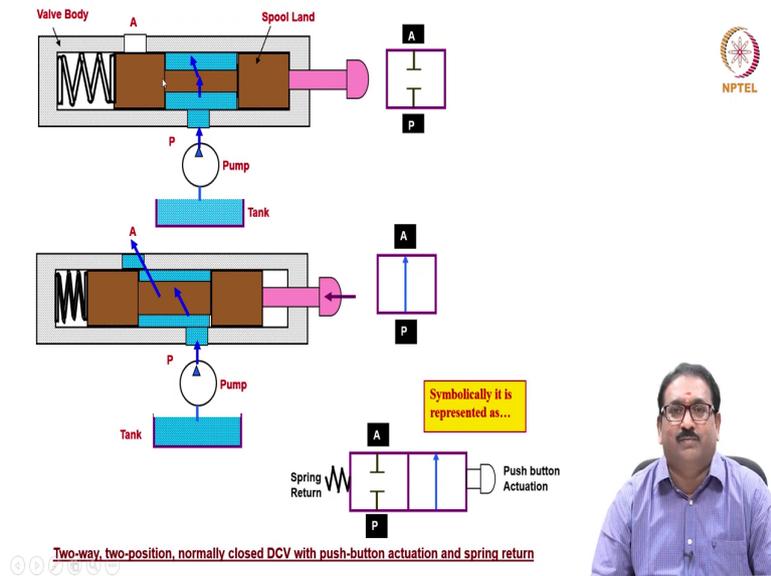
Then, can you please tell me important features of this valve? 2 ports, first one is as I have told you 2 way or 2 ports. What are those? Close that and tell one pressure port should be there, one user should be there. User means, A port should be there.

Then, down 2 represent the position; first position, whether P is off or P is on.

Meaning, 2 positions; null position or a active positions and then, normally closed means what friends? It is related to the pressure port. In null position P is open or closed. Here,

closed. Normally, closed means a null position P port is blocked. Please understand, these important features whenever you are discussing about the 2 by 2, 3 by 2, 4 by 2, what normally it is open or closed.

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Constructional feature you will see. This is a rectangular body, valve body having the two ports; A and P. P is a pressure port connected to pump here through the tank; then A is actuator port, actuator is not shown here. This is the spool land here friends. The spool land covers the port A here; meaning, in the null position flow is not going here, no passage.

How it is achieved friends? The one stiff spring is fitted on the other side of the spool valve, as shown here. Then, using this stiff spring, the spool land always close the A. This is represented in first valve position. P is no flow is not sending, A is not receiving flow. Then, when will receives the flow A? When we will push this, when we will push this, what happen

using the push rod? The spool will push and compresses the spring, then only P is going to A.

How it is? You see here, I pressed this, spring is compressed flow is taking place from P to A now. A is receiving the flow from P. Altogether, null position and activated position is represented using the one square box, another square box please be careful friends here, where to write the numbers A and P, you will see always at the spring side, which is a null position or a center position. Here spring is there, A and P are blocked.

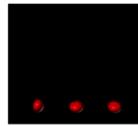
When you push this button, this is get activated. Do not write again P and A here. If you will write here, it get confused. In null position, whether P is open or closed, that is why I am telling you have to write always at the spring side. It completely read as two-way, two-position, normally closed DCV with push-button actuation and a spring return. Meaning here friends, when you will press one more time, what happen know valve will get released and this stiff spring which stores the energy previously, push back to get the this configurations.

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2/2 DCV Normally Open

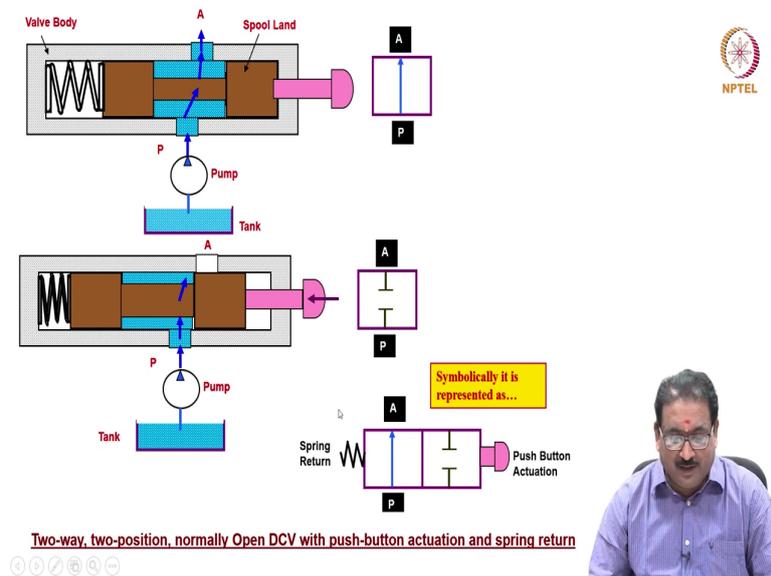


- Important features
- 2 Ports → P port and A port
- 2 Position → Null position and Active position
- Normally open means → At null position P port is open,



Now, we will see closed one you are seeing, now can you please draw the graphical symbol for 2 by 2 DCV normally open it is, how it is? Before that, you tell me the important features of 2 by 2 DCV normally open. 2 means 2 ports as you correct P port and A port. This 2 means positions; null position and active positions. Then, normally open means what? P is opened now in the null position; at null position, P port is open.

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See here now in the sketch, here spool lands are placed in such a fashion that using the stiff spring always A is receiving a flow from P that is why it is known as P is opened port in the null positions. When you will press this button, what happen? The spool land covers A. Then, no flow to A. This is represent A is not receiving the flow. Side by side if you will put, valve looks like this.

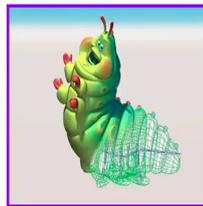
Be careful friends, the spring side you mark P and A. Normally open it is, you keep open this. You normally closed means close this. Now, it normally open P to A is open and this is blocked when by push button. Push button side is the actuated position. One more pressing, it will go to the null position.

What is the null position? Spring pushes back P is open to A always for the normally open valves. How to read this friends? As I have told you two-way, what is the two-way? P is open

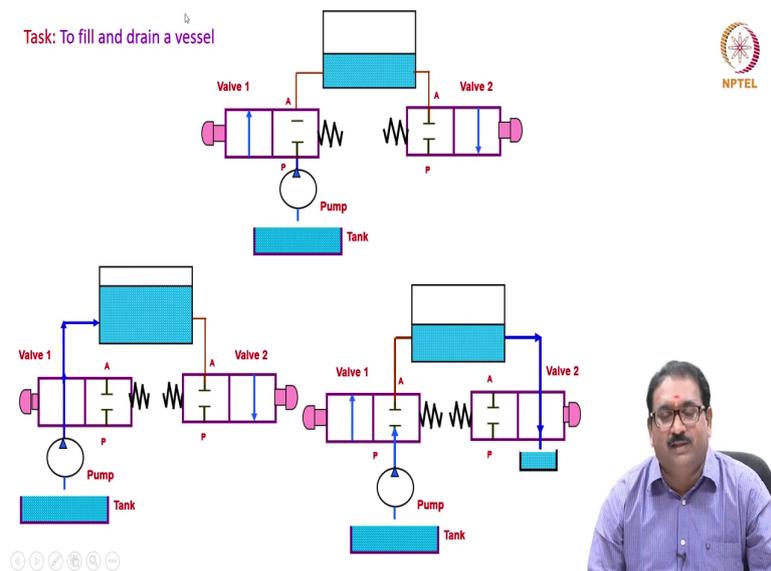
to A or P is blocked to A, there is a two-way. Two-position means this one position, second position; null position and activated position. Normally open DCV with a push button actuation and a spring return, how to read the valve we will see friends. The reading is very very important.

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Application of 2/2 DCV



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Application of 2 by 2 DCV, if you will see the very simple is task is to fill and drain a vessel filled with water. How to do it? The tank is there or a one beaker, I want to fill the water as and when required and then, I will drain the water as and when require using your valves. Now, I am using the two direction control valves as shown in the figure here. This is the tank. See the directions friends, always see the directions here; the valve 1 and valve 2 and connected to the pump.

What happens friends, when I will press this button? Automatically, it will go to the this position; meaning, the pump whatever it is sending the flow, it is used to raise the fluid in the vessel. Then, one more pushing, it will make to the null. Then, to draining how to do? You will push this, what happen? Valves get open here, then flow is going out of the tank. That is why if I am using the 2 by 2 DCV like this to drain and fill the vessel is very very easy.

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3/2 DCV Normally Open



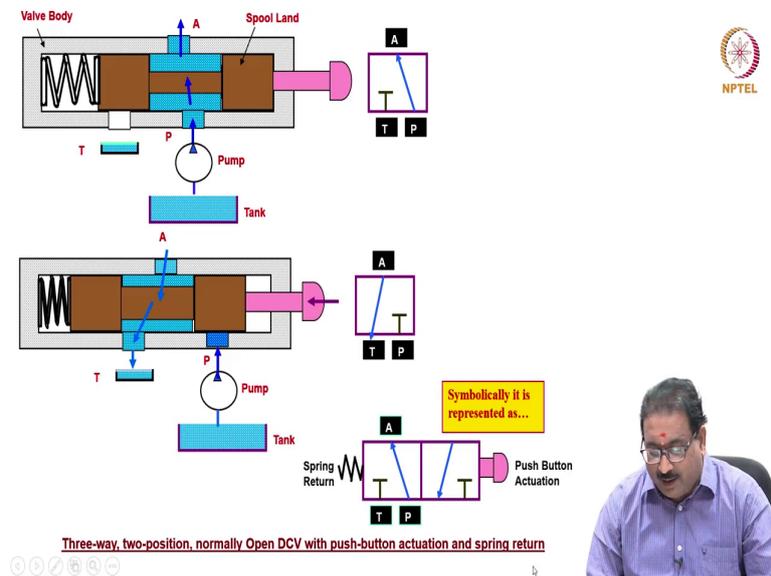
- Important features
- 3 Ports → P port, A port and T port
- 2 Position → Null position and Active position
- Normally open means → At null position P port is open



Now, quickly, we will move on to the 3 by 2 DCV Normally open. Then, can you please list it out yourself, what are the important features? What is this 3 friends? 3 means 3-ports. Close the eye and you will tell; P port should be there, one actuator port should be there; then, question arises what is one more.

One more should be a tank port or a return port or exhaust port. 3 ports are there as you know P port, A port, T port. And what is this 2 position? What is this position? Null position and activated positions ok. Normally open means P port is opened.

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You see, constructional detail valve body having three ports now; P port should be there, A port should be there, a tank port. Here you will see now normally open means P is connecting to A; normally open. Normally closed means what you will do?

A is connecting to T and P is blocked, always with respect to the pump ports. When you will press this button, what happen? The spool lands will divert the flow from A to T and pump flow is cut off, that is why it is here.

How to read this 3 by 2 way valve? One to another, see here very very important. Null position what it is? Normally open, normally close means this you have to do, null position it is. Actuated position, what happen? A is connecting to tank. Do not write any symbols here

and P is blocked, how it is? Push button actuation. How to read? Three-way, two-position, normally open DCV with push-button actuation and spring return.

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Application of 3/2 DCV

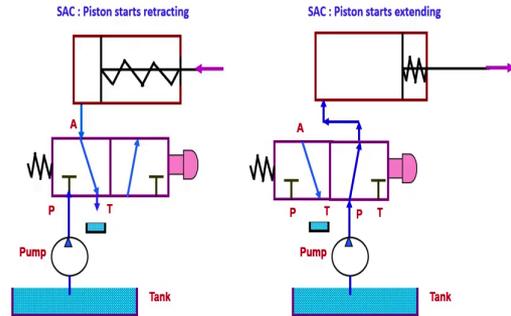


Quickly, you will see the application of 3 by 2 DCV.

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Task: Retract and extend the piston of a SAC with spring return



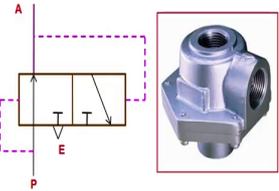
Extend and retract the piston of a single acting cylinder with spring return, how it is we will see now. See friends here, I have drawn the single acting cylinder with spring return connected to your 3 by 2 way valve, always whether we will connect here or here. As I have told you always it is in the retracted position, that is why I am connecting the A port to the tank, then only then it will come back using the spring force. When you will press this button, what happen? This flow will connecting to the head side, it will move see here, very very important; very very important it is.

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Directional Control Valves

Can you identify the valve ?

- Important Features
 - 3 Ports → P port, E port and A port
 - 2 Position → 1 Null Position and 1 Active Position
 - Pilot Signals
 - Any Guess ?



Quick Exhaust Valve
Or
Fast Exhaust Valve



Next, we will move on to another type of valve. Now, I am giving you some clues, how to identify the valves. Can you please tell me, what is this valve? List it out important features involved in the valve designation. This is a graphical symbol. When you will see in the hydraulic circuit or a pneumatics, immediately we will tell pneumatic circuit, this valve is this.

That is why I am telling what are the feature. How many ports are there friends here? Important features, you will see. Yes, you are rightly correct. 3 ports are there; P port, A port, exhaust port. How many positions friends? 2 positions; null position and active positions. Then, what is a null position? See the figure.

If assumed to be this is a null position, you normally open. Then, pilot signals are there, pilot signal; dotted means pilot signals. Any guess what it is? Already you will see here also, the

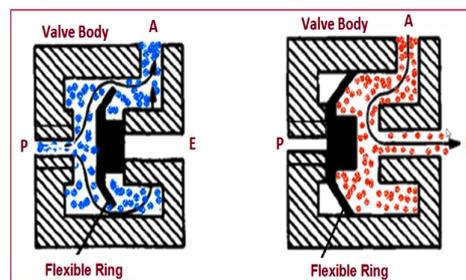
big port opening and small port opening is there and one port is here. This is a commercially available valve. What is this valve? Yes, quick exhaust valve or a fast exhaust valve.

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Fast Exhaust Valve



- It is a 3/2 way valve, with internal piloting that causes the fluid coming from the DCV sent directly to the cylinder (port A) but allowing fluid to go out of the cylinder directly to the atmosphere
- So it used to vent the cylinder very quickly
- It consists of a movable disc or flexible ring which allows Port A to be connected to pressure port P or large exhaust port E depending upon the fluid flow direction



I will quickly throw some lights on the quick exhaust valve. It is a 3 by 2 way valve, with internal piloting that causes the fluid coming from the DCV, sent directly to the cylinder port A; but allowing a fluid to go out of the cylinder directly to the atmosphere. So, it is used to vent the cylinder very quickly.

Constructional feature is here as I have shown you. This is the valve body. How many ports are there? Pressure port should be there, A port should be there and E port should be. It consist of a movable disk or a flexible ring which allows port A to connected to pressure port or a large exhaust port.

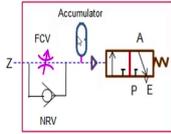
This exhaust port is bigger than the inlet port, depending on the flow direction. If flow is coming from the P, what happens? This flexible ring moves and closes the exhaust, the flow is going. If by mistake the flow is reversed from the A, A is an actuator end, what it will not go to the other valves, what happens here? This will move here, open big ports to send the flow.

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Directional Control Valves

Can you identify the valve ?

- Important Features
- 3 Ports → P port, E port and A port
- 2 Position → 1 Null Position and 1 Active Position
- Pilot Signal
- FCV
- NRV
- Accumulator
- Any Guess ?






Can you please tell me what is this valve? Tell me which type of valve it is, what I have shown here in the figure? Just see the figure and what are the things are there? How many ports are there in this valve? How many ports you will see now in the valve complete is a valve; how many ports are there? 4 ports are there here. If you will see in this here; pressure port is there, A port is there, exhaust port is there and one more port is there.

What is that? Z, Z is a pilot port. What for? To operate the left position. Wherever the spring is there, it is a null position. What is a null position friends? Normally closed, P is blocked;

the normally closed, P is blocked means automatically A is venting the flow. It is a null position.

Apart from this, some components are there, you will see. I am written already. It is accumulator. See the accumulator shape. Then, see here, there is a pilot, air pilot it is that is why it is opened; triangle open, not fields. Here, FCV is there. What is this? Flow Control Valve or a needle valve is there, needle variable type; meaning, you will open half or a full or a middle whatever it is to fill the reservoir.

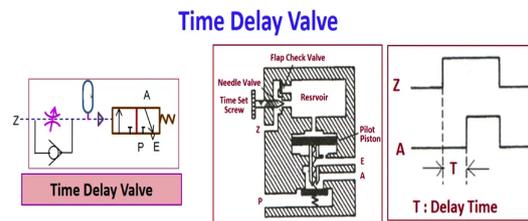
Needle valve filling of the accumulator is based on this. Then, you will see again I am putting parallel to the flow control valve. Now, what I am putting here? NRV; meaning, when the pilot signal comes here, meaning the air pressure from the fluid will come here; it will not pass through this, only it will pass through the FCV.

How much it is opened that much time is taking to fill the accumulator. After sufficient filling, the valve get opens. I am telling you so many clues. If the flow is coming from the reverse, when it will come reverse? When the pilot signal is removed, then flow will go by passed the flow control valve.

As I have told you, when the check valve is used parallel to the any valves, it will by-pass in the reverse direction; correct? Then, can you please quickly list the important features of this valve? 3 ports are there. Now, what I have told you here I am telling you 3 ports; actually, 4 port it is. P port, E port, A port. How many position? 2 position; 1 null position, another one is active position.

Pilot signal, that is why one more port pilot signal. Then, FCV - Flow Control Valve; then, NRV - Non Return Valve; then accumulator, all together is a valve. Can you please any guess what type of valve it is? Already told you many things here, can you please tell me? Can you please tell me which type of valve it is? Yes, it is a time delay valve; meaning, the actuation of this based on the throttling how much you are keeping to fill the accumulator.

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- This type of valve is used to **delay the operations** where time based sequences are required
- **Practical Case** : A double-acting cylinder is used to press together two components
 - Upon operation of push button, the **clamping cylinder slowly advances**
 - Once the **fully extended position is reached**, the cylinder has to **remain idle for 20 s** and then **immediately retract to the initial position**
 - After the cylinder has fully retracted and stayed again 30 s
 - During this delay time the finished part is manually removed and replaced with new parts



Let us will see the time delay valve constructional feature. This is a time delay valve body it is. Here how many ports are there? A port, exhaust port, P port and then, pilot piston is there here. Then, the top of this valve is a reservoir, big reservoir. Here, the fluid is stored through the Z port by using the needle valve opening.

Then, when is Z is applied, the A will open only after satisfying the certain delay what you will set. What is this? This type of valve is used to delay the operation when time-based sequences are required. One practical case, I will tell you. Assume to be a double acting cylinder is used to press the two components together. Upon operation of the push button, the clamping cylinder slowly moves.

Once extended completely, the cylinder remains 20 seconds to press this part together. After 20 seconds, immediately moves to initial position. After cylinder is fully retracted and stayed

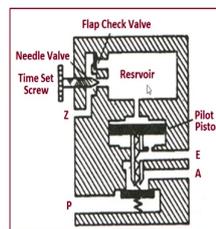
for 30 second. During this time delay, 30 second, the component whatever you pressed, you are removing from the time with new parts. This cycle will repeats.

Meaning what? 20 seconds, it will go and extend, press the parts, wait for 20 second until the both parts will be stick together; then, move back, wait for 30 second there, that time remove this part and load the new two plates. Here, time-based sequencing operations are taking place, such applications calls for the time delay valve.

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Constructional Features of Time Delay Valve

- Its construction is similar to a 3/2 pilot operated valve, but the space above the main valve is comparatively large and pilot fluid is only allowed via flow reducing valve
- There is thus a time delay between application → Pilot pressure to Port Z and the main valve operation
- Time delay is adjusted by the needle valve setting
- Built-in check valve causes the reservoir space above the valve to vent quickly → When pilot pressure Z is removed to give no delay off



See here it is a construction is similar to 3 by 2 pilot operated valve; but the space above the main valve. This is the main valve actually main valve is comparatively large here and pilot fluid is only allowed via the reducing valve. There is thus, a time delay between the application that is the pilot pressure to port Z and the main valve operation.

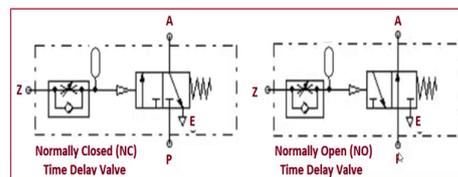
The time delay is adjusted by the needle valve setting that is screw. The built-in check valve causes the reservoir space above the valve to vent quickly, when the pilot line is removed; no delay, immediately whatever the air is stored here, it will bypass the your flow control valve through the check valve.

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Time Delay Valve



- Commercially time delay valves are available as
 1. Normally Closed (NC) type time delay valve and
 2. Normally Open (NO) type valves as shown in Figure



Commercially, time delay valves are available as normally closed type time delay valve. What is the meaning of normally closed DCV? Pressure port is blocked or normally open type meaning what it is? It is open. You will see here, the two types are available. Here same all are same ports; P port, E port, A port and Z.

But, here you will see as we have seen previously A is connected to E, it is what you will call normally closed NCV time delay valve. This is also available; normally open time delay

valve; meaning, it is opened. When you apply the time signal, it is get opened-up to the time. After reaching certain time set here, then it will be closed. Both are available in the markets.