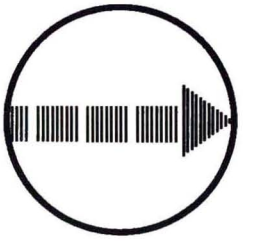
CHAPTER 7

Control of Hydraulic Energy

Working energy transmitted hydraulically must be directed and under complete control at all times. If not under control, no useful work will be done or a machine might be destroyed. One of the advantages of hydraulics is that energy can be controlled relatively easily by using valves.

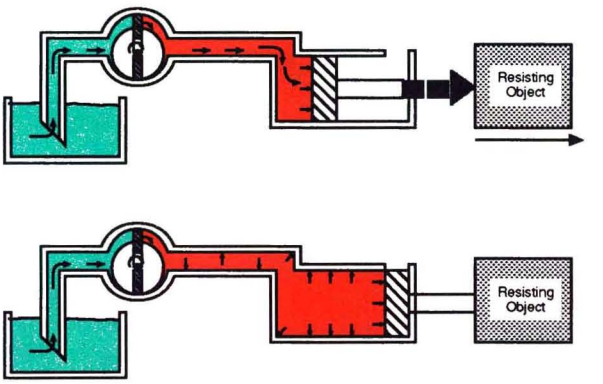


valves

A valve is a mechanical device consisting of a body and an internal moving part which connects and disconnects passages within the body. The passages in hydraulic valves carry liquid. The action of the moving part controls maximum system pressure, direction of flow, and rate of flow.

control of pressure

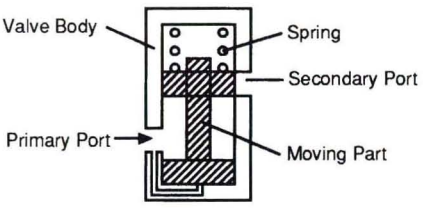
Hydraulic energy can be applied to a cylinder actuator, resulting in the performance of work. Once the cylinder is fully extended and the work is completed, a positive displacement pump will continue to absorb more energy from its prime mover and apply a higher pressure to the liquid. (Remember, the smallest resistance in the system signals the pump what pressure is to be applied.) With the cylinder fully extended, the smallest resistance becomes the physical strength of the system.



The pump will try to apply a pressure to overcome this resistance which would be damaging. One use of a pressure valve is to limit system pressure to a safe level.

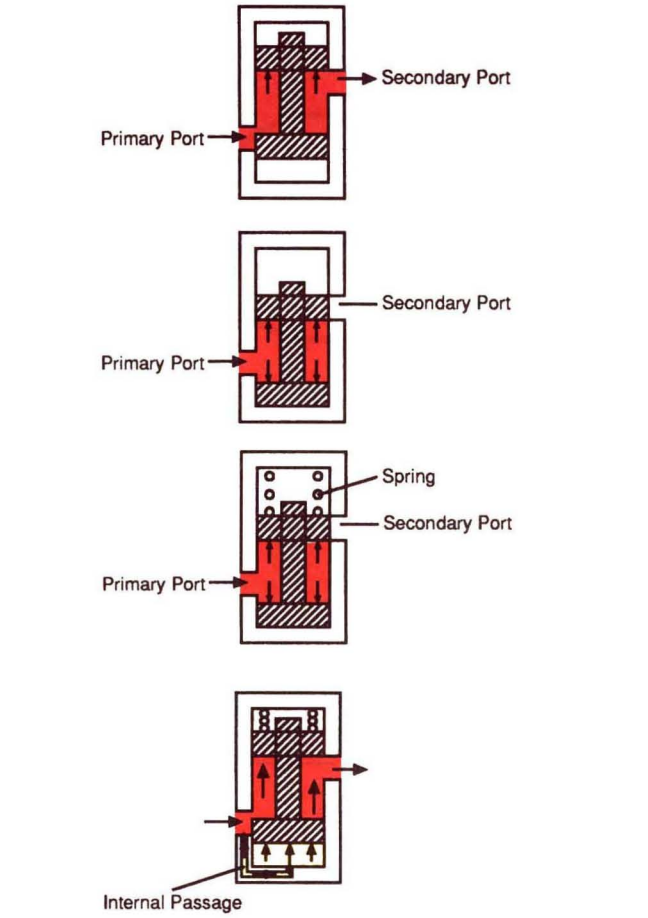
pressure control valve

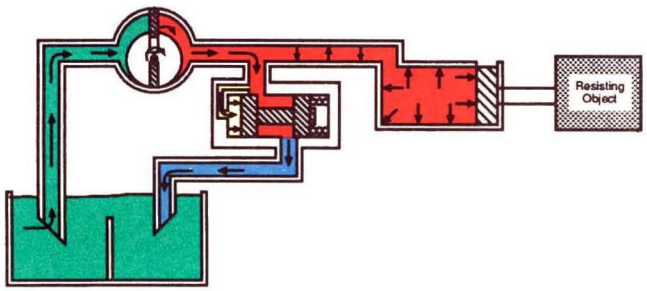
A pressure control valve has an internal moving part which is operated by pressure. When the pressure in a system reaches a certain level, the internal moving part connects or disconnects passages in a valve body, allowing the liquid to follow another path.



what a pressure control valve consists of

A pressure control valve consists of a valve body with a primary and secondary passage and an internal moving part (spools). The external openings of the passages are known as primary and secondary ports, respectively.





how a pressure control valve works

Many times, the internal moving part of a pressure control valve is a spool. In one extreme position, the spool connects the passages, allowing the fluid to flow through the valve. In the other extreme, the passages are disconnected and the flow path through the valve is blocked.

In pressure control valves, the spool is held biased in one extreme position by a spring. If the passages are disconnected and the flow path through the body is blocked in its normal condition, the valve is designated a normally non-passing pressure control.

Pressure is sensed at the bottom of the spool by an internal passage connected to the primary passage. When system pressure overcomes the force of the spring, the spool moves and the passages are connected. Fluid is free to flow through the valve.

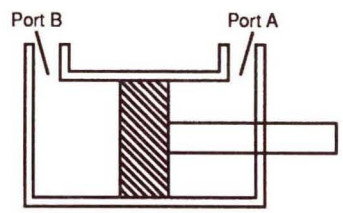
(The fluid pressure used to operate the spool is known as pilot pressure. Pilot pressure is a common way of operating many types of hydraulic valves.)

If the primary port of this type pressure valve were connected to system pressure, and the secondary port were connected to the tank, the flow from the pump could be directed back to tank when pressure applied by the pump becomes excessive. A normally non-passing pressure valve used in this manner is called a relief valve.

control of actuator direction

Once a cylinder is extended, it has to be retracted so that work can be done again.

To perform this task, a cylinder which is operated hydraulically in both directions is generally used, as well as something to change the direction of liquid flow.

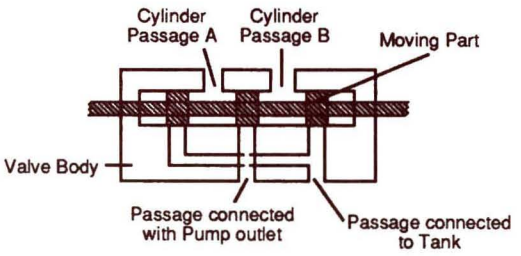


double-acting cylinder

A double-acting cylinder has a port at each end of the cylinder body by which fluid can enter and exit. This allows the piston rod to move in two directions (double-acting). To distinguish the ports on a double-acting cylinder, we will label one "A", the other "B."

directional control valve

The moving part in a directional control valve connects and disconnects internal passages within the valve body, which action results in a control of fluid direction.



what a directional control valve consists of

A typical directional control valve consists of a valve body with four internal passages and a sliding spool moving part which connects and disconnects the passages.

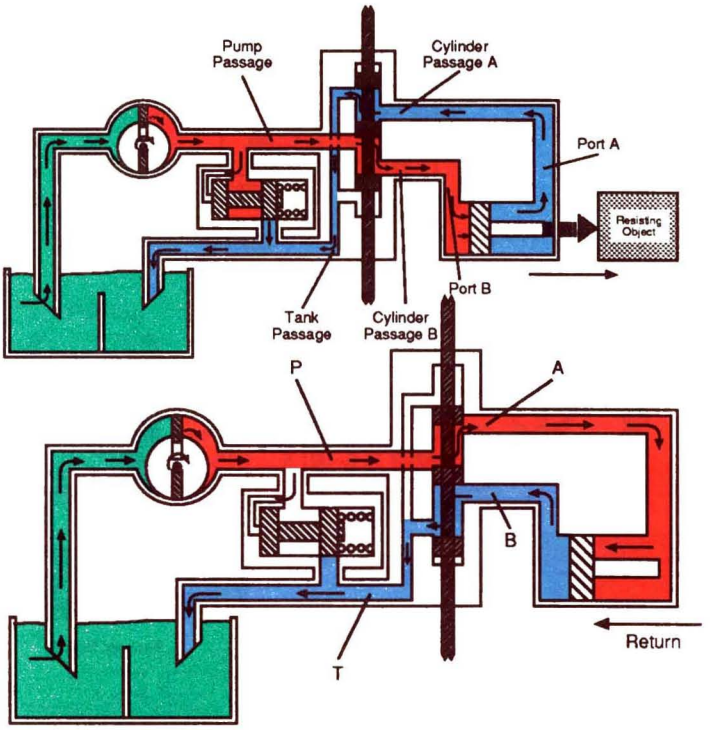
how a directional control valve works

With the spool in one extreme position, the pump passage is connected to cylinder passage B and tank passage is connected to cylinder passage A.

With the spool in the other extreme, the pump passage is connected to cylinder passage A and tank passage is connected to cylinder passage B.

With a directional control valve in a circuit, the cylinder's piston rod can be extended and work performed.

By shifting the spool to the other extreme, flow is directed to the other side of the cylinder. The piston rod retracts.



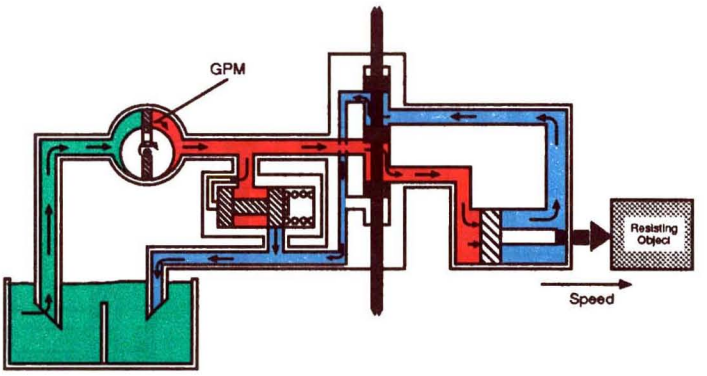
control of actuator speed

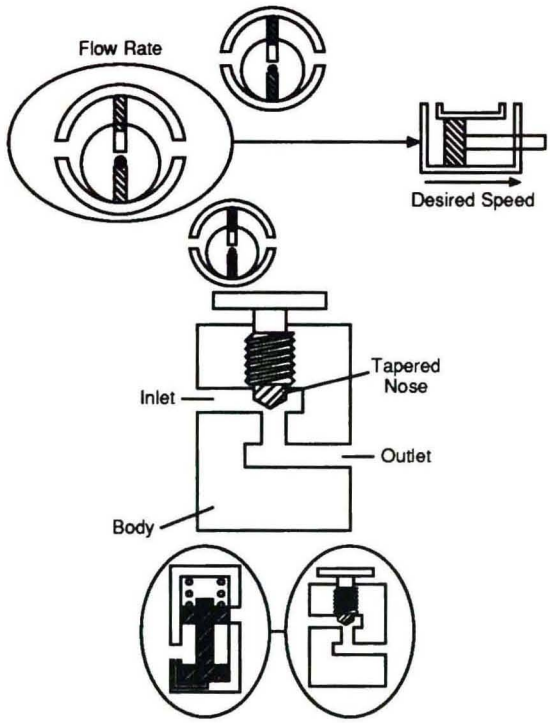
In many applications, it is desirable and even necessary to control the speed at which an actuator does work.

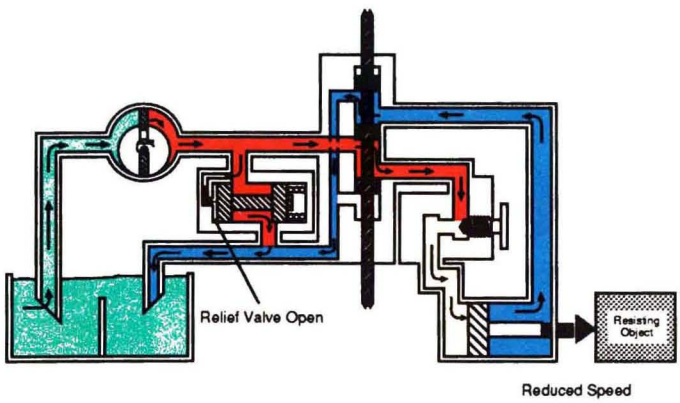
It has been shown previously that the speed at which an actuator (cylinder, motor) does work is the direct result of how quickly it is filled. In other words, actuator speed is the result of the GPM flowing to the actuator.

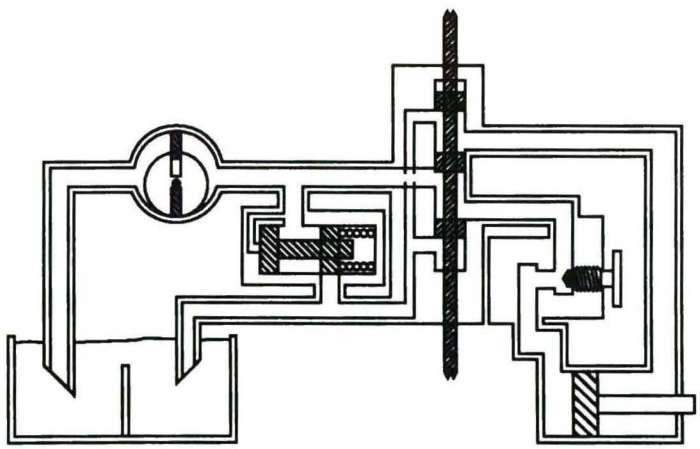
Since the pump in a hydraulic system can be at constant displacement, it would make sense to select a pump with the desired flow rate. This is usually the case when only one actuator is used in a system.

Many times in a hydraulic system, there is more than one actuator. If the system is designed for the cylinders to act individually, then the pump's flow rate is selected for the required speed of the









largest cylinder. This means the smaller actuators will move more quickly, which may be undesirable. To reduce the flow rate to these or any actuator, a flow control valve is used.

flow control valve

A flow control valve, when properly used, always reduces the flow rate from a pump to an actuator.

what a flow control valve consists of

A typical flow control valve consists of a valve body and movable part. The movable part in our example is a "tapered-nose" rod which is threaded into the valve body. The movable part in our flow control valve is better described as "adjustable" since no movement takes place while the valve is operating.

how a flow control valve works

In a hydraulic system, there is many times a direct working relationship between a flow control valve and a pressure valve functioning as a relief valve.

The flow control valve is a resistance which results in a higher pressure being applied by the pump. This pressure partially opens the relief valve. The result is some flow goes over the relief valve and less flow through the flow control and to the actuator.

a simple hydraulic system

The components which have been described make up a simple hydraulic system. The system can perform useful work because hydraulic working energy in the system can be controlled.

Hydraulic systems are found in many diverse fields, from aerospace, aircraft, and military operations, to industrial, mobile, and steel mill applications. All hydraulic systems operate on the same principles which have been discussed up to now. However, the difference between each "type" of hydraulics is in the components.

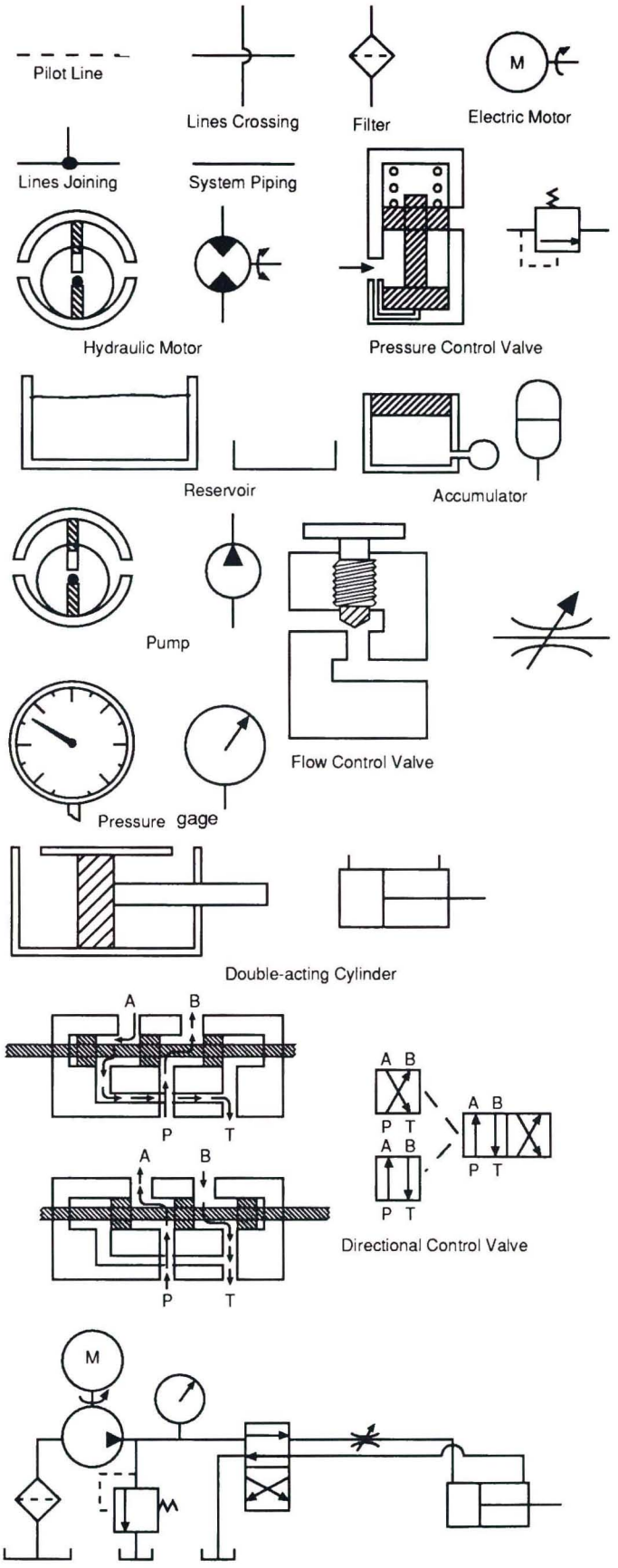
We shall, in the remaining text material, concentrate on some of the various types of components which are available in industrial hydraulics. We shall also design some elementary circuits to illustrate how these components may be used.

hydraulic symbols

The hydraulic components and elementary systems which have been shown to this point, have been illustrated in a pictorial manner. System diagrams have been cutaway to illustrate internal component operation. This technique is beneficial from an instructional point of view, but it is impractical from a workaday standpoint.

In hydraulics, just as in other technologies, symbols are used to describe components and systems. The symbols for the components which have been discussed and the simple system which has been developed can be illustrated using either ANSI Y32.10 graphic symbols or ISO 1219 graphic symbols for fluid power.

NOTE: In addition to the components which have been discussed, the system also consists of an electric motor and a hydraulic filter. Hydraulic systems are generally driven by a prime mover like an electric motor. And, in order to achieve a degree of reliability, hydraulic systems should be protected from dirt with a hydraulic filter.



exercise
control of hydraulic energy

50 points Instructions: In this assignment the answers are already given. You write the questions.

ANSWER 1. It operates by causing a resistance.

ANSWER 2. Under complete control.

ANSWER 3. Direction of flow, rate of flow, and maximum pressure.

ANSWER 4. It has a working relationship many times.

ANSWER 5. A body and an internal moving part.

ANSWER 6. Pump applies an additional pressure.

ANSWER 7. Has a normally closed condition.

ANSWER 8. A pump is selected with the desired flow rate.

ANSWER 9. Pilot pressure.

ANSWER 10. The physical strength of the system.