Pumps

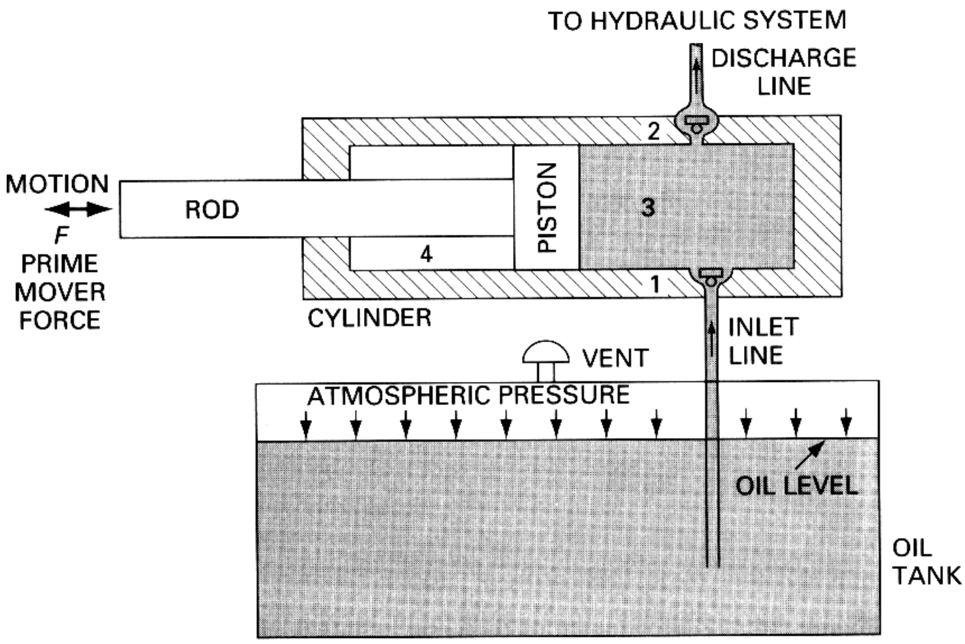
Pump Theory

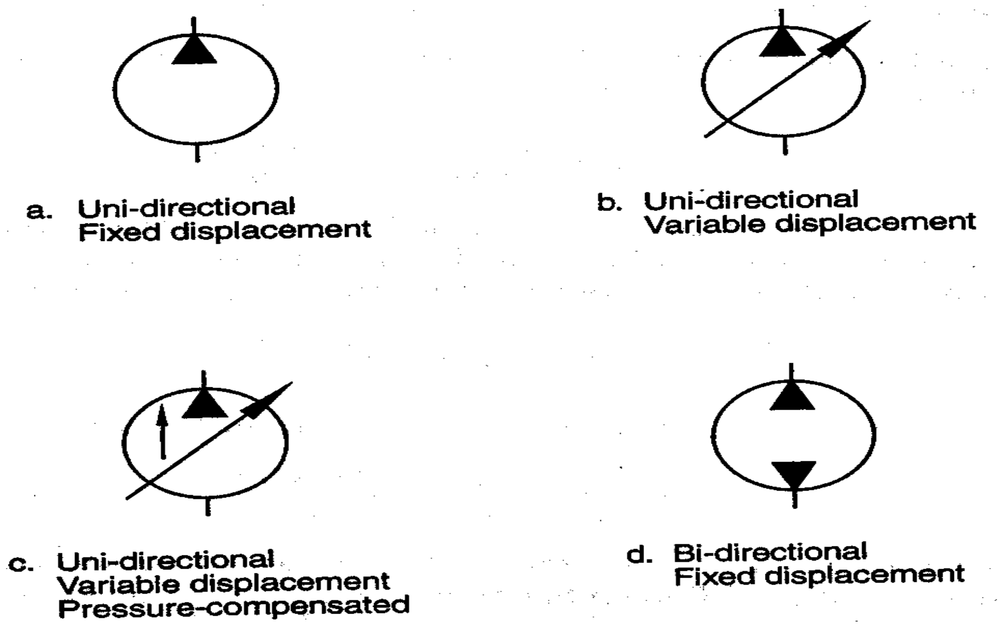
A Pump, which is the Heart of a Hydraulic System, converts Mechanical Energy into Hydraulic Energy. The Mechanical Energy is delivered to the Pump via a Prime Mover such as an Electric Motor. Due to Mechanical Action, the Pump Creates a Partial Vacuum at its Inlet. This permits Atmospheric Pressure to Force the Fluid through the inlet line and into the Pump. The Pump then pushes the Fluid into the Hydraulic System.

Pumps operate on the Principle whereby a Partial Vacuum is created at the Pump Inlet due to the Internal Operation of the Pump. This allows Atmospheric Pressure to push the Fluid out of the Oil Tank (Reservoir) and into the Pump Intake. The Pump then mechanically pushes the Fluid out the Discharge Line.

For Example

Note that this Pump contains Two Ball Check Valves, which are described as follows:
Check Valve 1 is connected to the Pump Inlet Line and allows fluid to enter the pump only at this location. Check Valve 2 is connected to the Pump discharge Line and allows fluid to leave the pump only at this location. As the Piston is pulled to the Left, A Partial Vacuum is generated in Cavity 3, because the close tolerance between the Piston and Cylinder (or the use of Piston Ring Seals) prevents Air inside Cavity 4 from traveling into Cavity 3. This Flow of Air, if allowed to occur, would Destroy the Vacuum. This Vacuum holds the Ball of Check Valve 2 against its seat (lower position) and allows Atmospheric Pressure to push Fluid from the Reservoir into the Pump via Check Valve 1. This Inlet Flow occurs because the Force of the Fluid pushes the ball of Check Valve 1 Off its Seat. When the Piston is pushed to the Right, the fluid movement closes Inlet Valve 1 and Opens Outlet Valve 2. The Quantity of Fluid, displaced by the piston, is forcibly ejected Out the Discharge Line leading to the Hydraulic System. The Volume of Oil displaced by the Piston during the Discharge Stroke is called the Displacement Volume of the Pump.



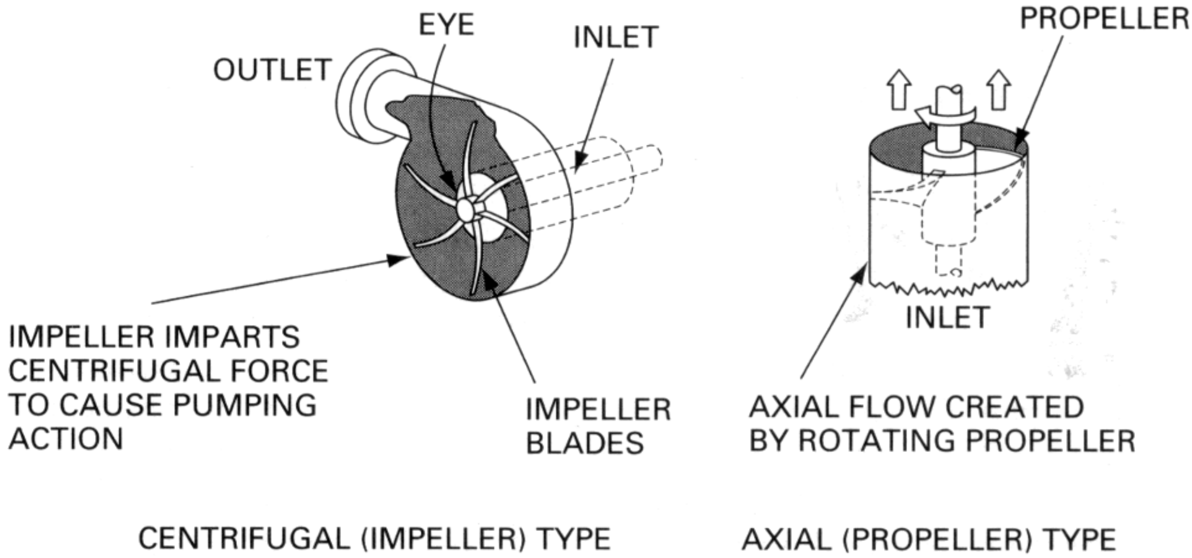


Pump Classification

1. Dynamic (Non-Positive Displacement) Pumps
2. Positive Displacement Pumps

1. Dynamic (Non-Positive Displacement) Pumps

This type is generally used for: Low-Pressure, High-Volume Flow Applications because they are Not capable of withstanding High Pressures. They are of Little Use in the Fluid Power Field. This type of Pump is primarily used for transporting fluids from One Location to Another. The Two Most Common Types of Dynamic Pumps are: The Centrifugal (Impeller) and The Axial flow Propeller pumps.



Although these Pumps provide Smooth Continuous Flow, their Flow Output is reduced as circuit Resistance is increased and thus are Rarely Used in Fluid Power Systems. In Dynamic Pumps there is a great deal of Clearance between the Rotating Impeller or Propeller and the Stationary Housing. As the Resistance of the External System starts to increase, some of the Fluid Slips Back into the Clearance Spaces, causing a Reduction in the Discharge flow-rate.

This Slippage is due to the Fluid Follows the Path of Least Resistance. When the Resistance of the External System becomes Infinitely Large (For Example, a valve is closed in the outlet line) Pump will produce No Flow.

Dynamic Pumps are not Self-Priming unlike Positive Pumps. If the fluid is being pumped from a Reservoir located Below the Pump, priming is required. Priming is the Pre-Filling of the Pump Housing and Inlet pipe with Fluid so that the Pump can initially draw in the fluid and pump it efficiently.

2. Positive Displacement Pumps

This type is universally used for Fluid Power Systems. It ejects a Fixed Amount of Fluid into the Hydraulic System per revolution of pump shaft rotation. Such a Pump is capable of Overcoming: the Pressure resulting from the Mechanical Loads on the System as well as the Resistance to Flow due to Friction.

Positive Pumps have the following Advantages over Non-Positive Pumps:

a. High-Pressure Capability (up to 12,000 psi)
b. Small, Compact Size
c. High Volumetric Efficiency
d. Small Changes in Efficiency throughout the design pressure range
e. Great Flexibility of Performance

(can operate over a wide range of pressure requirements and speed ranges)

There are Three Main Types of Positive Displacement Pumps:

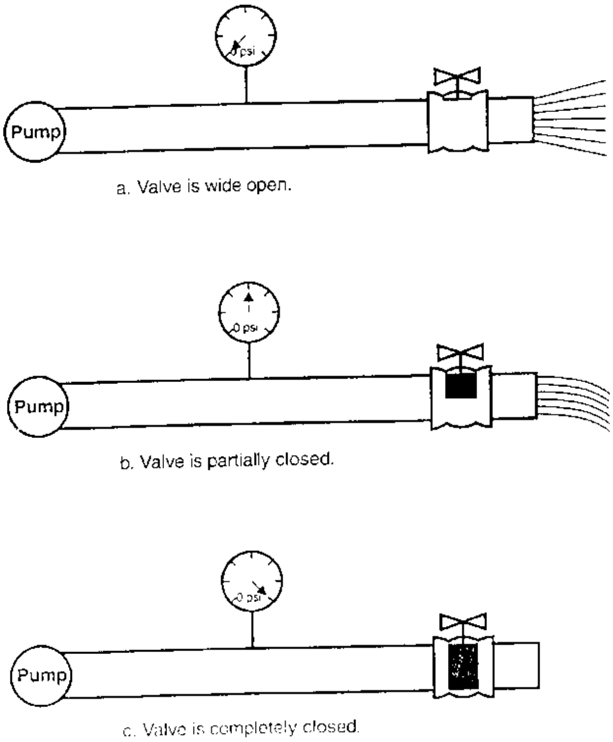
1. Gear,
2. Vane, and
3. Piston.

Many Variations exist in the Design of each of these Main Types of Pumps. For Example, Vane and Piston Pumps can be of either Fixed or Variable Displacement.

A Fixed Displacement Pump is one in which the amount of Fluid ejected per revolution (displacement) cannot be Varied. In a Variable Displacement Pump, the Displacement can be varied by changing the physical relationships of various pump elements. This Change in pump Displacement produces a Change in Pump Flow Output even though Pump Speed remains Constant. It should be understood that **Pumps Do Not Pump Pressure, instead they produce Fluid Flow.** The Resistance to this Flow, produced by the Hydraulic System, is what determines the Pressure.

For Example,

If a Positive Pump has its Discharge Line opens to the Atmosphere, there will be Flow, but there will be No discharge Pressure above Atmospheric because there is essentially no Resistance to Flow. If the Discharge Line is blocked, then we have Theoretically Infinite Resistance to Flow. Hence, there is No Place for the Fluid to go. The Pressure will therefore Rise until some Component Breaks unless Pressure Relief is provided. This is the Reason a Pressure Relief Valve is needed when a Positive Displacement Pump is used. When the Pressure reaches a Set Value, the Relief Valve will open to allow Flow Back to the oil Tank. A Pressure Relief Valve determines the Maximum Pressure Level that the System will Experience regardless of the magnitude of the load Resistance.



Pressure is the result of Resistance to Flow

Some Pumps are made with: Variable Displacement and Pressure Compensation Capability. Such Pumps are designed so that as System Pressure Builds up they produce Less Flow. Finally at some Predetermined Maximum Pressure Level, the Flow Output goes to Zero due to Zero Displacement. This prevents any additional Pressure Buildup. Pressure Relief Valves are not needed when Pressure-Compensated Pumps are used. The Hydraulic Power developed by Pumps is converted back into Mechanical Power by Hydraulic Cylinders and Motors, which produce the useful Work Output. A variable Displacement, Pressure-Compensated, Axial-Piston Pump is used to provide Optimum Performance in both Backhoe and Loader Operations. The Backhoe portion of the machine performs operations such as digging a Trench. The Front Loader portion can then be used to Load a Dump Truck with the earth removed from the Trench Dug by the Backhoe. The Pump delivers the Desired Flow to the Hydraulic Cylinders at the Required Pressure to Fulfill implement Demands.

Pump Output Flow, Neglecting changes in the Small Internal Leakage, is Constant and Not Dependent on System Pressure. This makes them particularly well suited for Fluid Power Systems. Positive Displacement Pumps must be protected against over pressure If the Resistance to flow becomes Very Large. This can happen If a Valve is completely closed and there is No physical Place for the Fluid to Go. A Pressure Relief Valve is used to protect the pump against Overpressure by Diverting Pump Flow Back to the Hydraulic Tank, where the Fluid is stored for system use.
Positive Displacement Pumps can be classified by the Type of Motion of Internal Elements.