Allegheny York

Principles of Hydraulics

How Pressure is Created.

Pressure results whenever there is resistance to fluid flow or to a force which attempts to make the fluid flow. The tendency to cause flow (or the push) may be supplied by a mechanical pump or may be caused simply by the weight of the fluid.

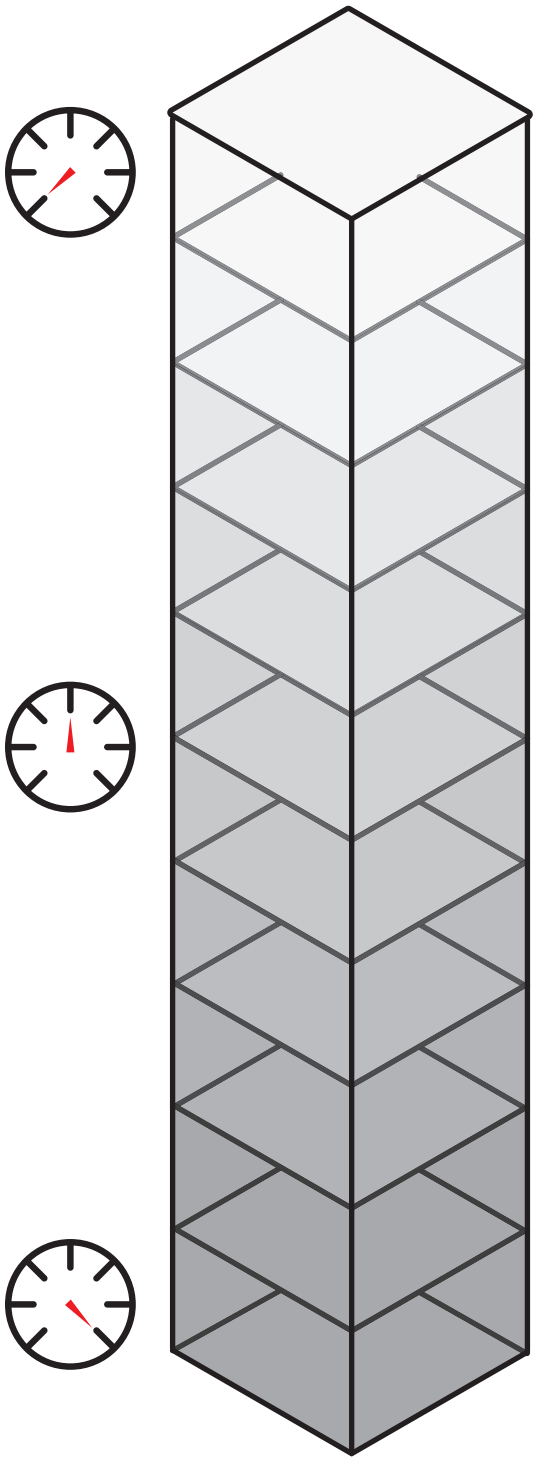
It is well known that pressure increases with depth in a body of water. The pressure is always equal at any particular depth due to the weight of the water above it. An Italian scientist named Torricelli proved that if a hole is made in the bottom of a tank of water, the water runs out faster when the tank is full and the flow rate decreases as the water level lowers. In other words, as the *"head"* of water above the opening lessens, so does the pressure.

Torricelli expressed that the pressure at the bottom of the tank only as *"feet of head"*, or the height in feet of the column of water. Today, with the pound per square inch (psi) as a unit pressure, we can express pressure anywhere in any liquid in more convenient terms.

All that is required is knowing how much a cubic foot of the fluid weighs.

Allegheny York

Principles of Hydraulics



Then the total weight is 624 lbs. This weight is divided over 144 square inches. This gives us a pressure of 4.33 psi at the bottom of the 10 foot column of water.

Allegheny York

Principles of Hydraulics

Principles of Flow

Flow is the action in the hydraulic system that gives the actuator its motion. Pressure gives the actuator its force, but flow is essential to cause movement. Flow in the hydraulic system is created by the pump.

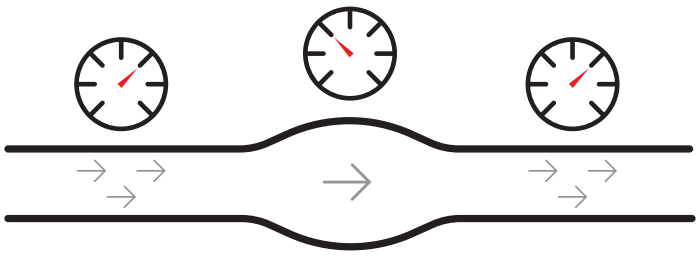
How Flow is Measured

There are two ways to measure the flow of a fluid:

- Velocity is the average speed of the fluid's particles past a given point or the average distance the particles travel per unit of time. It is usually measured in feet per second (fps), feet per minute (fpm), or inches per second (ips).

- Flow rate is a measure of the volume of fluid passing a point in a given time. Large volumes are measured in gallons per minute (gpm). Small volumes may be expressed in cubic inches per minute.

Bellow illustrates the distinction between velocity and flow rate. A constant flow of one gallon per minute either increases or decreases in velocity when the cross section of the pipe changes size..



Allegheny York

Principles of Hydraulics

Flow Rate and Speed

The speed of a hydraulic actuator, always depends on the actuator's size and the rate of flow into it. Since the size of the actuator will generally be expressed in cubic inches, use this conversion factor:

$$\frac{\text{gpm} = \text{in}^3/\text{minute}}{231}$$

Flow Rate and Pressure Drop

Whenever a liquid is flowing, there must be a condition of unbalanced force to cause motion. Therefore, when a fluid flows through a constant diameter pipe, the pressure will always be slightly lower downstream with reference to any point upstream. This difference in pressure, or pressure drop, is required to overcome friction in the line.

Fluid Seeks a Level

Conversely, when there is no pressure difference on a liquid, it simply seeks a level. If the pressure changes at one point the liquid levels at the other points only rise until their weight is sufficient to make up the difference in pressure. The difference in height (head) in the case of oil is one foot per 0.4 psi. Thus it can be seen that additional pressure difference will be required to cause a liquid to flow up a pipe or to lift the fluid since the force (due to the weight of the liquid) must be overcome.

In circuit design, naturally, the pressure required to move the oil mass and to overcome friction must be added to the pressure needed to move the load. In most applications, good design minimizes these pressure "drops" to the point where they become almost negligible.