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WHAT IS HEAD?

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Head, what's it about? Find out and don't get hung-up on that term ever again!

Head is the one term that most scares people when talking about how pumps work. After all when you talk about pumps you should be talking about pressure, everyone knows what pressure is. You put a pressure gauge on the outlet of a pump and you read the amount of pressure.

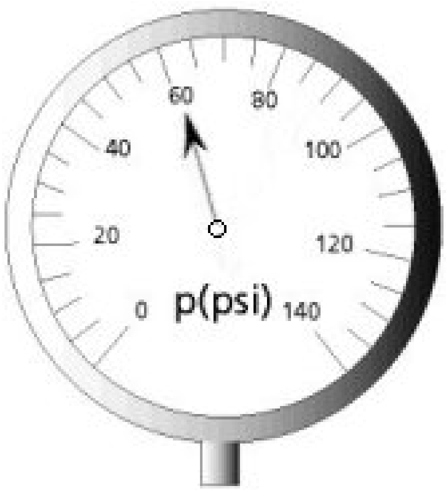

Figure 1 Measuring pressure with a pressure gauge.

You read 60 psi on the gauge of the pump in your house and you know everything is fine, everything should work properly.

So what is it about head? Why do people even talk about it, and what does it have to do with pressure?

So we are gonna get over this head problem right now, and you'll never get the googly eyes when you here that term ever again.

Assume that you have a pump that you can disconnect the discharge pipe or tube and are able to extend it vertically. Head is the height at which a pump can raise water up, that's it, it's that simple.

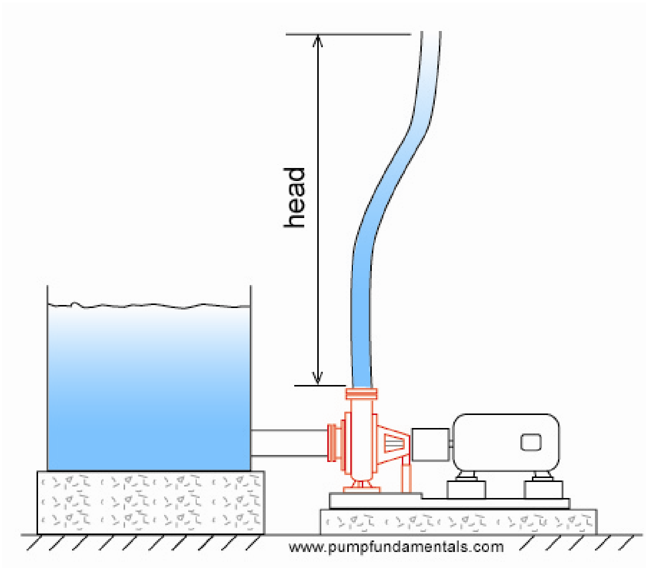

Figure 2 The meaning of head.

<u>I will be continuing on this topic later.</u>

OK, so head is somehow linked to pressure, in what way? We will get to that later. For now let's agree to state that the more pressure the pump delivers the higher the head will be in the Figure 2.

Let's say the head we measure in the above situation is 60 ft (18 m), what happens to the head measured if the level in the suction tank is higher. Will the head measured be higher or lower?

If h_2 is the head measured in Figure 2, will h_3 be higher than h_2 in Figure 3?

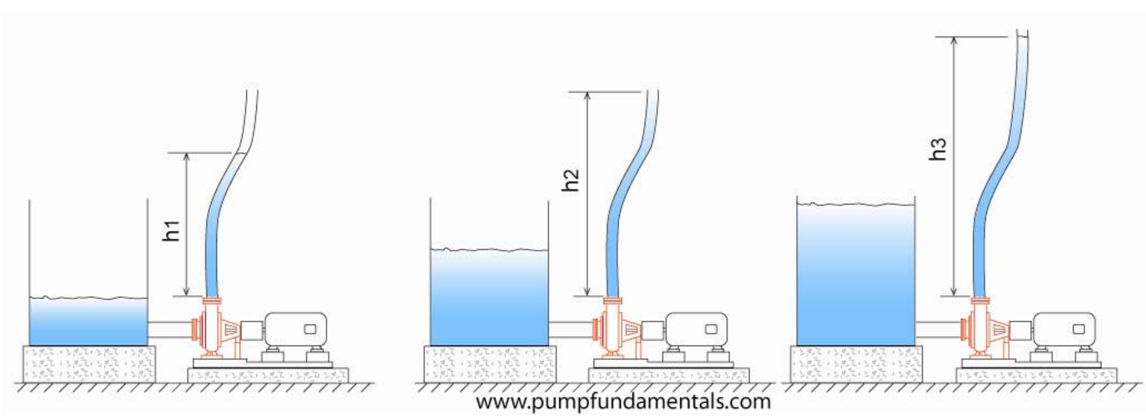

Figure 3 How discharge head varies with suction tank level.

The answer is yes.

If you lower the suction level the head measured will be less and the opposite is true if you raise it. That's all normal since the pump is just doing a mindless job and if you provide more energy to it in the form of more pressure at it's suction then that pressure increase will add to the pump's ability to produce pressure and create a higher water level at the discharge.

The pump manufacturer's want to tell you how much head their pump's will produce but they don't know what type of water supply will be available, so how can they get around this. Ingeniously simple, they subtract the head available at the suction from the head produced at the discharge, they call this **Total Head**. Then it doesn't matter what the suction tank level is, they are telling you only what the pump can do regardless of the water supply pressure at the suction.

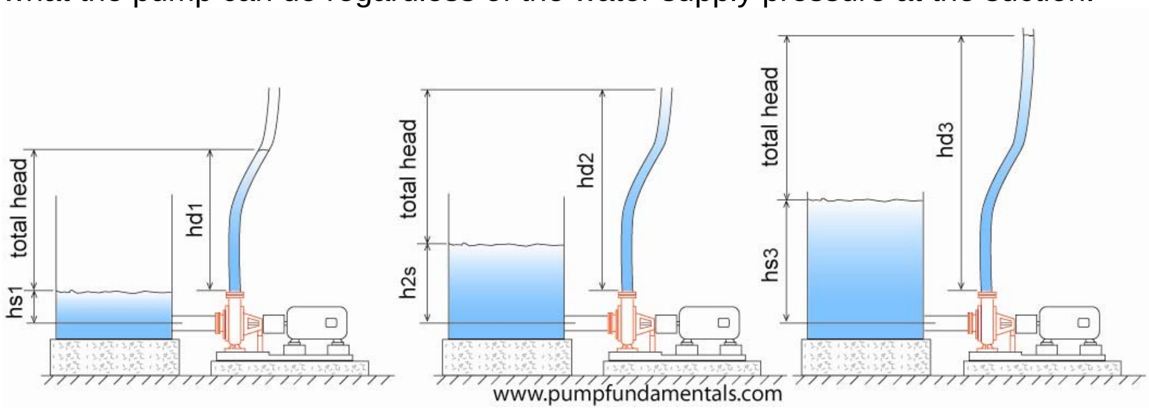

Figure 4 Total head vs. discharge and suction head.

Total Head (H_T) is:

$$H_T = H_d - h_s$$

So if you want to know what the discharge head is all you need to do is add the total head (H_T) to the discharge head h_d.

OK smart guy, what if I don't have a tank and I'm pulling water from a lake and the lake is lower than my pump. Ha!

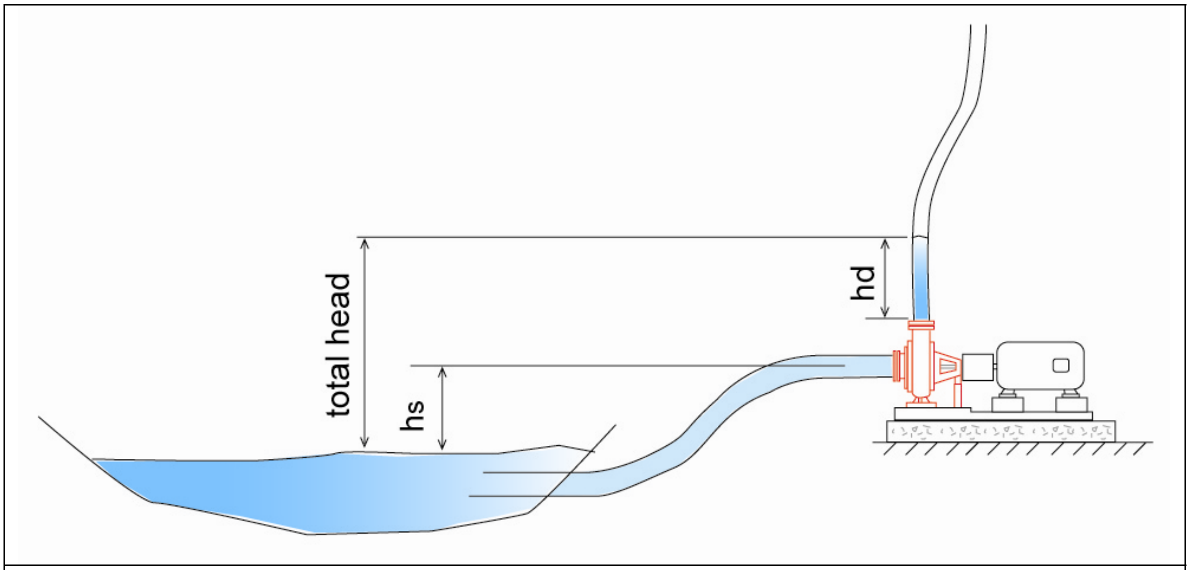

Figure 5 The effect of low level on the pump suction.

The pump will still produce the same total head but the discharge head will go down. This means you may not have enough pressure to run your devices and you may need to consider getting a pump with a higher total head.

When you buy a pump, you will try to find a pump that has the total head you require at the flow you require. In the example above the total head produced by the pump was at zero flow, nothing is coming out of the tube. Centrifugal pumps are like that, they can pump water up to a height and create pressure at the discharge without flow going through them; they are just sitting there churning up the same water. *Note: it is not advisable to keep a pump running at zero flow for long periods of time.* The total head at zero flow is the maximum head also called the shut-off head, the total head decreases as the flow increases.

The plot of total head vs. flow for a centrifugal pump is very typical and it looks like this:

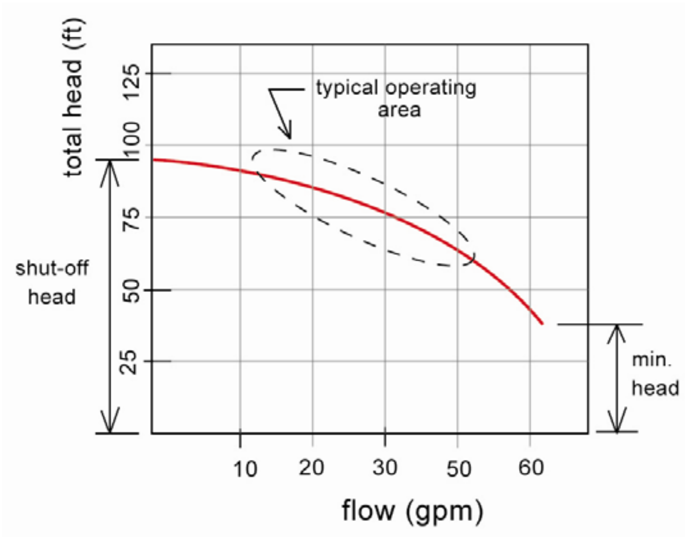

Figure 6 Typical curve of total head vs. flow for a centrifugal pump.

To buy the correct pump for your application you first have to know what total head you need and at what flow rate. Follow these links to get a good idea on how to establish this, it's not difficult, and for home owners all you need is a couple of key pointers. The static head requirement is often the main component of total head, how high do you need to get the water based on the level of the suction tank? The next important consideration is how much friction do you need to allow for, this depends on the length of pipes and their diameter. The sum of the static head and friction head will give you the total head. The total head and your flow requirement will allow you to buy the right pump. You are looking for a pump to operate in the area shown in Figure 6.

When you look at the curve in Figure 6 it seems counter-intuitive that the maximum flow should occur at the minimum head. After all if you have a high head, which means a high pressure, shouldn't that push more water through the pipes. Think of it this way, the pump is always turning at the same speed regardless of whether the pipe is fully open or whether the valve at the end of the pipe is closed. When you close the valve the energy that the pump imparts to the water now goes into increasing the pressure since there is no place for the water to go. As pressure increases, total head increase and reaches a maximum at zero flow.

This is also why it is not a good idea to let a pump run with a discharge valve closed. The energy that goes into the water to produce pressure also produces heat and since there is no flow the heat cannot be dissipated, the end result can be a very hot pump indeed. All residential pump systems have a pressure switch, the switch cuts off the power to the pump when the pressure gets to a certain level.

Since total head is the difference between the discharge head and the suction head using head makes it easy to evaluate the suction head,

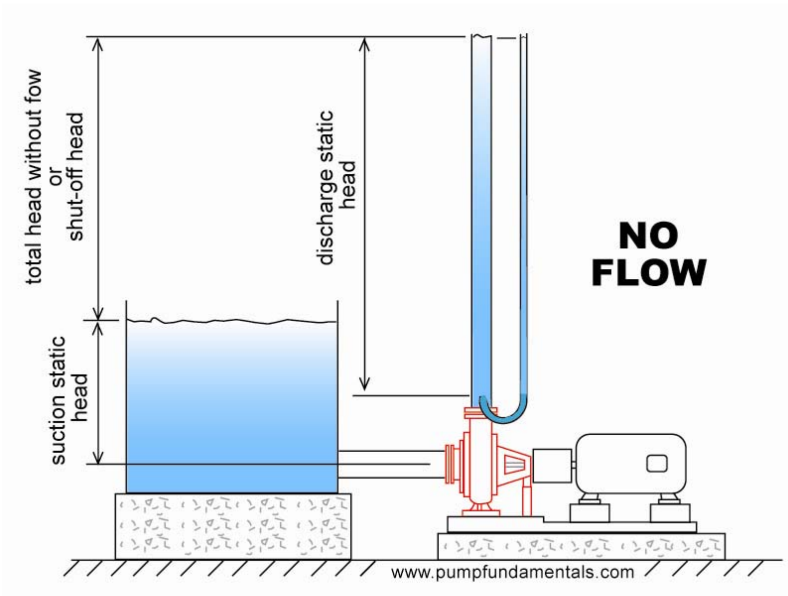

Figure 7 Total head with no flow.

We need to make a distinction between a system with no flow and a system with flow. The difference is flow produces friction.

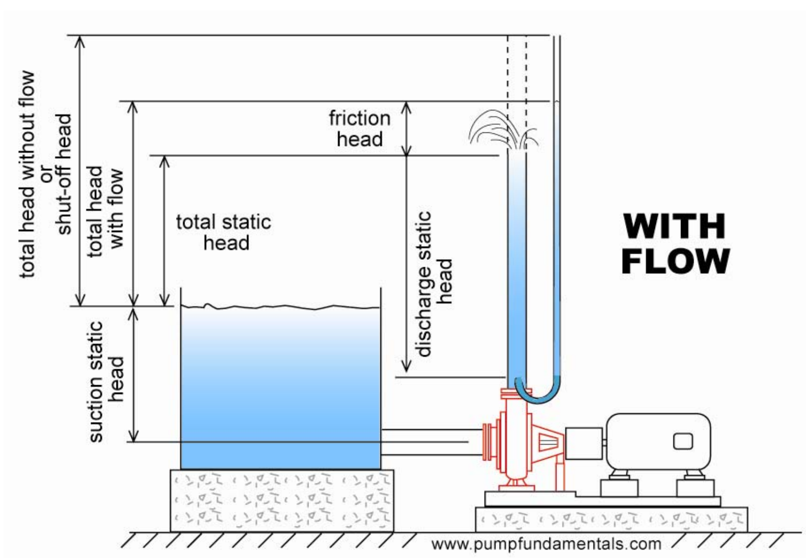

Figure 8 Total head with flow.

Assume we have a system such as in Figure 7 where the discharge pipe is high enough that no flow can come out. In other words the pump cannot develop enough pressure to push water out of the pipe. Now suppose you cut a piece off the pipe end, this will lower the discharge head or the height at which the liquid is pumped as in Figure 8. This lowers the overall total head and flow starts to come out of the pipe. Since we have flow we now have friction and the influence of friction is known as friction head. This is exactly as predicted by the curve in Figure 6. In a system with flow, the total head is the difference between the discharge and the suction head plus the friction head and the sum is less then the shut-off head.

Suction and discharge static head are often combined. The difference between discharge and suction static head is the total static head (see Figure 8).

Short quiz:

1. What happens to the pressure at the discharge of the pump when the flow increases, or when the discharge valve goes from a fully closed position to fully open?

   It decreases.

2. What are the 2 major components of total head?

   Static head and friction head.

3. If you increase the total static head what will happen to the flow?

   It will decrease.

4. If you decrease the discharge static head, what will happen to the flow?

   It will increase.

Why use the term head as opposed to pressure? There are some pump manufacturer's that use pressure (i.e. differential pressure or difference of pressure at the discharge vs. the suction) to characterize their pumps but not many. Head is a very useful and practical term to use when evaluating a pump's capacity to do a job. Many pump applications involve pumping to a higher level. If you have to pump liquid up 30 ft and your pump doesn't have at least 30 feet of head then there is no chance that your system will work. Your pump will have to have at least 30 ft of total head plus the friction loss for you to get the require flow at the discharge point.

Also, head is independent of the type of liquid pumped as long as the viscosity is low and similar to water. If you are pumping sea water or some heavy acid, the head achieved by the pump in Figure 2 will be the same as that for water. The pressure at the discharge of the pump however will be higher. The explanation for this involves a little bit of math, nothing heavy, and the realization that head is a form of energy (potential energy) just like a cyclist at the top of a hill has potential energy. Also pressure is another form of energy like soda pop under pressure in a can. The explanation can be found here.