Estimating Pump Head in a Closed System

We are asked time and again “what is the simplest way to estimate pump head”? Surprisingly this question comes from young engineers and contractors alike. Let’s start at the beginning, with some definitions.

Pump Head is the total resistance that a pump must overcome. It consists of the following components:

- **Static Head**: Static head represents the net change in height, in feet, that the pump must overcome. It applies only in open systems. Note that in a closed loop system, the static head is zero because the fluid on one side of the system pushes the fluid up the other side of the system, so the pump does not need to overcome any elevation.

- **Friction Head**: This is also called pressure drop. When fluid flows through any system component, friction results. Components causing friction include boilers, chillers, piping, heat exchangers, coils, valves, and fittings. The pump must overcome this friction. Friction head is usually expressed in units called “feet of head.” A foot of friction head is equal to lifting the fluid one foot of static height.

- **Pressure Head**: When liquid is pumped from a vessel at one pressure to a vessel at another pressure, pressure head exists. Common applications include condensate pumps and boiler feed pumps. Condensate pumps often deliver water from an atmospheric receiver to a deaerator operating at 5 PSIG, meaning that in addition to the other heads, the pump must overcome a pressure head of 5 PSIG. One PSIG equals 2.31 feet, so the differential head in this application is $5 \times 2.31 = 11.6$. Pressure head is a consideration only in some open systems.

- **Velocity Head**: Accelerating water from a standstill or low velocity at the starting point to a higher velocity at an ending point requires energy. In closed systems the starting point is the same as the ending point. Therefore the beginning velocity equals the final velocity, so velocity head is not a consideration. In an open system, the velocity head is theoretically a consideration, but the pipeline velocities used in hydronics are so low that this head is negligible, and is ignored. (Note that the velocity head is defined by the formula $V^2/2g$ where $V$ is the fluid velocity in feet per second and $g$ is the gravitational constant 32 feet/second 2. Therefore at typical velocities of 2-6 fps, the velocity head is a fraction of a foot. Since head loss calculations are really estimates, this small figure becomes insignificant).

The term pump head however, has nothing to do with height. It is a term we use that is the circulator’s ability to overcome the friction that’s created when fluid
flows through a pipe. Once a system is filled with fluid – the pump merely has to overcome this friction. There are a few that struggle with this concept, but an easy way to think about it is that as water goes up one side of the loop – it also comes down the other side of the loop. The two cancel each other out – there is no lifting going on here. A good illustration is like a Ferris wheel. One car going up balances the other car coming down. These are in balance and the motor only has to overcome the friction in the bearings and we are off and spinning. The pump in a closed loop system in simple terms is like the motor on a Ferris wheel. All the pump has to do is overcome the friction that is created when the water rubs against the pipes – and that friction has nothing to do with height. In fact we could take a ten story building, size a pump for it, knock the building over on its side and we would still need the same exact pump. Pump head has to do with the friction caused by flow – and that is all. We have to have a pump with enough head to move the fluid through the longest circuit (or the one with the highest pressure drop in multiple zones). Pump head is based on the worst case.

If a pump is big enough to handle the longest run, or the run with the most resistance to flow, then it will also handle all the smaller runs. If we size the pump for more than this, it is a waste of energy and first cost and all you will get for your efforts is probably velocity noise in the piping.

There is another consideration when trying to estimate pump head. When water flows through a straight run of pipe, only the water on the outer edge of the flowing water touches the pipe, but when the fluid flows through an elbow or valve or some other fitting, the smooth flow becomes turbulent. When this happens more of the fluid comes into contact with that particular fitting, and this increases the required pump head. As an example, you can go thru nearly 9 feet in a straight run of ¾” pipe with the same amount of energy it takes to go thru a ¾” check valve. (A ¾” elbow is equivalent to nearly 4-1/2’ of straight pipe).

After a while this extra friction adds up and we need to make allowances for it. And if you are retro-fitting an existing system – you may not be able to see all the fittings in walls, above ceilings etc. A good rule of thumb to handle these “extras” is to take the longest run and add 50% to get what is termed the Total Equivalent Length of the pipe. Another rule of thumb – when we are sizing a system – is to design our piping for the flow required without giving us velocity noise. It adds unnecessary expense to oversize the piping (to keep noise downs) but under sizing to save piping costs will give us velocity noise. We want to size our piping for the maximum flow rate that will fit through our piping without making velocity noise and to do this the required pump head will be 4 feet for every 100 feet of Total Equivalent Length. This can be estimated as follows:

**Simple Pump Head Rule of Thumb:**

1. Measure the longest run of pipe in feet
2. Add 50% to this
3. Multiply by .04
This is pretty basic – but the principle applies to large multizone systems as well. We need a pump that can overcome the resistance to flow in the worst case zone.

There are other pump basics that can be reviewed in an easy multi-media format on line website for Armstrong Pumps.

You can go to www.armstrongpumps.com and click on the link to the “Knowledge Exchange” and follow the instructions for free on line learning. You can also earn Professional Development Hours for viewing these modules in your free time and passing a short quiz afterwards. For more information, please contact your Michigan Air Products sales representative.