



# Design Considerations for Hydronic Pumping Systems

An Online Continuing Education Course for Engineers

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**Credit: 5 Hours / 5 PDH / 5 CPD**

## Design Considerations for Hydronic Pumping System

### Abstract

In a pumping system, the objective, in most cases, is either to transfer a liquid from a source to a required destination, e.g. filling a high level reservoir, or to circulate liquid around a system for heat transfer. A pressure is needed to make the liquid flow at the required rate and this must overcome head 'losses' in the system. Losses are of two types: static and friction head. Most systems have a combination of static and friction head.

The most common application for hydronic (water) pumps is for fresh/raw water supply, process heat exchangers/boilers, cooling & chilled water systems, heating and steam systems, wastewater treatment and drainage. Although many pump types are available to the designer, the most common type of pump is the centrifugal pump. Among centrifugal pumps, there are many styles: single or double suction, in line or base mounted, close or flexible coupled and vertical turbine pumps. All have their specific uses and wide overlap. So in many applications, more than one pump style could be used. However in general:

1. Higher flow rates are better served by double suction pump in which axial forces tend to balance one another.
2. In line mounted pumps range from very small, fractional horsepower circulators to large pumps capable of handling several thousand GPM.
3. Close couple pumps are more compact than flexible coupled pumps, but they require motors with special faces that can be bolted up to the pump mounting bracket and longer shafts for mounting the impeller.
4. Vertical split casing, double suction pumps might serve best where the installation footprint plus the access space required to service the pump is tight.
5. Using a vertical turbine pump is a way to avoid suction lift situation that can be difficult for a standard centrifugal pump. For example, a vertical turbine pump is particularly well suited to application such as a cooling tower in which water from a tower basin must be elevated to the condenser and then to the tower.

Before we jump to system design opportunities, let's refresh few fundamentals. Don't bother on the sequence of listing; concepts get clear as you proceed.

Sno.	PUMP TERMINOLOGY
1	<p><b>Pump Energy Consumption</b></p> <p>The energy consumption of the pumps depend on two factors:</p> $\text{BHP} = \text{GPM} \times \text{TDH} \times \text{SG} / (3960 \times \text{Efficiency})$ <p>Where</p> <ul style="list-style-type: none"> <li>• BHP = brake horse power</li> <li>• GPM = water flow, gallons per minute</li> <li>• TDH = Total Dynamic Head, feet</li> <li>• SG = Specific Gravity, for water it is 1</li> <li>• Efficiency = Pump efficiency from its pump curves for the water flow and TDH</li> </ul> <p>Power consumption, KWH = KW input x operating hours</p> <p>The KW input will depend on the motor efficiency and pump power requirement. (1 KW = 0.746 HP)</p>
2	<p><b>Pump Affinity Laws</b></p> <p>Effect on centrifugal pumps of change of speed or impeller diameter</p> <p>Capacity varies directly as the speed or impeller diameter (GPM x rpm x D)</p> <p>Head varies as the square of speed or impeller diameter (GPM x rpm<sup>2</sup> x D<sup>2</sup>)</p> <p>BHP varies as the cube of the speed or impeller diameter (BHP x rpm<sup>3</sup> x D<sup>3</sup>)</p>
3	<p><b>What is head?</b></p> <p>The term head is commonly taken to mean the difference in elevation between the suction level and the discharge level of the liquid being pumped. Although this is partially correct, it does not include all of the conditions that should be included to give an accurate description.</p>
4	<p><b>What is suction lift?</b></p>

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	<p>A Suction Lift exists when the liquid level is below the centerline of the pump suction.</p> <p>The term static suction lift is used to describe the vertical distance from the pump centerline down to the free level of the liquid source below the pump.</p> <p>Typically, atmospheric pressure limits vertical suction lift of pumps to 25 feet at sea level. This does not mean that you are limited to 25 feet of pipe, you could use upwards of 300 feet of suction pipe, so long as the liquid source is not lower than 25 feet below the pump centerline.</p>
5	<p><b>What is suction head?</b></p> <p>The static suction head exists if the liquid source is located above the centerline of the pump. This may also be referred to a flooded suction.</p> <p>The term static suction head is used to describe the vertical distance from the centerline of the pump up to the free level of the liquid source above the pump.</p>
6	<p><b>What is dynamic suction lift?</b></p> <p>The dynamic suction lift includes static suction lift, friction head loss and velocity head.</p>
7	<p><b>What is dynamic suction head?</b></p> <p>The dynamic suction head includes static suction head minus friction head and velocity head.</p>
8	<p><b>What is Static Head?</b></p> <p>Static head is simply the difference in elevations of the outlet vs. the inlet point of the system or height of the supply and destination reservoirs. The static head is the potential energy of the system. Static head is independent of flow and pipe diameter.</p>
9	<p><b>What is the friction head?</b></p> <p>Friction head is the energy loss due to resistance to fluid movement and is</p>

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	<p>proportional to the square of the flow rate, pipe diameter and viscosity. The Hazen William, Colebrook and Darcy equations are the most common method of calculating friction head. Friction head is expressed in lbs/sq inch (psi) or feet of liquid</p> <p><i>A closed loop circulating system without a surface open to atmospheric pressure, would exhibit only friction losses.</i></p>
10	<p><b>What is Discharge Head?</b></p> <p>This is the vertical distance that you are able to pump the liquid. Again say your pump is rated for a maximum head of 18 feet, this does not mean that you are restricted to 18 feet of pipe, you could use 300 feet, so long as the final discharge point is not higher than 18 feet above the liquid being pumped.</p>
11	<p><b>What is Dynamic head?</b></p> <p>The dynamic head includes the dynamic discharge head plus dynamic suction lift or minus dynamic suction head into one computation.</p>
12	<p><b>What is Total Head?</b></p> <p>Total Head is the difference between the head at the discharge vs. the head at the inlet of the pump. It is sum of discharge head, suction lift and friction loss.</p> <p>Total Head is a measure of a pump's ability to push fluid through a system. This parameter (with the flow) is a more useful term than the pump discharge head since it is independent of a specific system.</p> <p>The Total Head produced by a pump is independent of the nature of the liquid (i.e. specific gravity or density) as is the head in any part of the system.</p>
13	<p><b>What information is required to determine the Total Head of a pump?</b></p> <p>Flow rate through the pump and throughout the system.</p> <p>Physical parameters of the system: length and size of pipe, number of fittings and type, elevation of inlet and outlet.</p> <p>Equipment in the system: control valves, heat exchangers etc.</p>

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	Fluid properties: temperature, viscosity and specific gravity
14	<p><b>Is the head at the discharge side of the pump equal to the Total Head?</b></p> <p>No, the Total Head is the difference in head between the discharge and the suction.</p>
	<p><b>What is Velocity head?</b></p> <p>Velocity head is the head corresponding to the velocity of the fluid. It is given by the simple formula <math>\frac{V^2}{2g}</math>. For a velocity of 32.16 ft/sec, the velocity head is 0.16 ft, which is a very small energy loss.</p>
16	<p>Water at 60°F has a specific weight of 62.4 lb/ft<sup>3</sup>. The head corresponding to a pressure of 1.0 psi is <math>\frac{2.31 \times P_w}{\rho}</math> ft. For a pressure of 1.0 psi, the head is 2.31 ft. The relationship between head and pressure is given by the formula <math>H = \frac{2.31 \times P_w}{\rho}</math>.</p>
17	<p>The difference between head and pressure is that head is a measure of energy per unit weight of fluid, while pressure is a measure of force per unit area. Head is usually expressed in feet, while pressure is usually expressed in pounds per square inch.</p>
18	<p><b>What is the difference between head and pressure?</b></p> <p>To start, head is not equivalent to pressure. Since the pump is a dynamic device, it is convenient to consider the head generated rather than the pressure. The term "Head" is usually expressed in feet whereas pressure is usually expressed in pounds per square inch. The relationship between two is given by the formula <math>H = \frac{2.31 \times P_w}{\rho}</math>.</p>

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