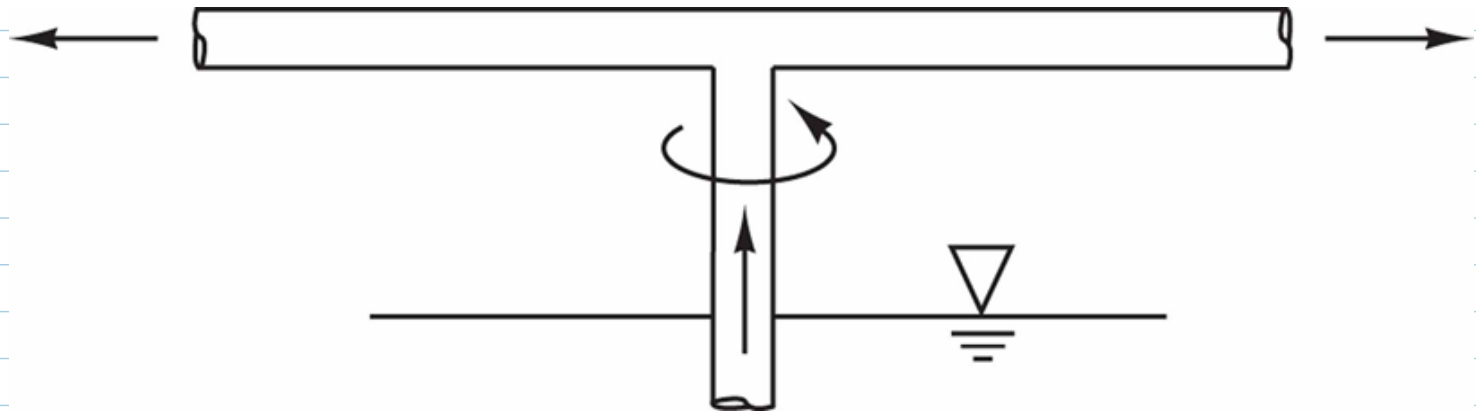
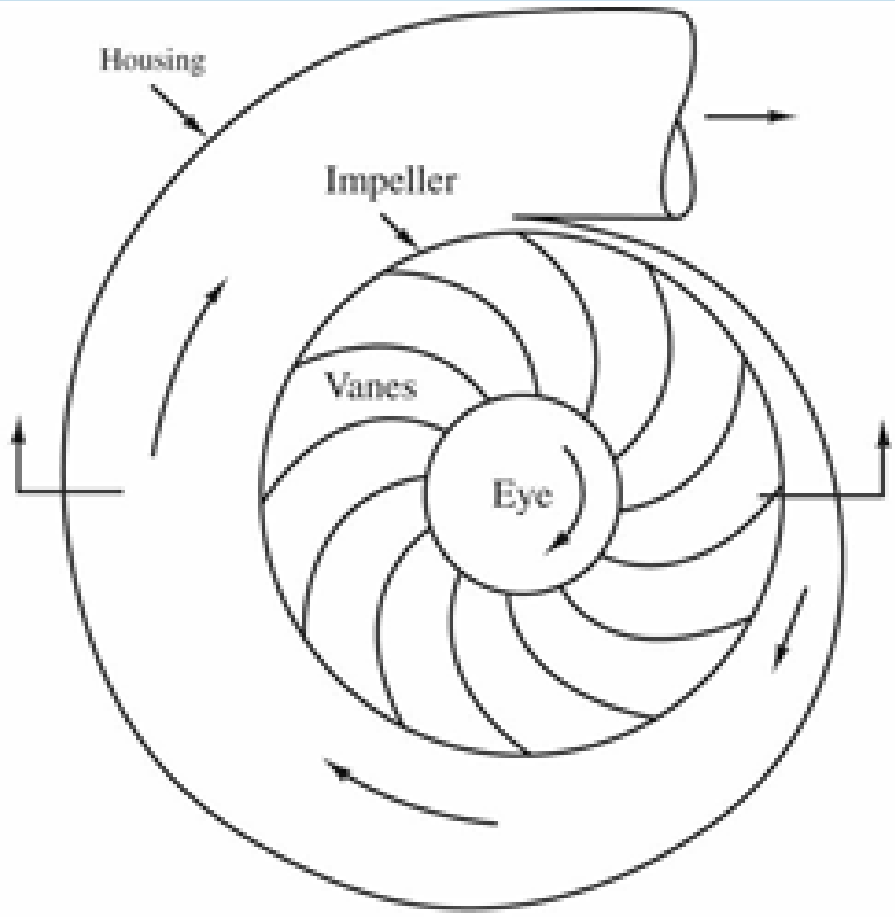
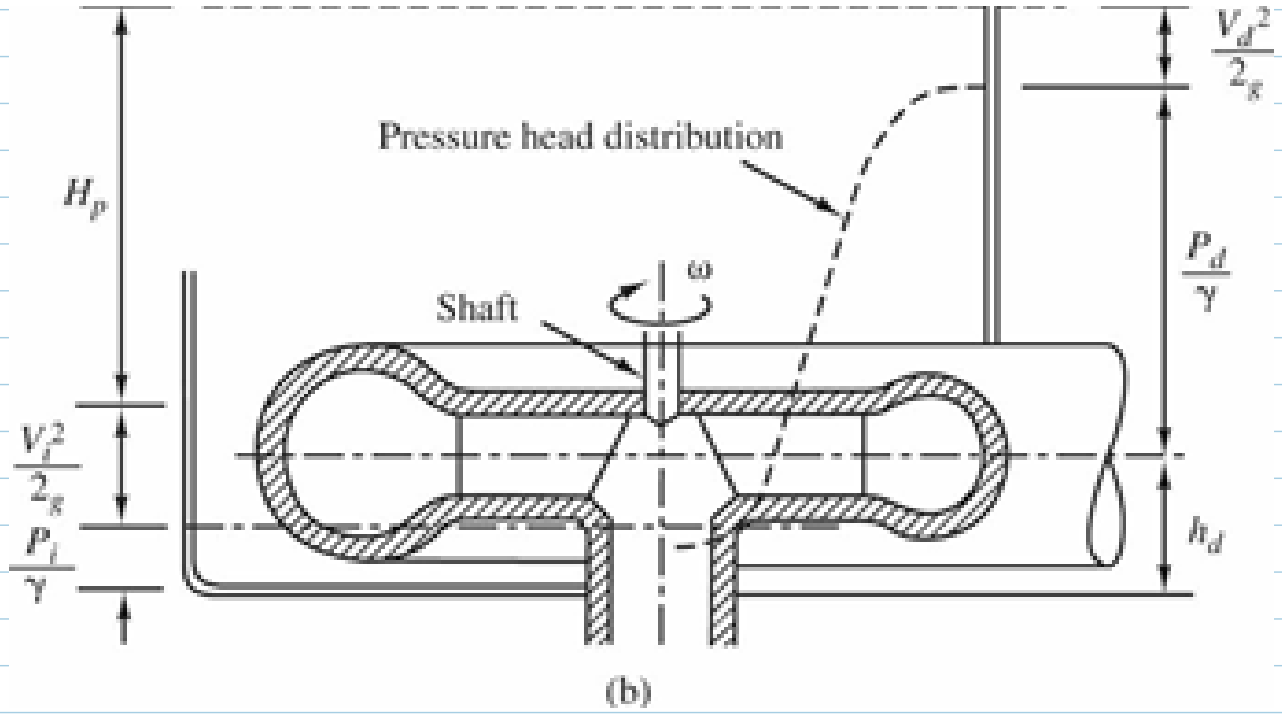
5.1Pumps

Sunday, September 12, 2010
10:34 AM

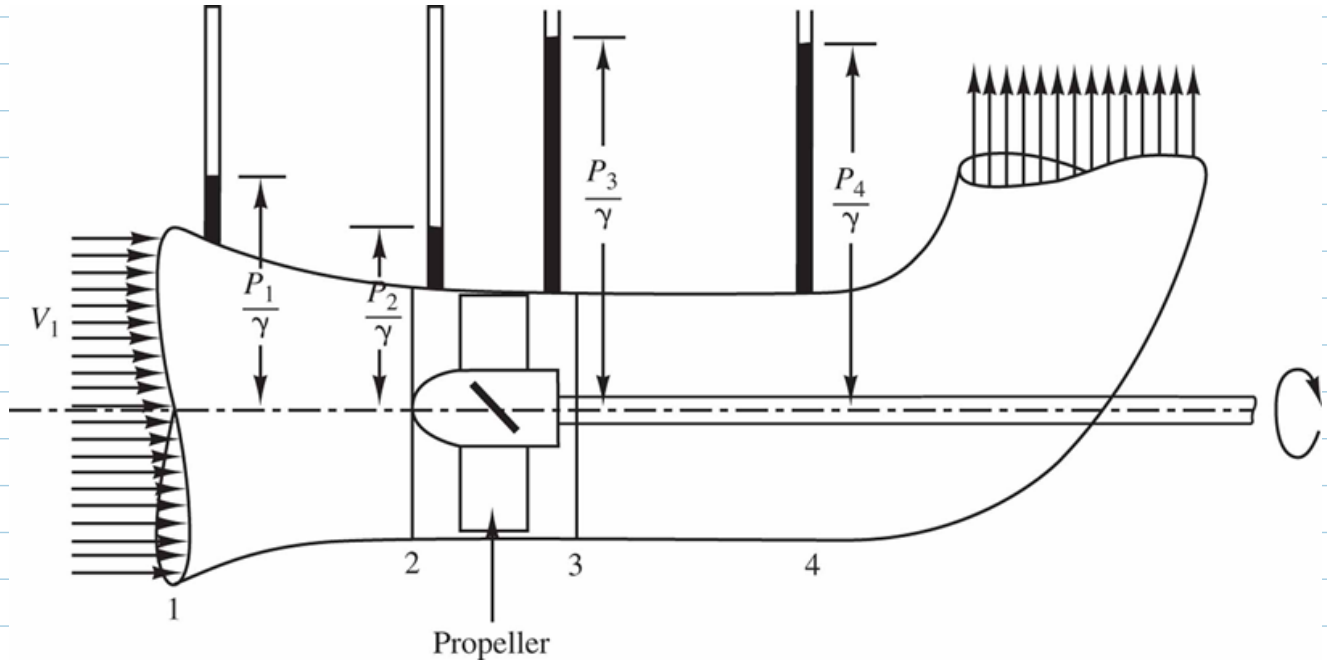




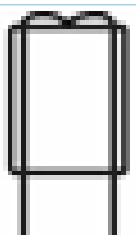
(a)

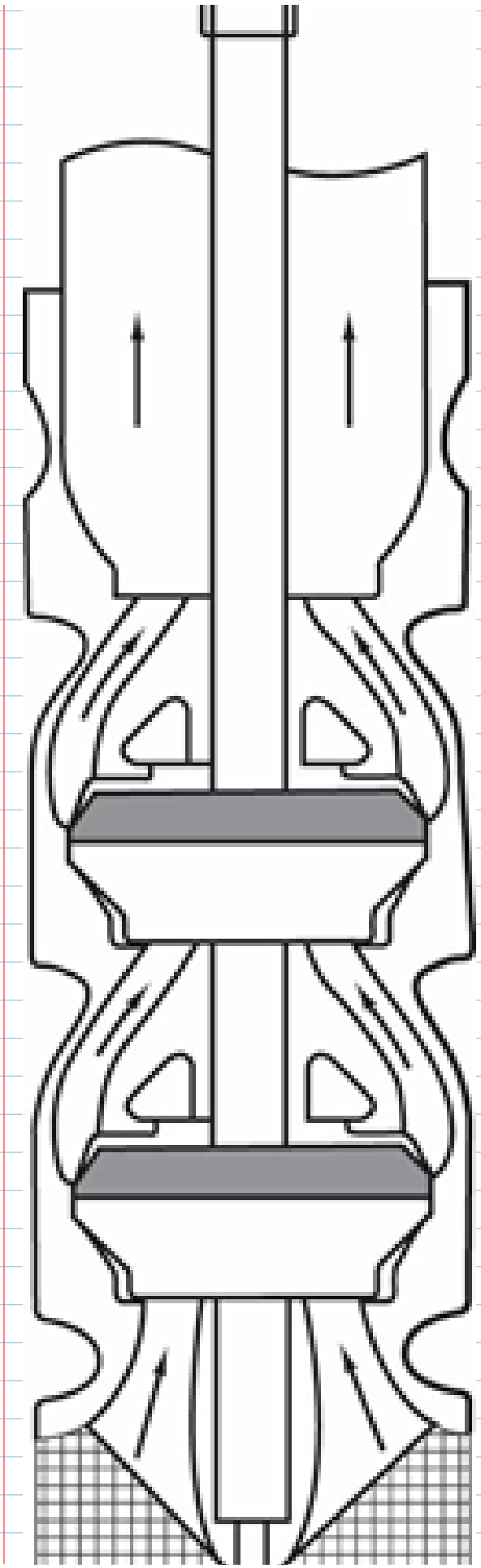


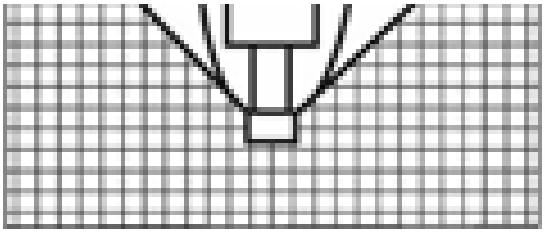
Propeller Pump



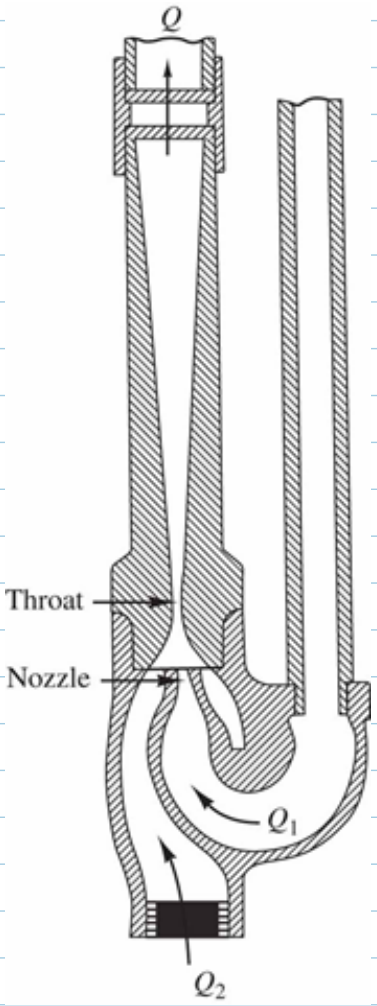
Multistage propeller pump







Jet pump



Pumps

Monday, September 10, 2007
12:35 PM

A **pump** is a device used to move liquids or slurries. A pump moves liquids from lower pressure to higher pressure, and overcomes this difference in pressure by adding energy to the system (such as a water system). A gas pump is generally called a compressor, except in very low pressure-rise applications, such as in heating, ventilating, and air-conditioning, where the operative equipment consists of *fans* or *blowers*.
Pumps work by using mechanical forces to push the material, either by physically lifting, or by the force of compression.

Pasted from <http://en.wikipedia.org/wiki/Pump>

Pumps fall into two major groups: rotodynamic pumps and positive displacement pumps. Their names describe the method for moving a fluid. Rotodynamic pumps are based on bladed impellers which rotate within the fluid to impart a tangential acceleration to the fluid and a consequent increase in the energy of the fluid. The purpose of the pump is to convert this energy into pressure energy of the fluid to be used in the associated piping system.

Pasted from <http://en.wikipedia.org/wiki/Pump>

A positive displacement pump causes a liquid to move by trapping a fixed amount of fluid and then forcing (displacing) that trapped volume into the discharge pipe.

Pasted from <http://en.wikipedia.org/wiki/Pump>

Centrifugal Pumps
Centrifugal Pumps are rotodynamic pumps which convert Mechanical energy into Hydraulic energy by centripetal force on

the liquid. Typically, a rotating impeller increases the velocity of the fluid. The casing, or volute, of the pump then acts to convert this increased velocity into an increase in pressure. So if the mechanical energy is converted into a pressure head by centripetal force, the pump is classified as centrifugal. Such pumps are found in virtually every industry, and in domestic service in developed countries for washing machines, dishwashers, swimming pools, and water supply.
A wide range of designs are available, with constant and variable speed drives. Horizontal shafts are the most common. Single-stage pumps are usual in the smaller ratings. Pumps with up to 11 stages are in service. A demanding duty is boiler feed, and today's designs are typically 3 - 4 stage, with speeds of up to 6000 r/min.
After motors, centrifugal pumps are arguably the most common machine, and they are a significant user of energy. Given design margins, it is not unusual for a pump to be found to be over-sized, having been selected poorly for its intended duty. Running a constant speed pump throttled causes energy waste. A condition monitoring test can detect this condition and help size a smaller impeller, either new, or by machining the initial one, to achieve great energy reduction.

Pasted from <http://en.wikipedia.org/wiki/Pump>

A **centrifugal pump** is a rotodynamic pump that uses a rotating impeller to increase the pressure of a fluid. Centrifugal pumps are commonly used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber, from where it exits into the downstream piping system

Pasted from <http://en.wikipedia.org/wiki/Centrifugal_pump>

A centrifugal pump works on the principle of conversion of the

kinetic energy of a flowing fluid (velocity pressure) into static pressure. This action is described by Bernoulli's principle. The rotation of the pump impeller accelerates the fluid as it passes from the impeller eye (centre) and outward through the impeller vanes to the periphery. As the fluid exits the impeller, a proportion of the fluid momentum is then converted to (static) pressure. Typically the volute shape of the pump casing, or the diffuser vanes assist in the energy conversion. The energy conversion results in an increased pressure on the downstream side of the pump, causing flow.

Pasted from <http://en.wikipedia.org/wiki/Centrifugal_pump>

Cavitation is a general term used to describe the behavior of voids or bubbles in a liquid. Cavitation is usually divided into two classes of behavior: inertial (or transient) cavitation and non-inertial cavitation. Inertial cavitation is the process where a void or bubble in a liquid rapidly collapses, producing a shock wave. Such cavitation often occurs in pumps, propellers, impellers, and in the vascular tissues of plants. Non-inertial cavitation is the process where a bubble in a fluid is forced to oscillate in size or shape due to some form of energy input, such as an acoustic field. Such cavitation is often employed in ultrasonic cleaning baths and can also be observed in pumps, propellers etc.

Pasted from <http://en.wikipedia.org/wiki/Cavitation>

Pump Curves

Sunday, September 12, 2010
10:39 AM

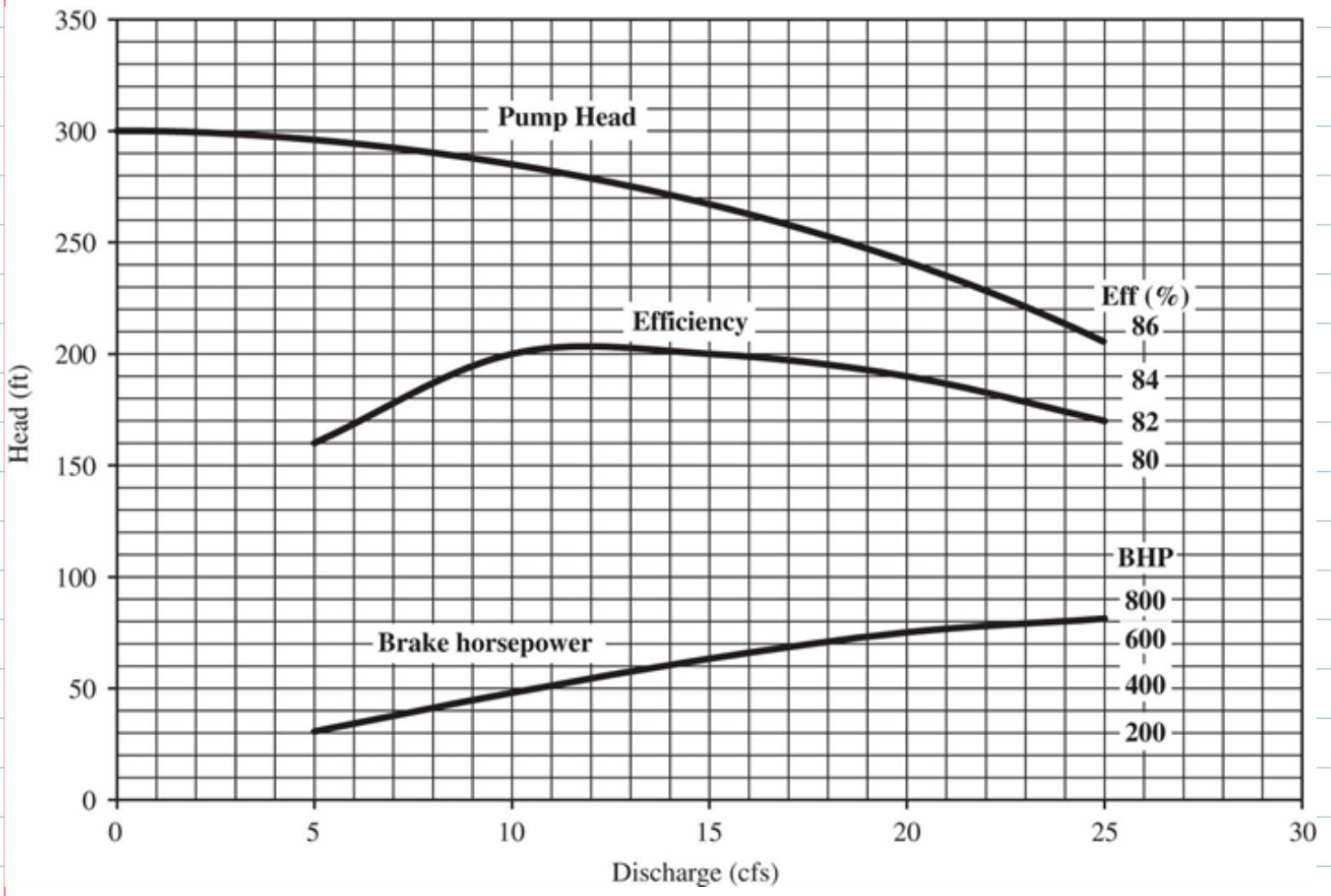
Pump performance curves are obtained from manufacturer

Discharge decreases with increasing head

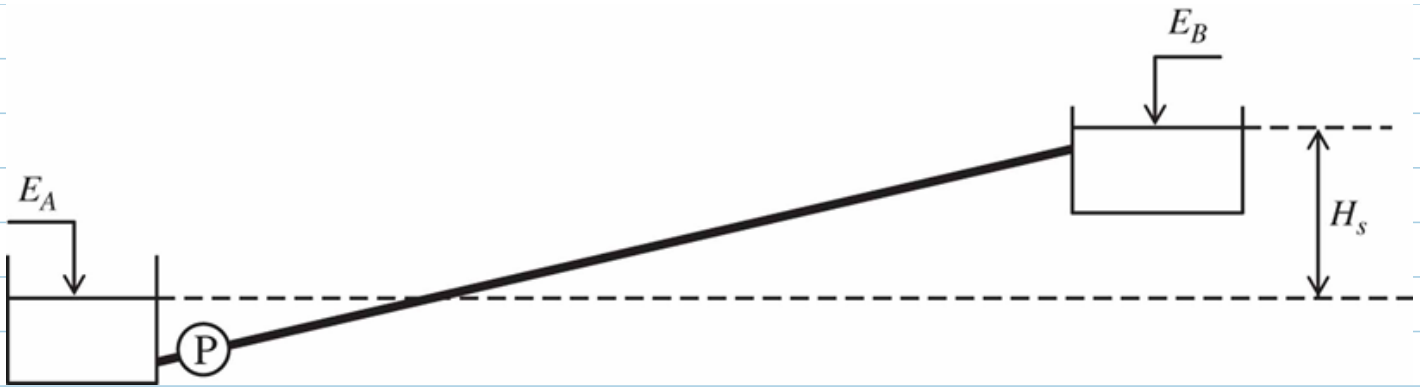
Efficiency is input/output energy, pumps have an optimal efficiency

Brake horsepower in the power input required by the pump

Discharge at maximum efficiency is the rated discharge



Consider a simple system with a pump



Energy equation on simple system gives (show steps)

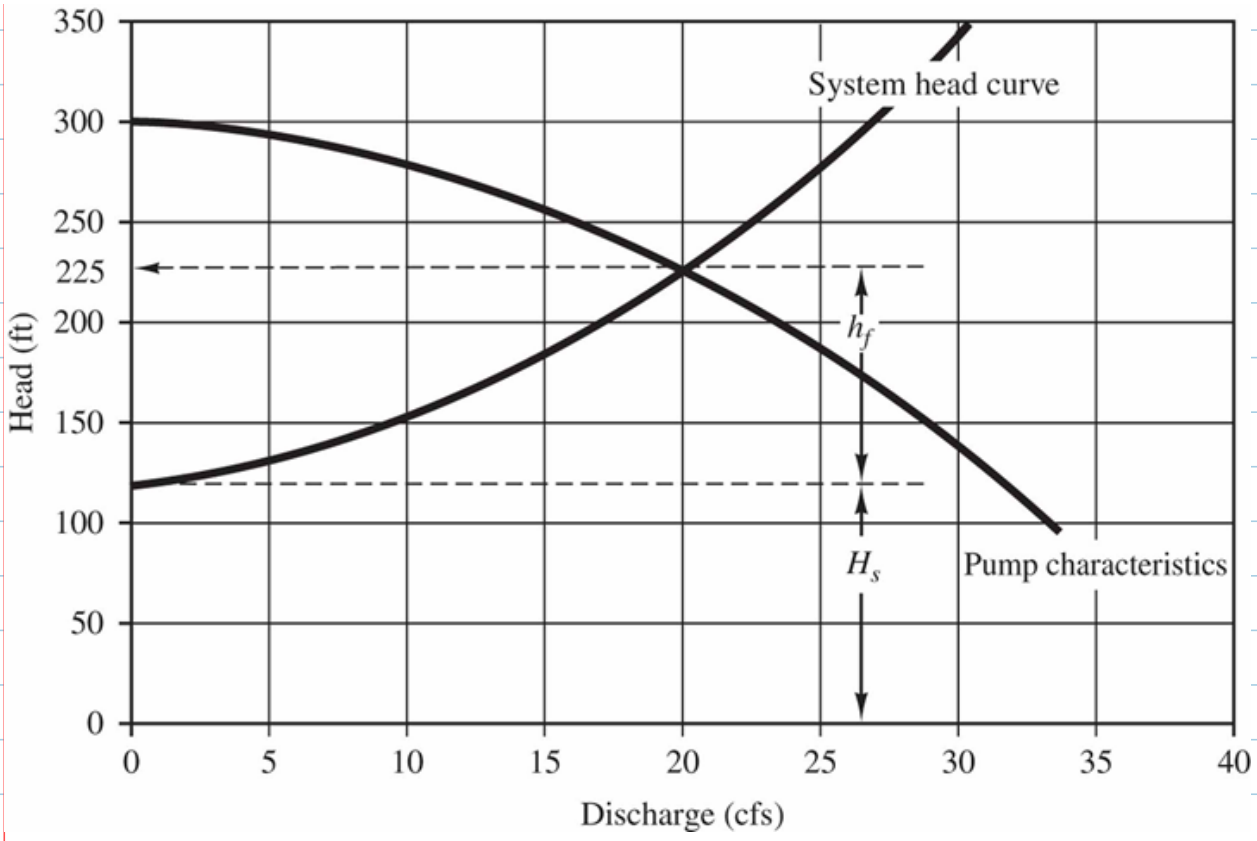
$z_1 + h_{pump} = z_2 + h_{loss}$

z_1-

$Z1\text{-}z2 + h_{pump} = V2/2g\ (f\ L/D)$ solving for h_{pump} gives:

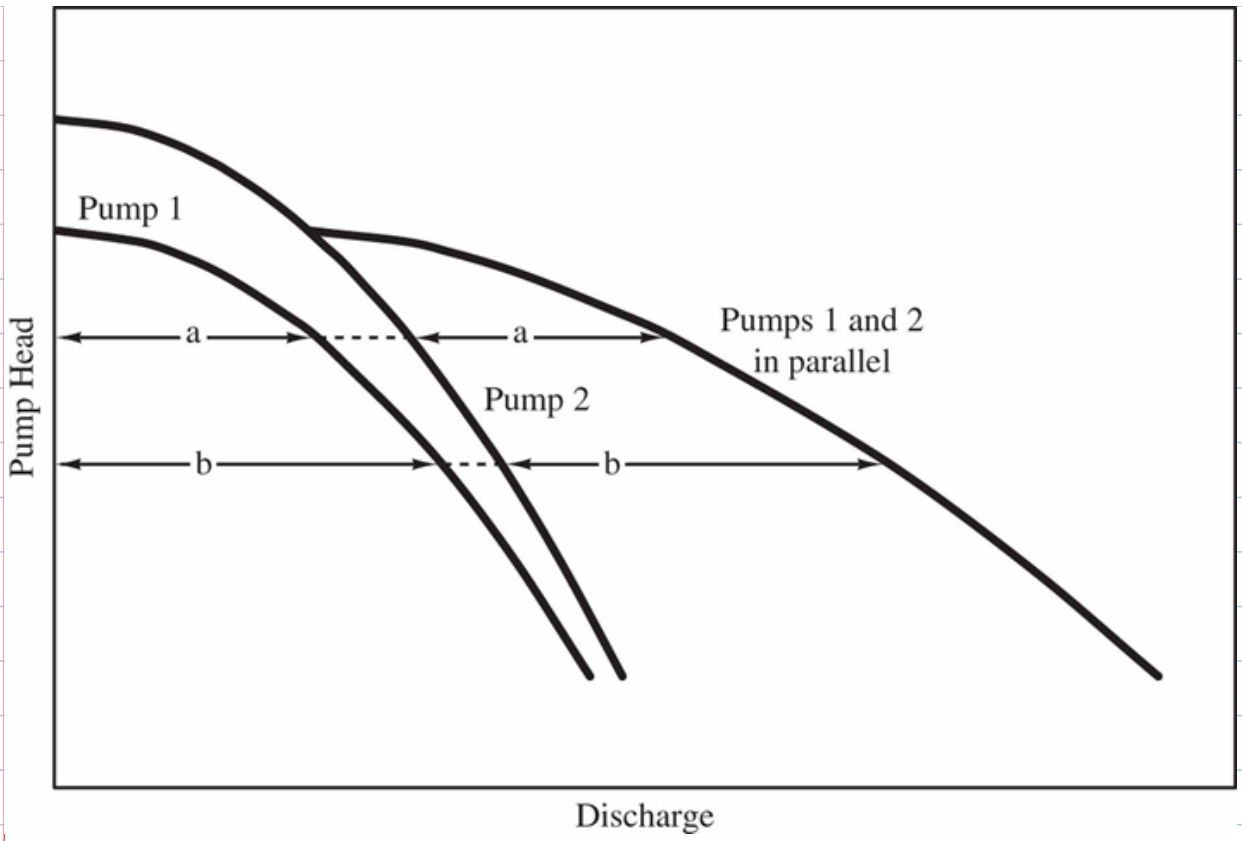
So the needed head from the pump increases with velocity and thus discharge, squared

this is called the system curve

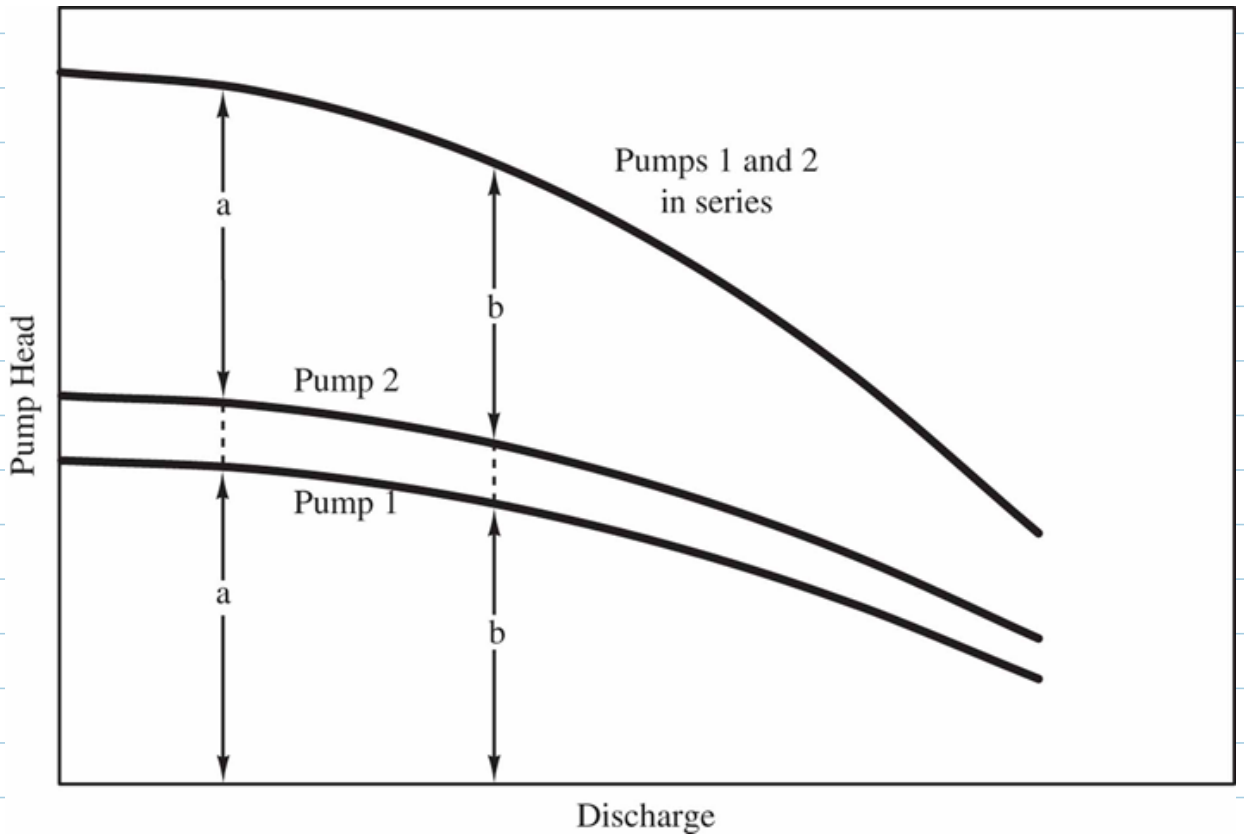


If we buy any old pump and insert it, the system will operate where the pump curve and system curve intersect (see above)

pumps in parallel - sum the discharge



pumps in series, sum the pump head


Pump Head
Pumps 1 and 2
in series
Pump 2
Pump 1
a
b
a
b
Discharge

Positive Displacement Pumps

Sunday, September 12, 2010
10:26 AM

A **positive displacement pump** is one in which a definite volume of liquid is delivered for each cycle of pump operation. This volume is constant regardless of the resistance to flow offered by the system the pump is in, provided the capacity of the power unit driving the pump or pump component strength limits are not exceeded. The positive displacement pump delivers liquid in separate volumes with no delivery in between, although a pump having several chambers may have an overlapping delivery among individual chambers, which minimizes this effect. The positive displacement pump differs from centrifugal pumps, which deliver a continuous flow for any given pump speed and discharge resistance.

Positive displacement pumps can be grouped into three basic categories based on their design and operation. The three groups are reciprocating pumps, rotary pumps, and diaphragm pumps.

Screen clipping taken: 9/12/2010 10:27 AM

All positive displacement pumps operate on the same basic principle. This principle can be most easily demonstrated by considering a reciprocating positive displacement pump consisting of a single reciprocating piston in a cylinder with a single suction port and a single discharge port as shown in Figure 12. Check valves in the suction and discharge ports allow flow in only one direction.

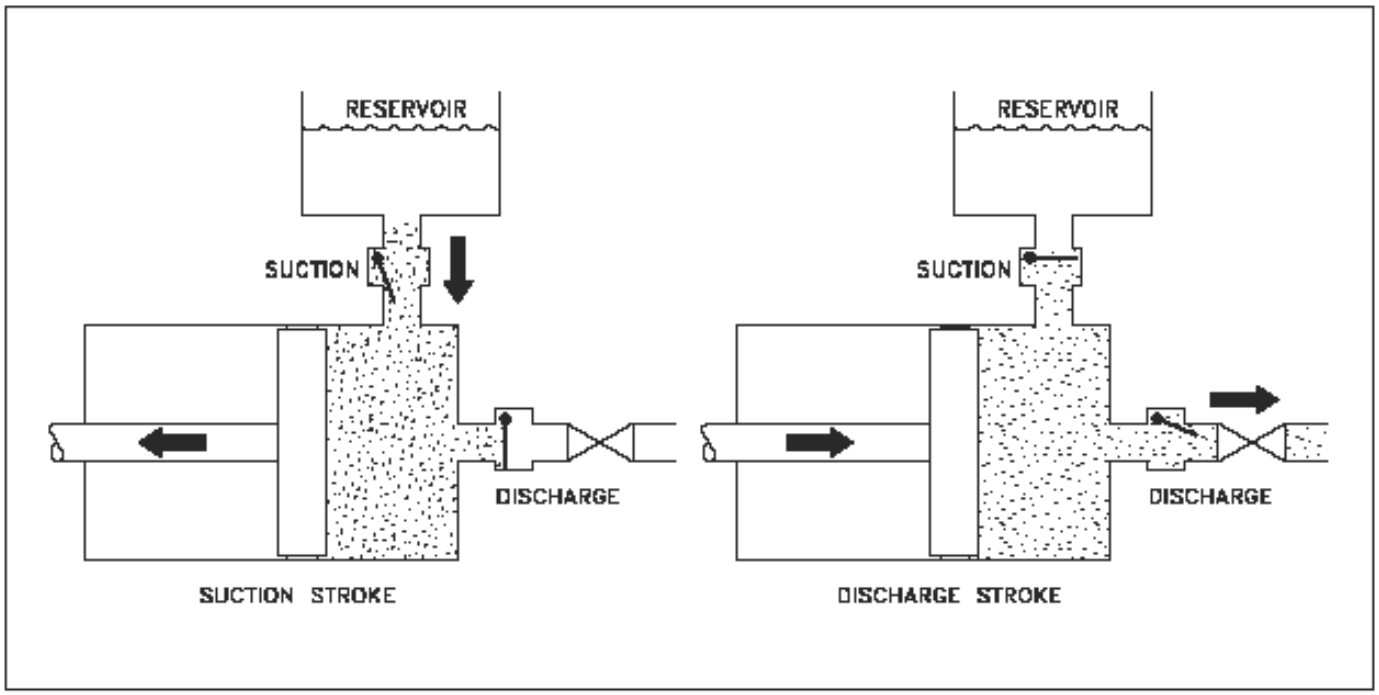


Figure 12 Reciprocating Positive Displacement Pump Operation

During the suction stroke, the piston moves to the left, causing the check valve in the suction line between the reservoir and the pump cylinder to open and admit water from the reservoir. During the discharge stroke, the piston moves to the right, seating the check valve in the suction line and opening the check valve in the discharge line. The volume of liquid moved by the pump in one cycle (one suction stroke and one discharge stroke) is equal to the change in the liquid volume of the cylinder as the piston moves from its farthest left position to its farthest right position.

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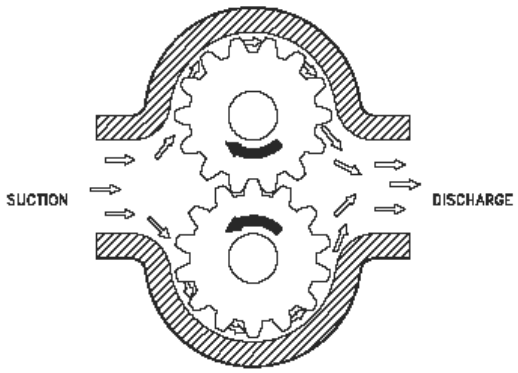

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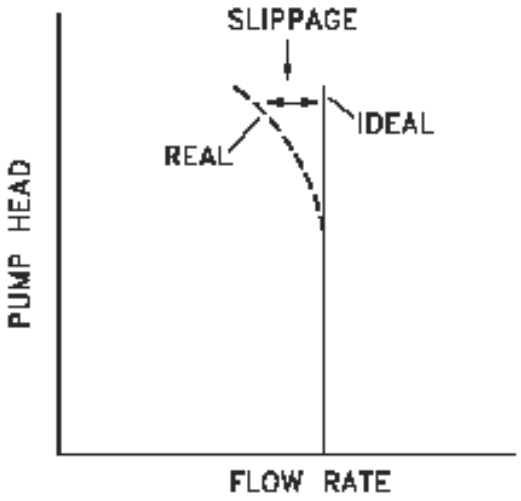
Positive displacement pumps deliver a definite volume of liquid for each cycle of pump operation. Therefore, the only factor that effects flow rate in an ideal positive displacement pump is the speed at which it operates. The flow resistance of the system in which the pump is operating will not effect the flow rate through the pump. Figure 21 shows the characteristic curve for a positive displacement pump.

The dashed line within the illustration below, shows actual positive displacement pump performance. This line reflects the fact that as the discharge pressure of the pump increases, some amount of liquid will leak from the discharge of the pump back to the pump suction, reducing the effective flow rate of the pump. The rate at which liquid leaks from the pump discharge to its suction is called slippage.



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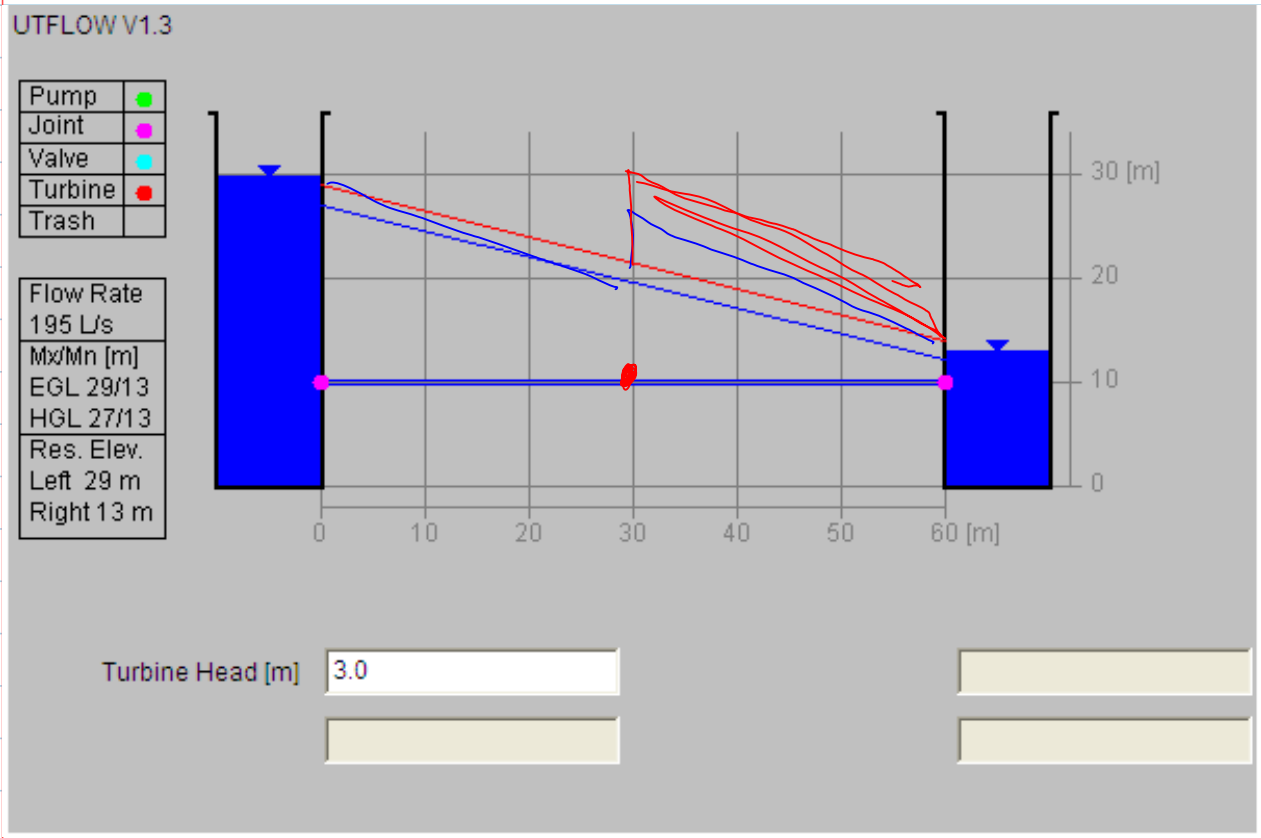
UTFLOW

Tuesday, September 11, 2007
10:44 AM

http://www.ce.utexas.edu/prof/maidment/gishydro/ferdi/webedu/utflow/utflow.html



UTFLOW - Pipe System EGL and HGL Visualization Tool.
http://www.ce.utexas.edu/prof/maidment/gishydro/ferdi/webedu/utflow/utflow.html
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System and Pump Curves

Tuesday, September 18, 2007
8:32 AM

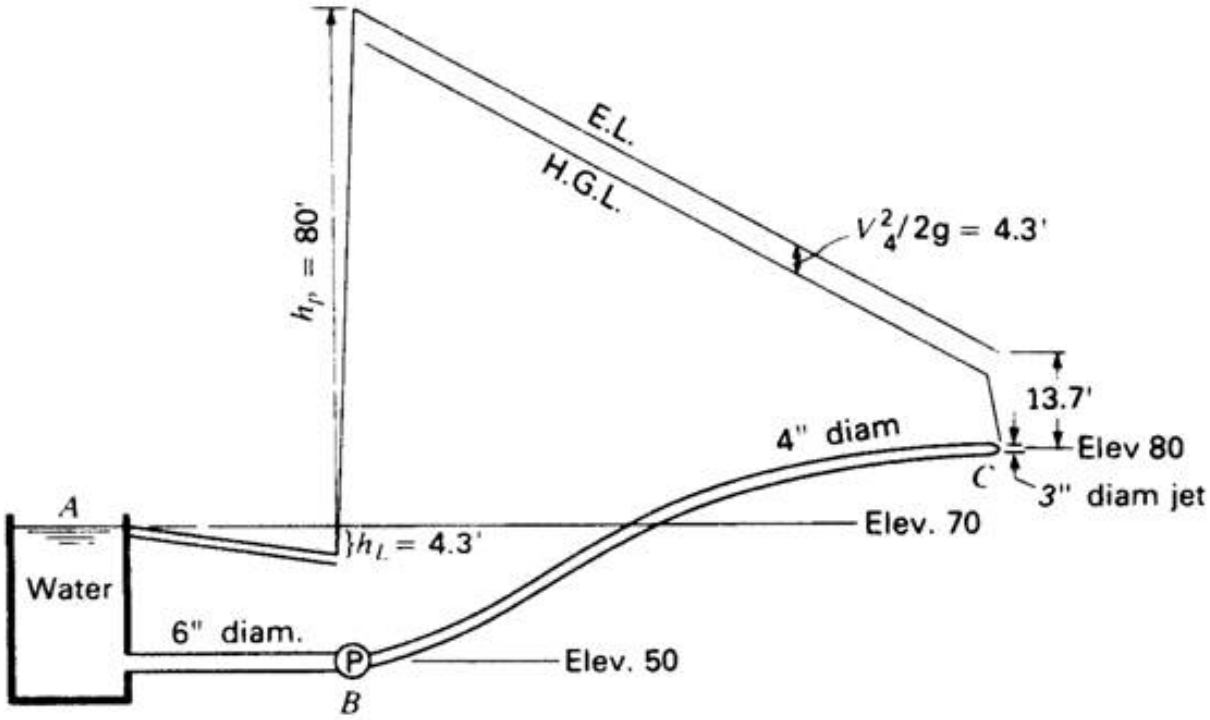
Figure below shows a system with two potential pumps, what is the operating point for each?

To find operating point:

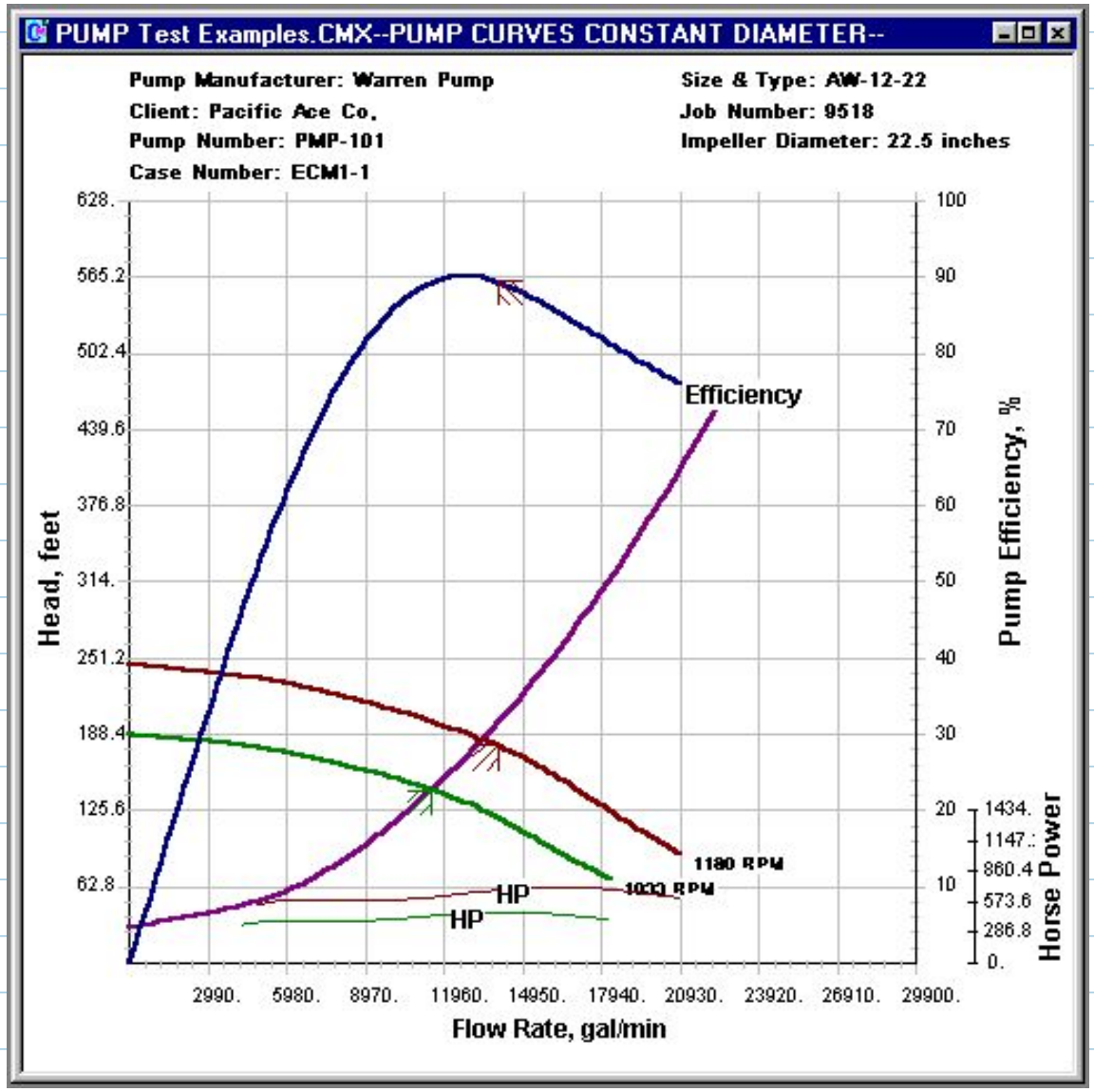
a) obtain pump curve from manufacturer, pumps pump less water at higher heads
b) calculate the system curve, the system curve is an equation that tells how much water flows through a pipe system as a function of the head (energy per unit weight) added by the pump.

Energy efficiency is maximized when the operation point (intersection of pump and system curves) is at the point of maximum pump efficiency

Here is a system with a pump; the system curve shows how much water flows through the system with hp changes from the 80ft shown in the figure:



Manufacturers test pumps by measuring how much water they pump when the head loss across the pump changes



a) plot a curve of flow rate as a function of pump head added for the pipe system of interest; as the pump supplies greater head the flow rate through the system increases, because head loss is "almost" proportional to velocity squared this looks like and $y=x^2$ curve

b) obtain a curve of the head a pump can produce versus

the flow rate from the pump manufacturer; as flow rate increases the pump supplies less head "it can't keep up"

c) the intersection of the two curves is where the system will perform.

d) another concern is energy efficiency; pumps have an optimum point of efficiency = work done/ energy input

Quiz: why is the efficiency the lowest where the pump head produced is the highest?

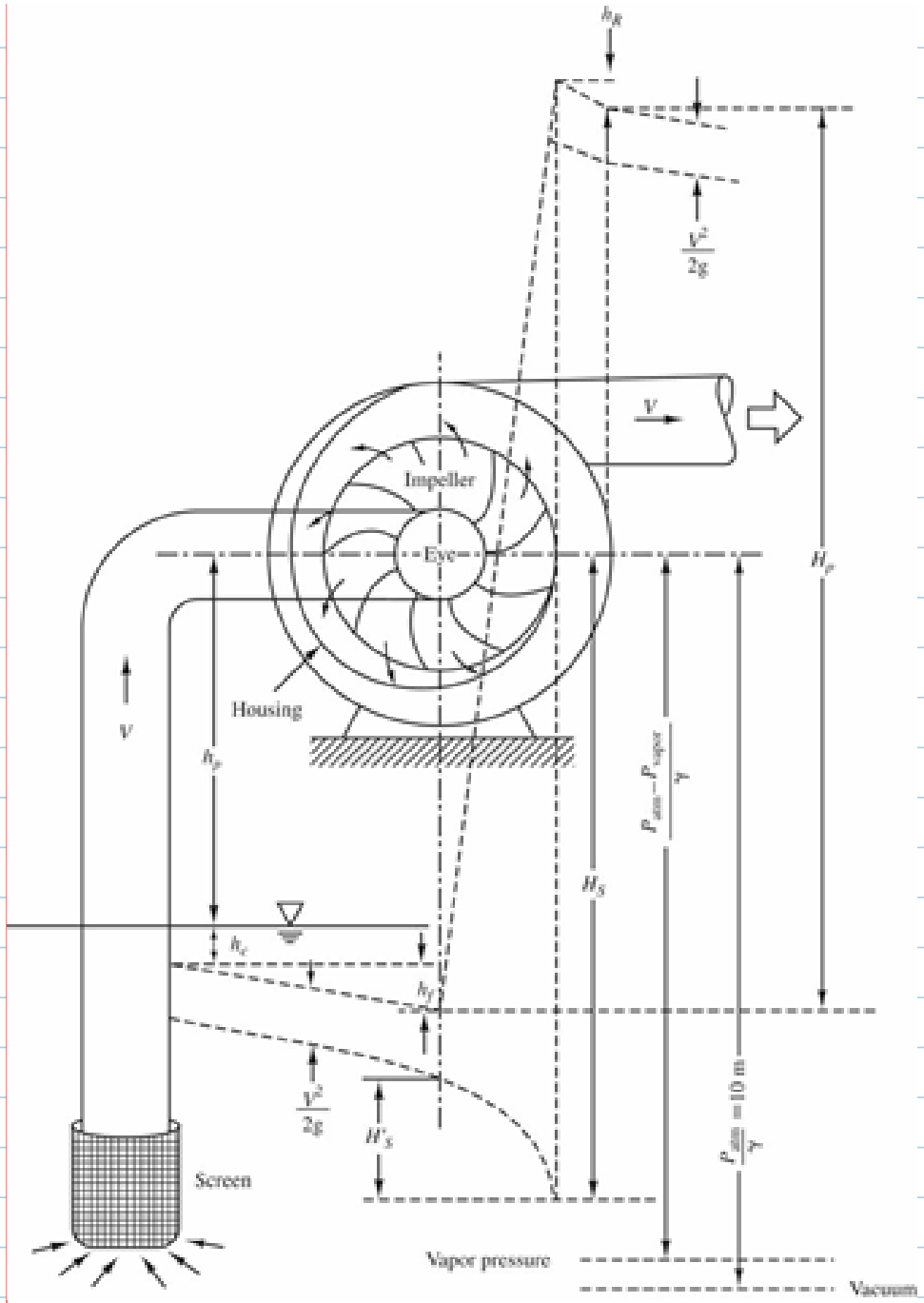
5.9 Cavitation

Sunday, September 12, 2010
11:01 AM

cavitation can occur whenever the absolute pressure locally gets below the vapor pressure of the water

frequent issue when pump is higher than water reservoir but can occur with any pump

common site of cavitation is near tips of impellor vanes where velocity is high

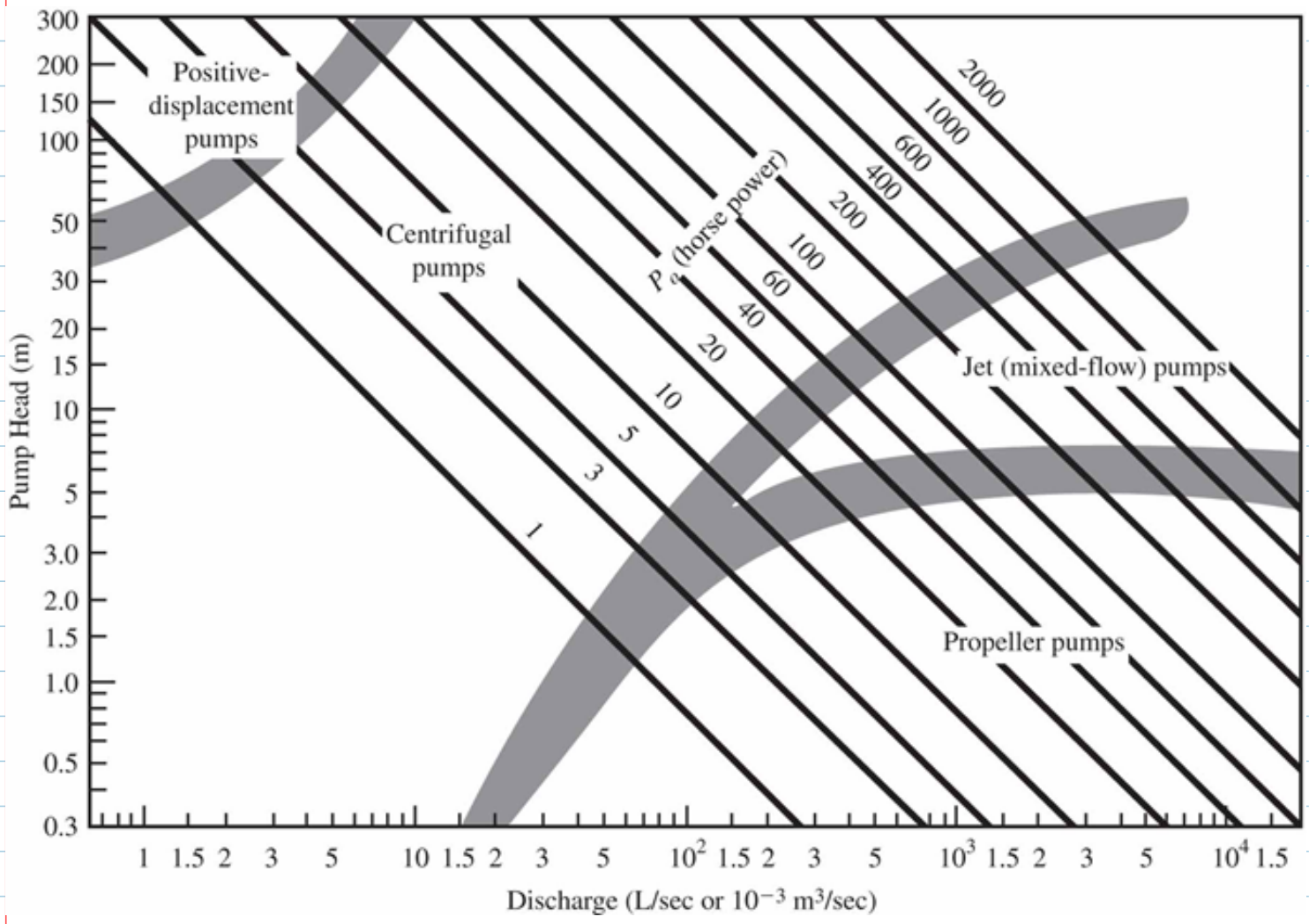


NPSH = net positive suction head = pressure drop between eye of pump and tip of impellor vanes

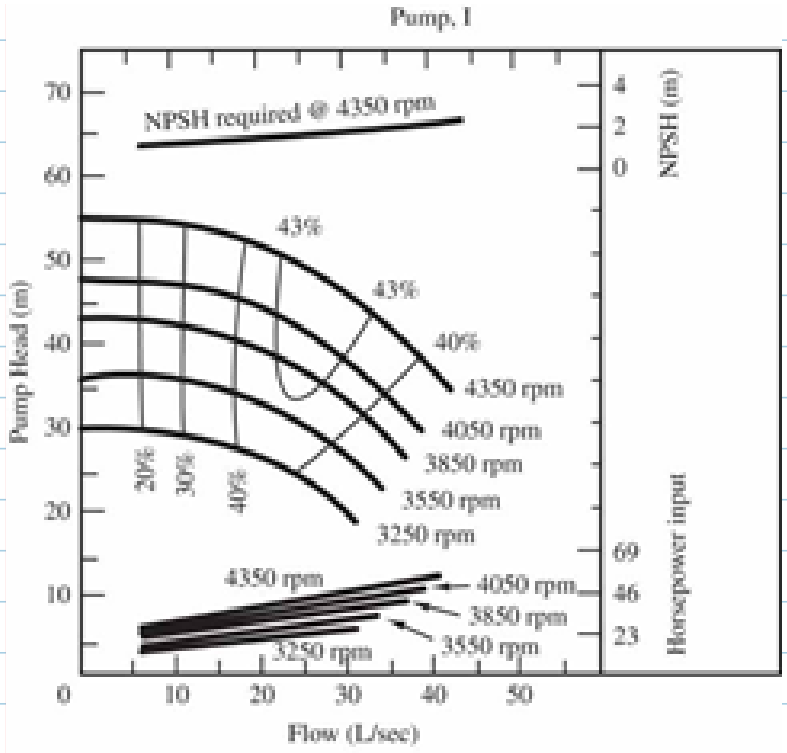
Pump Selection

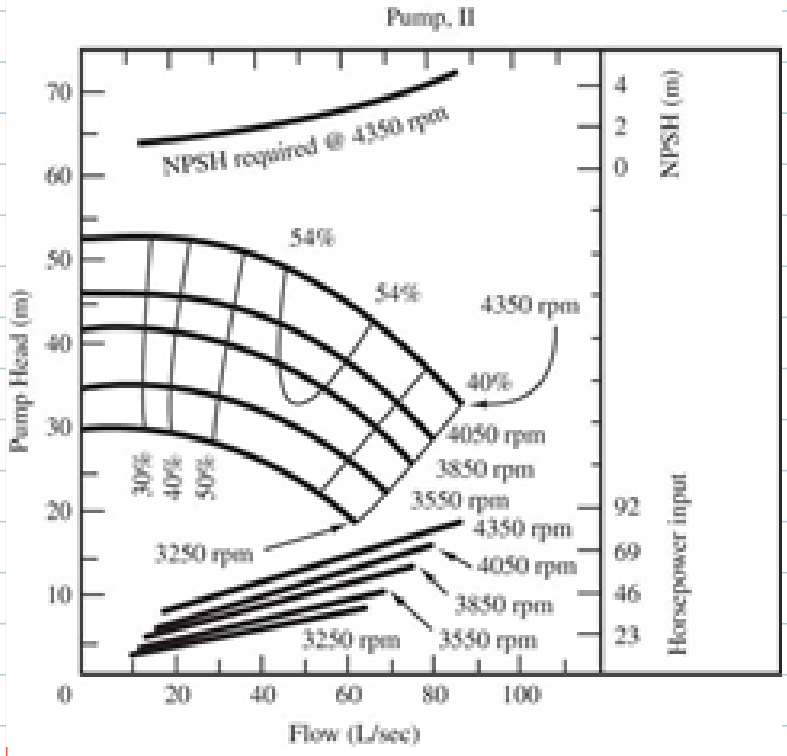
Sunday, September 12, 2010
11:08 AM

cost, energy efficiency, reliability, ability to pump desired quantity of water under system heads



Pump curve examples





http://www.rainforrent.com/Training/PumpTraining.pdf

Tips

Sunday, September 12, 2010
1:20 PM

http://www.pumpfundamentals.com/centrifugal-pump-tips.htm