From: Max Flowe

Subject: Project 315-2: Frictional Loss Coefficient Testing

To: XYZ Consulting Inc

Nearcreek is doing some work putting a new cooling system into a water treatment plant on Vancouver Island. It's not performing nearly as well as expected, so we wanted to get some experimental numbers for frictional losses over as wide a range of flow rates as possible.

What we need is:

- Minor loss coefficients for an elbow, Tee, globe valve (open)
- Some experimental numbers for pipe friction coefficients and the best way to predict them (Moody diagram, Colebrook equation, etc)
- Validation of the manufacturer's pump curve and performance specs.
- Area of greatest variability. We designed the cooling system using tabulated friction values - where should we start looking for the biggest deviations from that?

If you could put all of this in pdf format on the Canvas system within two weeks, our design team should have enough time.

I'll have accounting draft a PO.

Regards,

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Theoretical Background

When a pump operates at a constant speed, there is a relationship between the pumping head, or pressure, and the pump discharge. A pump can operate at any point on its head-discharge curve. If the head is fixed, it will produce the corresponding discharge. Similarly, if the discharge is fixed, it will produce the corresponding head. You will see that the head decreases as the discharge (Q) increases.

The pump curve is called the pump characteristic and can be represented approximately by:

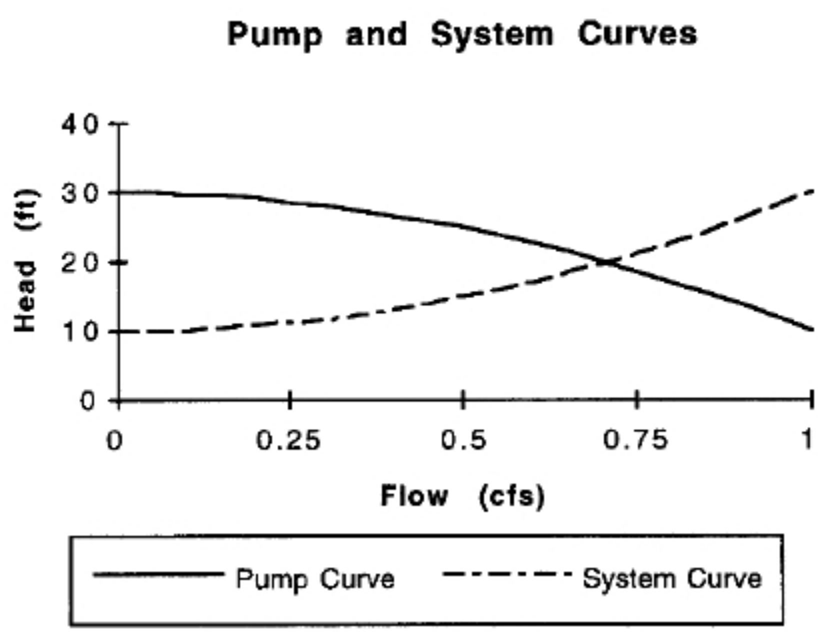
$$H = H_o - KQ^2$$

where: H is the pump head, H_o is the pumping head at zero flow, and K depends on the pump. In a pipe system there is also a relationship between head and discharge called the system or system demand curve and it is usually of the form:

$$H = f(Q^2)$$

This relationship can be calculated if all the components of the system are known, or it can be determined experimentally and is generally referred to as the system curve.

The actual flow in a pipe system is given by the point where the pump curve and the system curve cross. At this point (and only at this point) both head-discharge relationships are satisfied, as shown in the Figure 1 below. If Ho, K, and the system curve are known, the operating point can be determined. You will be asked to construct the two curves on a graph. The pump curve in Figure 2.1, should be compared against the manufacturer's pump curve provided in Figure 2.3.



In order to avoid cavitation within the pump, there must be sufficient positive head at the suction side of the pump. This amount of pressure is referred to as Net Positive Suction Head or NPSH. The pump requires a certain NPSH and this required NPSH is provided by the pump manufacturer on the pump curve. The NPSH provided by the pipe can be evaluated using the energy equation and for a pump just downstream of a reservoir, like system you will be using in the lab, it is given by

$$NPSH = H_a - H_v - Z_s - \Delta H$$

where H_v is the vapor pressure (0.50 ft, 0.015 m absolute at 15ºC); H_a is the atmospheric pressure (needed here because vapour pressure is usually given on the absolute (not gage) pressure scale, 33.8 ft, 10.8 m at UBC); Z is the height of the pump above the inlet tank water level (it may be negative if the pump is submerged); and ΔH is the head loss from the tank to the pump

If the suction pressure (NPSH) is too low, then cavitation will occur within the pump and damage will occur. We can simulate a low NPSH value by throttling the valve (A on figure 2.1) on the inlet side. This will cause cavitation, which can be seen in the Plexiglas pipe.

Air entrainment at the intake to the pump will also adversely affect the pump operation. Air entrainment can be caused by vortices at the inlet and these cause a large drop in efficiency. This will be demonstrated to you by the TA at the end of the experiment.

Before you turn on the pump, record the “zero” water level in the sump, which is where water sits at the very bottom of the V-notch. You will measure h (depth of water above the V-notch) relative to this level. The formula for the V-notch discharge is:

$$Q(cfs) = 2.54h^{5/2} \quad (h \text{ in ft})$$

$$Q(cms) = 1.4h^{5/2} \quad (h \text{ in m})$$

Apparatus

The apparatus is a recirculating system with various fittings. Figure 2.1 shows a schematic of the system. The pump circulates water from the sump, which has two chambers. A V-notch weir separates the two chambers and can be used to measure the flow rate. There are pressure taps at a number of points around the circuit. Most are simple water manometers, however there are 3 special manometers at the end of the apparatus used to measure differential pressures. The red liquid is water coloured with dye. There are also two digital pressure gauges installed in the system, which measure the pressure before and after the pump.

Caution

Unlike other experiments, which only have a valve on the outlet side of the pump, this apparatus also has one on the inlet side. To avoid damaging the pump, ensure that the **inlet valve A is fully open** and that the **outlet valve B is fully closed** before starting the pump. If in doubt, ask your TA.

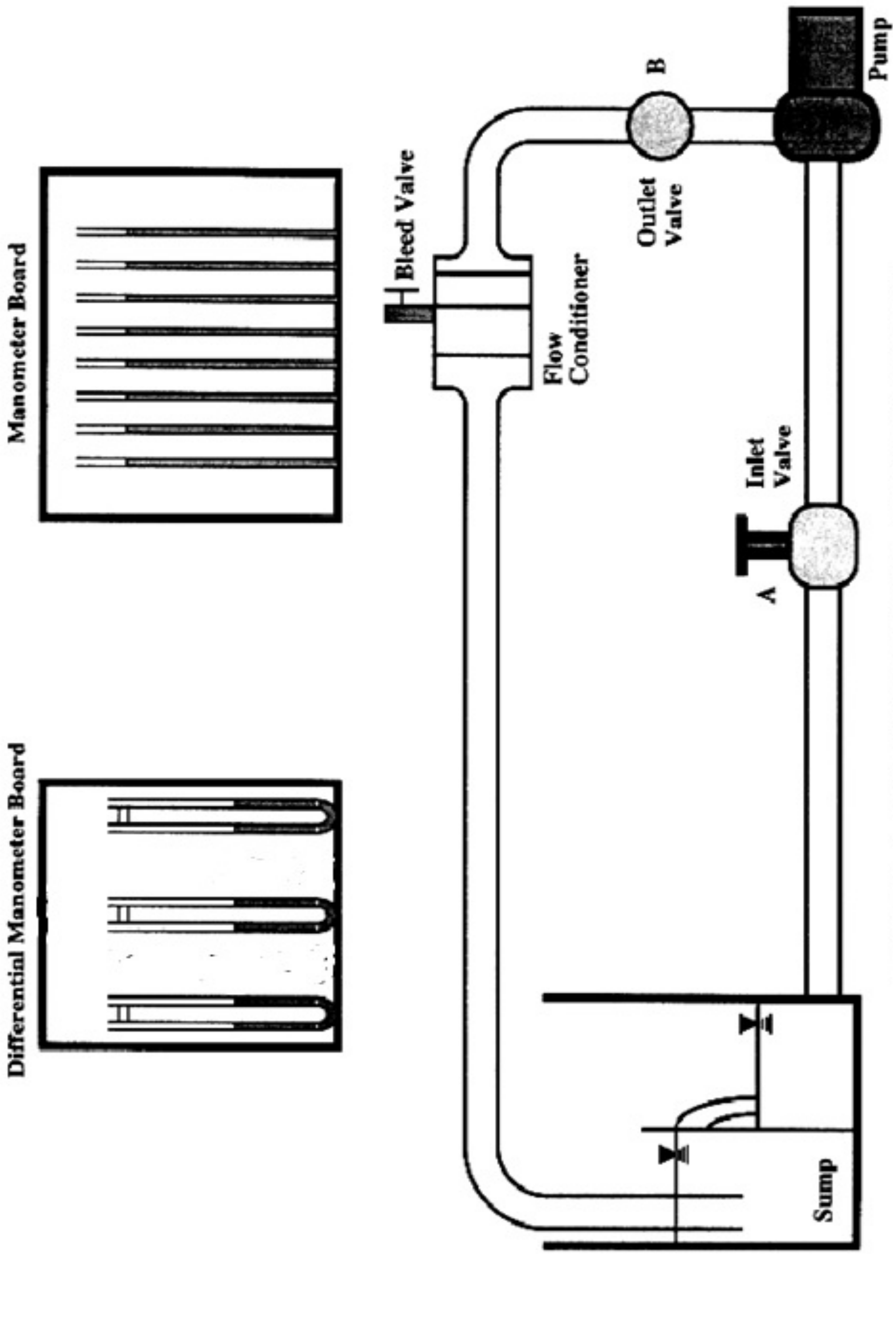


Figure 2.2 Schematic of experimental setup

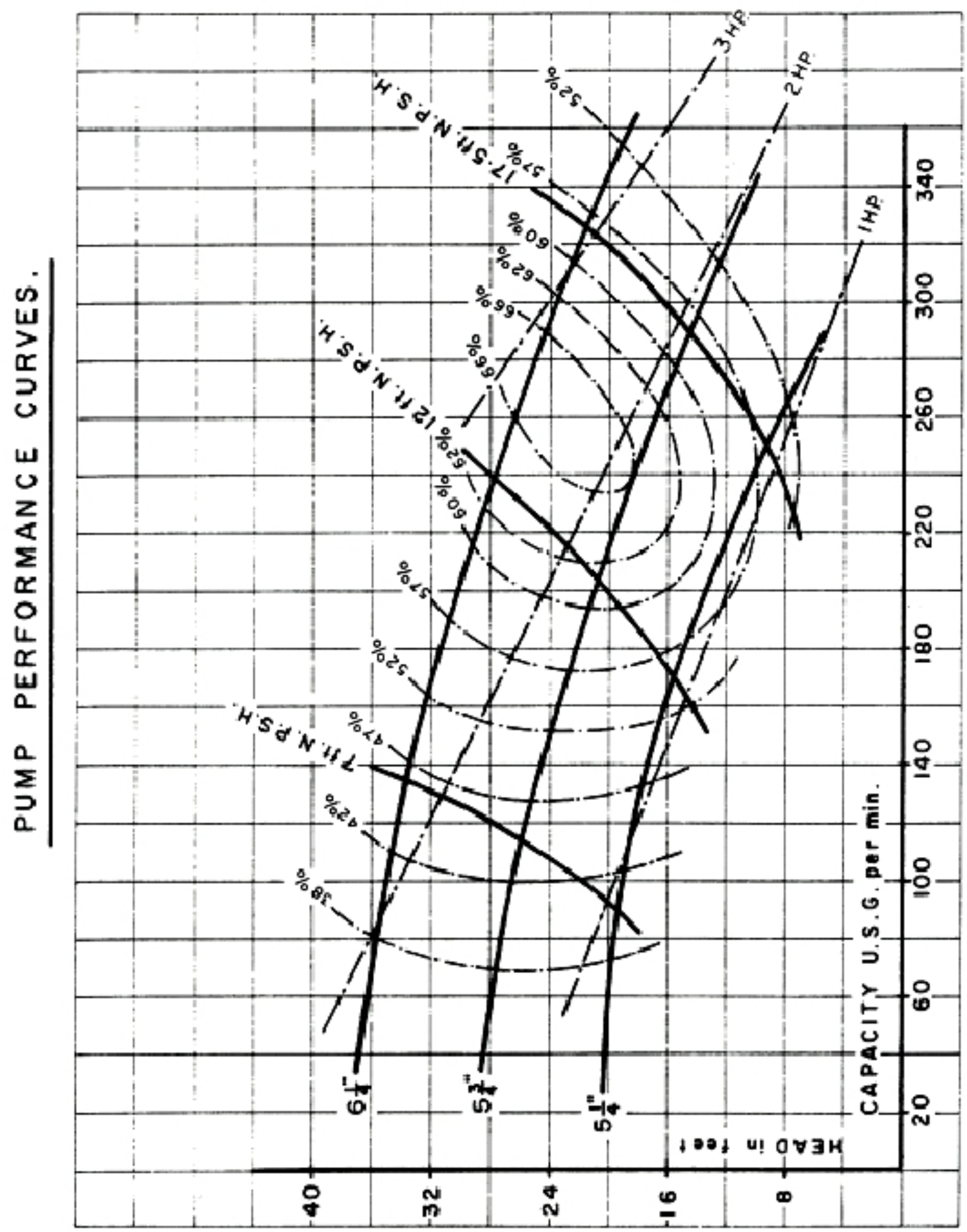


Figure 2.3 Pump curve provided by the manufacturer. You need to determine the impeller diameter for the pump in the lab in order to use this.