

# Lab 7: Pipe and Fittings

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Group Number: \_\_\_\_\_ Section Number: \_\_\_\_\_

Name \_\_\_\_\_

Other team members \_\_\_\_\_

(Circle the name of the person who acted as leader/coordinator this week--make sure you get a turn every 4th lab)

## SAFETY SECTION:

Remember to note the safety issues with operating the Pump Cart that you determined in Lab 5. In addition, review the safety section in Lab 6 on proper operation of the pump. Please alert the instructor or TA if you have a safety incident or you note any spilled liquid. As always, long pants, closed toed shoes and safety glasses must be worn at all times.

## Begin your lab by holding a team planning session (3 minutes):

1. Review the information in this document as well as in Labs 5 and 6 to remind yourself of safety information and how to control the Pump Cart.
2. One person should serve as leader/coordinator. All team members should strive to make the team function better through various roles: observer, recorder, devil's advocate, etc. Ask for each other's input and opinions, help each other, and try to come to consensus after an appropriate amount of brainstorming and analysis.
3. Make a plan for how you will complete the lab activities. Each person should fill out their own lab report as activities are completed. At the end of the hour, after cleaning up, get the TA to initial the end of your report. **This experiment is one of the longer ones** and additional time may be needed before and after the lab time to complete the calculations.

**Background:** Fluid friction in pipes and fittings can lead to significant pressure losses. In fact, because the flow loop in the Pump Cart has minimal height and kinetic energy changes, nearly all of the pressure energy provided by the pump is going toward overcoming friction. It is helpful to measure such losses for each fitting, and generalize them in terms of loss coefficients  $K_L$ , so that pressure losses can be predicted for future designs, and appropriate sizes can be used for pipes and pumps.

**Project:** Using pressure-difference readings, determine first the friction factor in a straight section of pipe, then the loss coefficients for various fittings such as elbows, T connectors, U bends, and valves. This must be repeated for two flow rates. The values can be compared to published values. Also answer the concept questions below.

1. **Pre-Lab Preparation:** Answer the following questions to prepare for the data collection and analysis

- a. The main part of the flow loop on the Pump Cart is made with 3/4-inch schedule 40 galvanized steel pipe. The designation "3/4-inch" is approximate or nominal pipe size (NPS), not actual size. Look online to determine the actual internal diameter of the pipe. You may have to do a calculation.
  
- b. What is the equation for dynamic pressure  $P_{\text{dyn}}$ ? Calculate  $P_{\text{dyn}}$  in units psi for the 3/4-inch pipe if it has a flow rate of 17 gal/min.
  
- c. What is the equation for pressure drop across a straight length of horizontal pipe, neglecting entrance effects, in terms of the Darcy friction factor  $f$ ,  $P_{\text{dyn}}$ , and other measurable quantities?
  
- d. What is the equation for pressure drop across a fitting, in terms of  $K_L$  and velocity? How is this related to  $P_{\text{dyn}}$ ?
  
- e. The control valve (or a hand-operated valve) can be used to change the flow rate through the flow loop, even though the pump is operating at the roughly the same speed throughout the process (while the pump impeller rotates at a constant speed, the flow rate the pump generates changes). How does this work?

2. **Collect Data:** Record pressure drops across the straight pipe section and for a couple fittings (your choice) for two different fixed flow rates. To get reliable values, you will need to have pretty high flow rates. You can use the web interface to collect repeated data points, download an Excel sheet containing the data, and average the data to obtain more reliable  $\Delta P$  values. You will also need to use a meter stick to record lengths of pipe between pairs of pressure taps. Summarize your results below.

3. **Determine  $f$  and  $K_L$  values**

- a. Determine  $f$  for the straight section of pipe that does not have any fittings. Does the value decrease as expected with increasing flow rate? How well does it match a value based on the Moody chart (around 0.035 for a rough pipe at flow rates typical of this experiment)?

b. Determine  $K_L$  values for a couple fittings (pick which ones you like) and compare to literature values. Make sure you subtract off the pressure drop that is due to the surrounding pipe. In other words,  $K_L$  should only account for the change in pressure drop due to the presence of the fitting. Do the  $K_L$  values change with flow rate? Do they match expected literature values?

c. What would happen to the required pump power if a pipe was replaced with a smaller pipe of half the diameter, while keeping the flow rate constant? Be specific and show the mathematical logic in your prediction.

- d. When you are designing a pipe system, how do you select the “best” or “optimal” pipe diameter? What is the problem if pipes are too small? Too large?

4. What is the difference between friction and friction factor?

- a. Write the equation that relates pumping power to frictional losses in a straight, horizontal pipe of constant cross section.

- b. What happens to friction factor when velocity increases?

- c. What happens to the friction itself when velocity/flow rate increases?

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**Grading Rubric (to be completed by TAs)**

Completed Activities and write-up  
Accurate calculations  
Safety and cleanup: **TA initial:** \_\_\_\_\_

	Points	Max
		8
		6
		1
Total		10