

PBL LAB: PRESSURE DROP ACROSS SHELL AND TUBE HEAT EXCHANGER

ChEn 475 – Knotts

Background and Objectives

Your task is to measure the pressure drop across two shell and tube heat exchangers from Standard Xchange (<http://www.standard-xchange.com/>). Each has a 3 inch shell diameter and 24 inch long tubes, but one has a baffle spacing of 1.5 inches and the other of 4 inches. The model information is found on the heat exchangers. The exchanger with the smaller baffle spacing is Part Number (P/N) SN516003024001 and the other is P/N SN516003024002. The Standard Xchange website has some information on it, but more information, provided by the manufacturer, is available under the hints for the shell and tube heat exchanger lab. Finally, remember that there are two sides to shell and tube heat exchangers, and you need to characterize both.

Accomplishing this task will include building and validating an experimental apparatus, measuring the losses, and delivering a final report. Multiple pieces of equipment are available for your use as outlined below. You will not (cannot) use all of them and are free to design the system however you see fit to achieve the design conditions given above. But note that part of your grade for this project is based on the quality of the design and your execution.

Preparation for Construction

Before beginning any assembly, please deliver a proposal to me outlining your approach. Only one proposal per team is needed. This email should have one or two paragraphs and one or two attached slides that explain your design plan and the rationale (calculations) for your approach. Your email should include an expected range of flowrates that you can access with your system with an appropriate figure.

On the first lab day, after acquainting yourself with the purpose of the lab and the tools you have to accomplish the design goals, you should complete the *Labview Assignment*. Labview is the system you will use to control your apparatus. This assignment will get you started on learning this tool. You may work as a team, but everyone on the team needs to write up a separate assignment to turn in.

Beginning either on the second or third day of the lab, after the Labview assignment, each member of the team will complete the *Pipes, Fittings, and Instrumentation Check-Off Assignment*. The purpose of this is to train you on how to physically construct an apparatus in the proper way. Part of the grade for the PBL lab covers the quality of your design which includes complying with the skills and concepts taught in this training.

One key part of a proper design is to *not* turn any flange already installed on a piece of equipment. More on this will be described in the aforementioned training, but the instructor or lab manager will specifically check this aspect as it has been a problem in the past and causes leaking. You will be able to identify the flanges that should not be turned by the presence of *hard, red pipe thread sealant*.

Construction and Safety

You may begin constructing your apparatus once you have 1) turned in your proposal, 2) turned in a completed Labview Assignment, 3) turned in a completed *Pipes, Fittings, and Instrumentation Check-Off Assignment*, and 4) receiving approval from the instructor. However, **before** powering on or plugging in any part of your apparatus, including the Labview modules, you must explain the safety procedures you have in place to prevent harm to equipment or person including some form of lock-out/tag-out. Again, *make sure your wiring is checked off with either Mike or Will before powering on any part of the system.* You will probably do this in stages because you will want to supply power to the Labview modules before powering on the pump. But make sure you fully understand where electrocution can take place for all parts of your system.

Due Date for Apparatus Demonstration and Evaluation

You have until the last PBL lab day to demonstrate that your apparatus fulfills the design requirements. To do this, you will simply show me and a lab manager that it works. At this time, we will also evaluate the quality of your design.

Final Report Requirements

Your final report should give the final results and validation of your project. This is an individual report. It is here that you show the “numbers” that answer the design problem. It should contain a description of the apparatus and quantitatively demonstrate that you achieved the design conditions.

Logistical and Equipment Considerations

Design Space

You will build the entire system on one of the wheeled, T-slot frames provided. Place this frame in one of the two areas, marked by yellow caution tape, in the middle of the projects lab.

Measurement Options

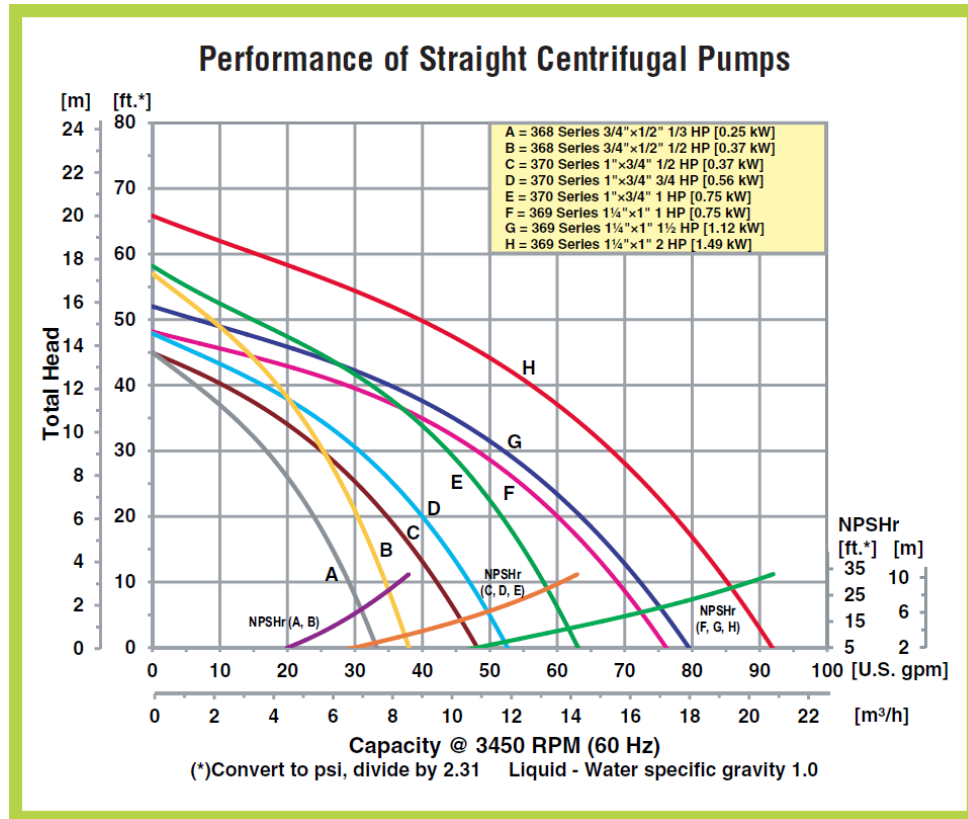
Two types of devices are available to measure pressures: Bourdon pressure gauges and pressure transducers. The transducers have been obtained from Omega (see website for calibration). Precision turbine flow meters are also available, but these are not the only way to measure flowrate. The pressure transducers and flow meters can be controlled using Labview. These don't have to be used, but are provided if you feel they are needed to achieve your aims.

Regardless of the measurement devices you use, you should be aware of the accuracy of each and factor this into your design and execution (and subsequent grade). Note also that the pressure transducers are expensive and can be destroyed if subjected to a differential pressure that is larger than the stated rating on the device. Also note that stainless steel flanges have been placed around the transducers and flow meters to preserve the threads and reduce replacement costs of these expensive pieces of equipment.

Pump Options

Four different pumps are available: 1/3 hp, 1/2 hp, 1 hp, and 2 hp. The pump performance curves for these is found below. For your convenience, an Excel file named “PBL Pump Performance Curves and Data.xlsx” is available on the website (under the hints for the PBL labs) that contains the numerical

data from these plots. (Note: stainless steel flanges have been placed on these pieces of “costly” equipment to preserve the threads.)



Pipe and Fittings Options

Schedule 40, galvanized pipe is available in 1/2", 3/4", 1", and 1 1/4" inch in lengths of 1', 3', and 5'. Jack stands fitted with t-slot are also available so that you can position pipe and equipment in desired locations and arrangements. Various brass and galvanized steel fittings are also available.

Ideas to Think About and/or Investigate

As you construct your experimental apparatus to answer the design problem, you are going to have to make several decisions. You are also going to answer several questions as you analyze or design the system. These include (but are not limited to) the following:

1. What size pump do you need?
2. How will you change flow rate?
3. What length(s) of pipe do you need?
4. What frictional losses do I need to take into account?
5. Does the length of the system affect your ability to take accurate measurements?
6. What height change is needed or demanded by the design constraints?

7. How will pipe size be determined or influence other design choices?
8. What will the Reynold's number be? How does it affect pressure drop?
9. How do pump size and pipe diameter affect the pressure drop?
10. How does heat exchanger shape and surface area correlate with pressure drop?
11. What applications exist for determining the pressure drop across a unit?

Deliverables

1. Proposal email (Team; email it to Dr. Knotts)
2. Labview assignment (Team; email it to TA)
3. Pipe fitting assignment (Individual; turn in paper to TA)
4. Quality of design (Team; Dr. Knotts will do this with you, nothing to turn in)
5. Final written report (Individual; email it to Dr. Knotts)
6. Leadership report (Individual; email it to Dr. Knotts)
7. Lab notebook (Team, email it to TA)