Purdue University
School of Nuclear Engineering

NUCL 355 - Nuclear Thermal-Hydraulics Laboratory

Lab 1: Basic Hydrostatic Pressure and Manometer Experiments

Objectives

1. Obtain experience with various pressure measurement instrumentation
2. Learn calibration techniques of pressure measurement instrumentation
3. Measure the local pressure in a stagnant fluid
4. Demonstrate the physics behind Bernoulli's equation
5. Observe a simple case of natural circulation

Experimental Apparatus:

The experimental apparatus is shown in Figure 1. The apparatus consists of a tank, tubing, valves for flow control, a pressure gauge and a pressure transducer.

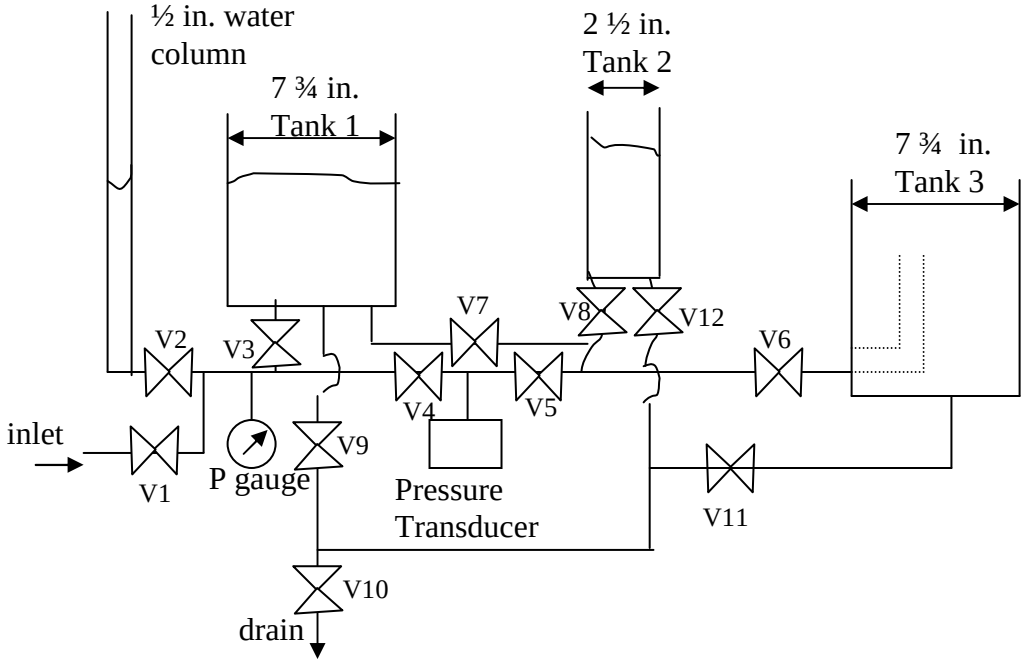

Figure 1 Experimental Apparatus

Experiment Procedure:

<u>Instrumentation Calibration and Static Pressure Measurement</u>

Referring to the setup in Figure 1, calibrate the pressure transducer as follows.

1.1 Make sure valve V3 is closed.

1.2 Fill the ½ in. tube with water. (Open valve V2 **VERY** slowly.)
Open V2 to increase water level, open V3 to reduce water level.

1.3 Open the water column to the pressure transducer by opening V4.
1.4 Vary the water level in the ½ in. water column and obtain a set of voltage readings from the pressure transducer. You will obtain a direct pressure reading from the pressure gauge and a signal in voltage from the pressure transducer.
Note: are you recording absolute pressure or gauge pressure?

Manometer Principle

In this part of the experiment, you will be observing changes of the water levels in different tanks and balances of pressures in the tanks.

2.1 Close V2.
2.2 Fill Tank 1 half full of water.
2.3 Measure water level in Tank 1.
2.4 Open V7 and V8.
2.5 Record at what elevations the water level in Tanks 1 and 2 stabilizes. Be patient, the flow through the tubing is very slow.
2.6 Close V7 and V8 and then elevate Tank 2.
2.7 Measure the static head in Tanks 1 and 2 using the pressure transducer.
To take the reading for Tank 1, close V5 and open V3 and V4.
2.8 Measure the elevation difference.
2.9 Open V7 and V8 and let the water level come to a new equilibrium level.
2.10 Record the new level.

Bernoulli's Equation

Here, you will be looking at the effect of flow on static pressure and demonstrating the physics behind Bernoulli's equation.

3.1 Isolate the tanks and change the elevation of Tank 2.
3.2 Measure the static head in Tanks 1 and 2.
3.3 Open V3, V4, V5 and V8 and take the pressure transducer reading after about 5 sec., while water is flowing between the tanks.
3.4 Record the pressure transducer reading for static head in both tanks again.
3.5 Evaluate whether the change in the reading when V3, V4, V5 and V8 were open corresponds to the static head(s).

Natural Circulation

In this section, you will observe how water can flow upward without any pumps, motors, etc. forcing it to flow. You should be able to explain why the water can flow upward.

4.1 Make sure that V4 and V5 are closed and open the drain valve to Tank 3.
4.2 Fill or drain Tank 2 to a depth of 1 in.
4.3 Open V6 and observe whether water flows through the vertical tube in Tank 3.
4.4 Fill Tank 2 to higher water levels and note the water elevation necessary for flow to first come out the vertical tube.
4.5 Fill Tank 2 about half full of water and elevate it. Observe how the flow rate through the vertical tube changes with time.

Data Analysis

(Some points that should be included in your lab report.)

Instrumentation Calibration and Static Pressure Measurement

1. Make a table of static pressure recorded from the pressure transducer versus voltage and plot the calibration curve.
2. Using the following equation, calculate the static pressure for various water column heights. Compare against your values measured with the pressure transducer.

   $P = \rho g h$

3. If necessary, correct your calibration curve.

Manometer Principle

1. Explain the measured pressure values.
2. Explain the equilibrium water levels in the tanks.
3. Evaluate the feasibility of using a water manometer to measure the pressure in a PWR. Do this by calculating the height of a water column necessary to measure a pressure differential of 1500 psi. Note that in this case, the two ends of the manometer are at different pressures.

Bernoulli's Equation

1. Using Bernoulli's equation, explain the change in the pressure reading when the water was flowing between tanks.

Natural Circulation

1. Discuss why water can flow vertically upward against gravity.
2. Discuss how this principle could be used in a BWR when the downcomer is liquid-filled and the region above the core is voided.

Reference

1. Robert W. Fox, Alan T. McDonald, Philip J. Prichard, *Introduction to Fluid Mechanics*, 6^{th} ed., New York, Wiley, 2004.