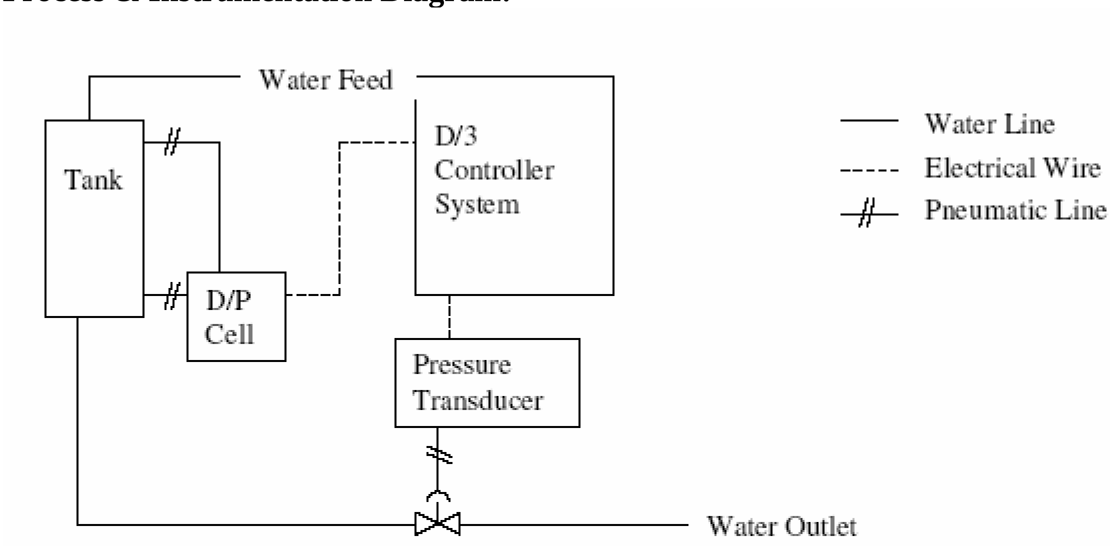
Objective: To investigate the dynamics of a liquid-level control apparatus using a simple PID controller and compare the results to a theoretical analysis.

Process & Instrumentation Diagram:



Experimental set up:

The experimental set-up is shown above. The tank has a volume of 24 gallons (~91 liters), and a diameter of 15inches (~38cm). The inlet cold water and hot water lines to the tank are each controlled by two valves. The first is an emergency shut off valve. This should be closed when the apparatus is not in use. The second is a coarse-metering valve used to adjust the inlet flow rate. The cold water inlet flow can be finely adjusted using the rotameter. The outlet flow from the tank and the inlet hot water flow are each controlled by a Badger Research control valve. The outlet line also includes an on-off valve to quickly drain the tank in the event of controller failure.

The main air line delivers air at 50psig. The air is filtered, and then regulated for two separate systems. The first is used to control pressure in the tank. The second regulates air at 20psig to be used in the control valve and current to the pressure transducer. DO NOT pressurize the tank above 40psig unless you would like to be impaled by exploding pieces of sight glass and fail the lab.

The height of the water in the tank is measured by using a Rosemont differential pressure cell. This D/P cell measures the pressure difference between the bottom of the sight glass and the top of the tank. It was calibrated for a range of 0-25 inches (0-64cm) of water. The output from the D/P cell is 4-20 milliamps, and is linear with the pressure difference. The output from the D/P cell is converted by the Barber Coleman controller to a % scale and is used to calculate the control signal (controller output) also 4-20 milliamps.

The output from the controller is converted to 3-15 psig signal by a Fairchild current to pressure transducer. This output is used to drive the control valve.

There are two thermocouples to measure the tank and the inlet water temperatures. The temperature controller also operates in the same manner as the level controller with the controlled variable being the tank temperature.

System startup procedure:

1. Set the D/3 system: level controller to automatic, temperature controller to manual and set point (SP)=10.

2. Make sure that the drainage hoses are in place to avoid spillage.

3. Turn on the main air and cold water supply. Set the rotameter to the maximum until system is near to the set point, then set it to 25(~80ml/s).

4. Check to verify that the tank pressure regulator is set to 10-30psig and the control valve and the I/P regulators are set to about 20-30 psig. DO NOT pressurize the tank above 40psig as this may lead to and explosion of the sight glass.

5. Set the control parameters. For the study on the level controller initially use the set point (SP)=10 cm, Proportional Band (PB=100/K_c)=10, Reset Rate (Rate=1/τ_I) =0.2 sec^{-1}, and τ_D= 10 sec.

6. Allow the system to attain steady state with the above settings.

Experiment:

1. Change the system to P only mode, using PB=10. For the 'P-only' mode perturb the system by introducing a set point change from 10 to 20 cm. Note the system response by viewing the real time plots for the External point names (EPNs).

2. Collect the data on an Excel spread sheet using the pre-made Macros.

3. Repeat the above procedure for the PI controls with PB=10 and Reset Rate = 0.2 sec^{-1}. Use a set point change from 20 to 30 cm.

4. Repeat the above procedure for the PID controls with PB=10 and Reset Rate = 0.2 sec^{-1}, and τ_D= 10 sec. Use a set point change from 30 to 40 cm.

5. Compare the results of the three controllers.

6. Repeat the above procedure for the PID controls with your choice of parameters, changing the set point from 40 to 50 cm. You may be guided in your choice of parameters by the observations you have made or by calculations from your homework. Attempt to achieve the new steady state as quickly as possible with little overshoot or oscillation.