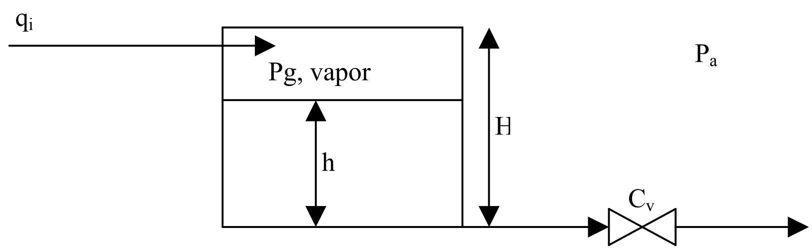
ChEE 413
Spring 2005
Homework Handout 1

1) Problem 1.1 from First edition - Consider a home heating system consisting of a natural gas-fired furnace and a thermostat. In this case, the process consistes of the interior space to be heated. The thermostat contains both the measuring element and the controller. The furnace is either on (heating) or off. Draw a schematic diagram for this control system. On your diagram, identify the process outputs and all inputs, including disturbance variables.

2) Problem 2.2 from First edition - Consider the stirred-tank heater example with steam heating. If the thermal capacitance of the coil wall is negligible, the dynamic model in Eqs. 2-17 through 2-19 can be simlified. In particular, show that the model can be reduced to a single differential equation which relates temperature T to steam pressure P_s. Interpret the heat transfer coefficient you obtain in terms of the usual overall coefficient between the steam and process liquid.

3) Problem 2.5 from First edition - Consider a liquid flow system consisting of a sealed tank with noncondensible gas above the liquid as shown in the drawing. Derive an unstead-state model relating the liquid level h to the input flow rate q_i. Is operation of this system independent of the ambient pressure P_a? What about for a system open to the atmosphere?



cross sectional area = A

You may make the following assumptions:
a) The gas obeys the ideal gas law. A constant amount of m_g/M moles of gas are present in the tank.
b) The operation is isothermal
c) A square root relation holds for flow through the valve.

4) Problem 2.10 from First edition - The chemical reaction sequence:

$$A \rightarrow B$$
$$A + B \rightarrow C$$

takes place isothermically in a continuous, stirred-tank reactor. Batch kinetic studies have indicated that the first reaction is second order with respect to C_A while th reaction rate for the second reaction is first order with respect to both C_A and C_B:

$$r_1 = k_1 C_A{}^2$$
$$r_2 = k_2 C_A C_B$$

where r_1 and r_2 have units of moles per ft^3 per h.

It can be assumed that the reactor has a constant volume V and constant feed rate q, and that the feed contains traces of B but no C. Derive an unsteady-state model that will yield the concentrations of A, B, and C for variations in the concentration of B in the feed.