Date: ________________ Name: ___________________________________

LABORATORY EXERCISE 4
FLOW CONTROL LOOP CHARACTERISTICS

OBJECTIVE: To demonstrate various aspects of flow control loops, including typical speed of response, measurement noise, and the effect of sticking valves.

PREREQUISITE: Completion of the following exercises:

2 Control Valve Characteristics
3 Valves and Positioners

BACKGROUND: Exercise 2 covered the relation between valve stem position and flow rate, for both equal percentage and linear valve characteristics, at varying pressure drop ratios. Exercise 3 covered valve actuators and their tendency to "stick" if not well maintained. Also covered in Exercise 3 was the effect of adding a valve positioner.

This exercise demonstrates additional characteristics of a flow loop, including measurement noise which is often present, typical speed of response and the effect of a sticking valve in a control loop.

1. STARTING THE PROGRAM

Start **Windows.**

Start **PC-ControLAB.**

2. PREPARATION

Confirm that the **Feedback** control strategy is being used.

Select **View | Horizontal Grid Scale | Seconds**.

Select **Process | Select Model**. Highlight "Flow.mdl" and press **Open**.

Enter the following tuning parameters:

Gain:	0.8
Reset:	0.05 minutes/repeat

3. FLOW CONTROL LOOP RESPONSE

Most flow loops exhibit some amount of measurement noise. The severity usually depends upon the type of measuring element used. Does this simulation exhibit measurement noise?

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Select **Process | Change Parameters** and highlight “Meas Noise Maximum”. Change the value from 1.0 to 0.5. Does that reduce the amplitude of the noise?

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Select **Process | Change Parameters** and highlight “Meas Noise Correlation.” Change its value from 0.8 to 0.95. Does that tend to smooth out the noise?

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This action was roughly equivalent to filtering the signal at the transmitter.

Select **Process | Change Parameters** and highlight “Valve Pos: 0=No; 1=Y”. Change the value from 0.0 to 1.0.

Put the controller in **Auto** and change the set point to 30 GPM.

Is there any overshoot of the set point? ________

How much time elapsed between the changing of the set point and when the PV first crossed the set point?

____

This demonstrates the relatively fast nature of most flow loops.

Before proceeding, change the set point back to 25 GPM.

4. STICKY VALVE

The simulation realistically exhibits flow measurement noise. However, because that tends to masks the points we wish to illustrate, we will remove it. We will also remove the positioner.

Select Process I Change Parameters and highlight "Meas Noise: 0=No; 1=Yes”. Enter 0.0.

Select **Process | Change Parameters** and highlight “Valve Pos: 0=No; 1=Y”. Change the value from 1.0 to 0.0.

Enter or confirm the following tuning values for the controller:

Gain:	1.0
Reset	0.05 minutes per repeat

Verify that the controller is in **Auto**. Then change the set point 30 GPM.

Observe the response. Both the controller output and the PV are moving up and down more or less like triangular waves. This type response is sometimes called “oscillation,” although it does not appear to be the sinusoidal wave typical of oscillation due to poor controller tuning.

Record the following:

Is the period regular or irregular? ____________________

Average (approximate) period of “oscillation”: ____________________

Peak-to-peak amplitude of controller output swing: ____________________

Note: If you did not change the horizontal scale to seconds, you will see both the PV and the controller output changing quite rapidly. This is due in part to the change of time scale, but possibly also due to numerical instability due to the attempt to simulate a fast process at a slow time scale. Better to be on the seconds scale for this exercise.

Suppose you (erroneously) interpreted the cause of the “oscillation” as improper tuning. Your action might be to reduce the gain of the controller. Change the gain from 1.0 to 0.5. Then record the following:

Average period of “oscillation”: ____________________

Peak-to-peak amplitude of controller output swing: ____________________

Note that the amplitude of oscillation did not change appreciably, but the period got longer.

REASON. Suppose the flow rate is below set point. The integral action of the controller will gradually increase the controller output. However, the valve itself will not respond until there is a sufficient difference in the signal to the valve and the spring force corresponding to the valve stem position. When there is a sufficient difference in force, the valve will move in a jump to a new position, consequently causing a jump in flow rate. If the flow rate is then above set point, the integral action will begin decreasing the signal to the valve, and the action repeats, except in the opposite direction. (Review the results of Exercise 3, Valves and Positioners.)

To see what the valve stem itself is actually doing, select **View I Variable Plot Selection**, then click on “yes” for PV-2. This is the signal which would be displayed if there were a valve position transmitter installed on the valve.

The amplitude of oscillation is really determined by the amount of “sticktion” in the valve itself. Reducing the gain (or lengthening the reset time), *merely slows down the rate of change of the controller output hence increases the period of osciliation. This is the wrong solution to the problem.*

A proper solution might be to perform maintenance on the valve to reduce the stem friction. Or add a positioner to the valve. The positioner, however, while overcoming the effect of packing and stem friction, can introduce a dynamic problem of its own.

Before we install a positioner, let’s see the best that could be achieved under ideal conditions, that is, with no stem friction and no measurement noise.

Go through **Process I Change Parameters** and change both “Deadband” and “Stick-slip” to 0.0. This simulates an ideal valve with no stem friction.

Change the tuning parameters back to Gain = 1.0; Reset = 0.05 minutes/repeat.
Did this appear to cure the problem? __________

Start with a set point of 25 GPM, then increase the set point by 5 GPM. Is the response acceptable?

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Put the set point back at 25 GPM. When the loop comes to equilibrium, put the controller in **Manual.**

Now add a positioner. (Select **Process I Change Parameters**. Highlight “0=No Pos; 1=Pos”. Enter 1.0.)

Change the controller output by 10%. (You should still have the stem position record on display.)

How did the stem position respond to a step change in signal to the valve?

Overdamped:________ Underdamped:________ No dynamic effect:________

Both the flow loop without a positioner and the positioner-stem-actuator combination are responding as slightly underdamped systems at approximately the same frequency. When we close the loop with a positioner on the valve, these two responses may interact, causing a “ringing” of the response (e.g., continuing oscillation, with very slight damping).

Put the controller in Auto. Set the set point at 25 GPM. When the loop settles down, change the set point to 30 GPM.

Is the loop more oscillatory than it was before adding the positioner? ________

To compensate for this, reduce the gain from 1.00 to 0.8

Change the set point change back to 25 GPM.

Is the loop behavior more acceptable? ________