Date: ________________ Name: ___________________________________

LABORATORY EXERCISE 6
PRESSURE CONTROL LOOP CHARACTERISTICS

OBJECTIVE: To demonstrate the characteristics of pressure control loops as exemplified by several application examples.

PREREQUISITE: Completion of Exercise 1, Process Dynamic Characteristics

BACKGROUND: Pressure control loops can be characterized in several ways, including by the state of the flowing medium and by the relative position of the pressure sensor and the control valve.

Liquid phase pressure loops are controlled by maintaining a flow balance into and out of an enclosed volume. The loops are fast and have somewhat the characteristics of flow control loops.

Two-phase (gas and liquid) pressure loops are usually controlled by the addition or removal of heat to vaporize liquid into the gas phase or condense gas into the liquid phase. An example is the control of steam header pressure leaving a steam generator. Two phase pressure control loops are relative slow and noise free; hence they have characteristics similar to temperature control loops.

Pure gas phase pressure control loops, with the exception of pressure control for a long pipeline, are typically fast, noise free and exhibit essentially no dead time. Consequently they can be controlled with high gain proportional controller with less emphasis placed on reset action.

In terms of the relative position of the sensor and control valve, if the sensor is located downstream of the control valve, the application is usually called a "pressure regulator" or "pressure reducer station." If the sensor is located upstream of the control valve, the application is usually called a "back pressure regulator."

The process models in this laboratory exercise simulate a gas pressure reducing station and a pressure regulator for a gas separator. Neither process model exhibits significant dead time. Process disturbances are the upstream pressure (accessible as a load change), downstream flow demand and enclosed volume. These latter effects are set via the "Change Parameters" feature of the process model.

1. STARTING THE PROGRAM

Start **Windows**

Run **PC-ControLAB**

2. PREPARATORY

Be sure you are using the FEEDBACK control strategy. (Check the top line of the display.)
Select **Process | Select Model**, then highlight “pressure.mdl” and press **Open**.

Click on **Load** (in the Menu bar), then in the sub-panel labeled “Auto Load Change”, click in the data field by the label “Correlation”.

Press **Esc** on your keyboard, then key in a new value of 0.97. Press the **Enter** button, then click on **Clear**.

3. EXERCISE – GAS PRESSURE REDUCING STATION

Change the controller output from 35% to 45%. Does the pressure go up or down? ___________

Observe that the process response is fast with relatively no dead time. It can be controlled with a controller with high gain proportion-only control action (i.e., no integral action).

Return the controller output to 35%.

Select **Control | Control Options**. In the first section of the drop-down list of options, select “Proportional Only.” Then press **Clear**.

Enter the following feedback controller tuning parameters.

Gain:	10.0
Manual Reset:	35%

Put the controller in Auto.

Press **AutoLoad**.

You are seeing a randomly varying load demand. Note that the pressure remains fairly close to set point even though the controller is proportional-only (no reset).

Press **AutoLoad** again to discontinue the randomly varying load.

If the load (read gray trace vs coordinates on left hand side of grid) is above 50% when AutoLoad was discontinued, press **StepDecr** until the load is below 50%.

Press **SP** and change the set point from 50 to 54 psig. Describe the initial response of the controller output:

___________ large change in controller output

Because of the high gain, a step change in set point produces a very large proportional response. Very quickly, the feedback action removes a large proportion of this proportional response. Even so, to avoid a proportional "spike" on the output, we should probably, it possible, avoid making step changes in set point. There are several alternative possibilities available with various makes of commercial systems (all of these are available with PC-ControLAB):

- *Use the configuration option "Proportional on Measurement." Then on a set point change, the integral action gradually moves the output to a new value.*

- *If set point jog buttons are available, use these for making gradual set point changes.*

- *The set point can be ramped (changed gradually at a user selectable rate) to new set point value.*

In practice, pressure control loops, probably more so than many other types of loops, frequently operate for long periods of time without encountering a set point change

Use the down jog button (on the right hand side of the vertical scale on the controller) to gradually move the set point down to about 48 psig. Do you see the large change in controller output that you saw when you made a step change to the set point?

____

Press **Process | Change Parameters.** Highlight "Supply Pressure-psig" and change it from 75.0 to 95.0 Does this tend to cause the valve to close (after equilibrium is reached)?

____

As the upstream pressure rises, the valve must move toward closed to maintain approximately the same downstream pressure.

*Change the Supply pressure to 55.0 psig. Does this tend to cause the valve to open?*__________

As the upstream pressure falls to just above the required output pressure, the valve must move wider and wider open to accommodate the demand. Hence with proportional-only control, we see a larger deviation from set point when the upstream pressure is low and the controller output is correspondingly high.

Press **AutoLoad** to reactivate random load changes. The random variations of the demand will cause the controller output to move up and down. Observe it at some time when the controller output is approximately 35%. At that time, what is the relation of the PV to the set point? (Press **StepIncr** or **StepDecr** if necessary to force the load into a region you want to observe.)

PV is above SP ________ PV is about equal to SP _________ PV is below SP _________

When the controller output is above 35% (higher demand), what is the relation of the PV and SP?

PV is above SP ________ PV is about equal to SP _________ PV is below SP _________

When the controller output is below 35% (lower demand), what is the relation of the PV and SP?

PV is above SP ________ PV is about equal to SP _________ PV is below SP _________

What is the significance of "35%"? ____

These later demonstrations have illustrated the gas pressure control loop's tolerance to both demand changes and set point changes, even though a simple proportional controller without reset action is being used. In fact, this entire exercise has demonstrated that a gas pressure control loop is a fairly easy loop to control, being relatively insensitive to load changes as well as parameters within the control loop itself. There are undoubtedly exceptions to this statement, but for most gas pressure control loops, these characteristics should hold true.

4. EXERCISE – GAS SEPARATOR

We will now read in a process model for a gas separator. The inflow is a two-phase stream, with the gas phase exhausted through a pressure control valve to a vent header. The valve is fail-open; in the event of a signal failure to the valve, the valve opens and relieves the vessel pressure to the vent header.

Select **Process | Select Model.** Highlight “Pressur1.mdl” and press **Open**.

When the model opens, press **Pause.** While in Pause, make the following changes:

Press **Control | Control Options.**

In the sub-panel labeled “Control Action” select **Direct**.

Scroll down until you see a sub-panel labeled “Reverse Output”. Select **Yes**.

Press **Clear** to remove the Control Options dialog box.

Press **Load** (in the Menu bar). In the sub-panel labeled “Auto Load Change” click in the field adjacent to the label “Correlation”. Press the **ESC** key on you keyboard, then key in a value of 0.97. Press **Enter** on your keyboard, then click on **Clear**.

Press **Out** and change the controller output to 35%.

Press **Tune** and enter the following tuning parameters.

Gain:	10.0
Reset:	4.0 minutes/repeat

Press **Run** then put the controller in **Auto**.

The controller PV should come to a set point of 50.0 psig.

Change the set point to 48 psig. Satisfactory response? __________

Press **AutoLoad**. The simulation now represents a varying amount of gas flow into the separator. Still a satisfactory response?

____

The controller output that is being trended represents the percent open condition of the valve. This is NOT the same as the signal to the valve, however. Since the valve is fail-open, then a 0% signal to the valve causes the valve to be fully open, and a 100% signal to the valve causes the valve to be fully closed. To achieve this, we reversed the output when we were in Control Options, above.

To see the actual signal going to the valve, press **View | Variable Plot Selection.** Select “Yes” for PV-2. You should see a magenta trace which is the mirror image of the controller output (blue) trace. OK?

____

In many applications of this type, in the event of failure of the signal to the valve, the valve would go fully open, relieving the gaseous contents of the vessel to the vent header. We will now simulate a signal failure to the valve.

Press **View | Discrete Controls.** In the sub-panel labeled “D-Out#1”, select **Off**.

Observe that the magenta trace immediately goes to 0, indicative of a break in the signal line. The valve opens fully (the actual valve position is unseen), causing the vessel pressure to drop. Because the controller is still in Auto, it tries (in vain) to close the valve to correct for the low pressure, hence its output drops.

Did you observe and understand all of these actions? ___________

You have observed a gas pressure control loop for a large vessel which does not respond as rapidly as the pressure station in Section 3. You have observed a typical configuration for a fail-open valve, and you have observed the need for a direct acting controller, where, on an increase in PV, the controller output must increase.

(If you wish to continue experimenting with the pressure control system, select **On** in the Discrete Control Panel, to reconnect the signal.)