Lab 5
Downstream Auto Pressure Control with the Smart Throttle Valve

Name: ________________________

Purpose

The purpose of this lab is to:

1) Understand the downstream mode of pressure control.
2) Be able to explain what PID control is and how it is applied in pressure control.
3) Compare auto pressure control to manual pressure control.
4) Understand the effects of varying the tuning (PID) parameters.

Review

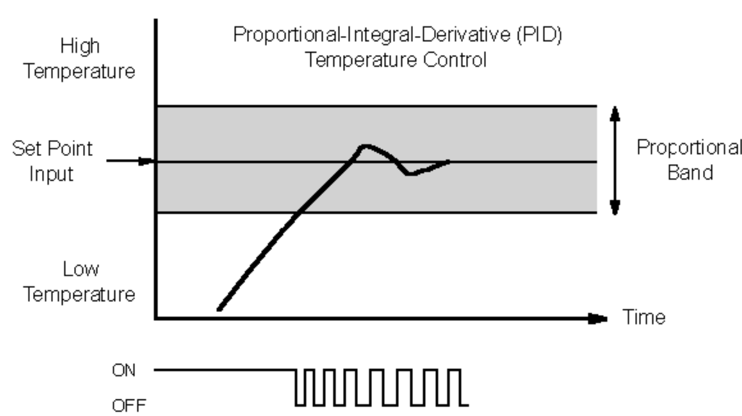
PID control stands for Proportional, Integral and Derivative control. In a pressure control system, the input to the control PID controller an error signal that represents the difference between the actual, measured, pressure in the vacuum chamber and the desired, set point, pressure.

The proportional element provides a valve action that is instantaneous and is a linear function of the error signal. It is also known as *gain*. The integral element provides an additional signal that is proportional to the length of time that the error signal has existed. The derivative element provides a signal that is proportional to the rate of change of the error signal. It is also known as *lead.*

Each of these elements is adjustable and system performance will depend upon the settings. For example, too high a gain setting will cause a pressure overshoot or even oscillation about the set point.

The PID tuning parameters have to be optimized for each system and set of conditions (flow rate, pumping speed, pressure set point). This is usually done manually, as we will do in this exercise. Adaptive, or self-tuning systems also exist.

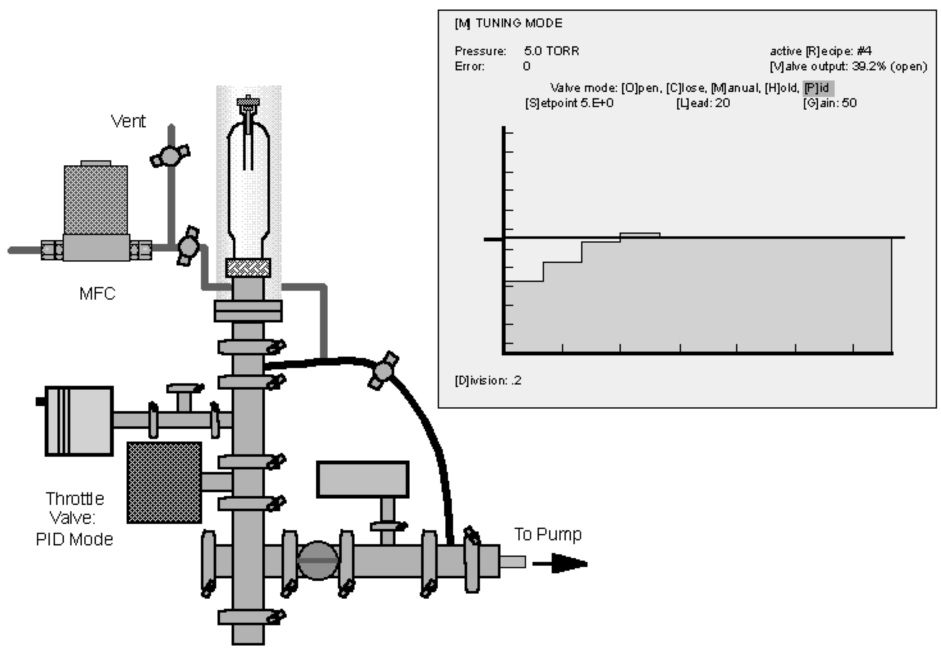
An example of PID temperature control with overshoot is shown in the figure to the left.



Procedure:

The figure below shows the equipment set up. You will be using the Tuning Mode screen (shown) for most of the exercise. Note the location of the convection Pirani gauge.

- Set the MFC to 40 sccm. Ensure that all of the pinch clamps are closed and the manual butterfly valve is open. On the Tuning Mode screen, page 1, the Valve Position item should indicate Open. (Use PgUp if the Tuning Mode opens to the wrong screen.) Note that only the lead and gain parameters are adjustable from this screen. The integral element can be changed on the second page.
- Turn on the vacuum pump and pump the system to its base pressure. Zero the capacitance manometer if that has not been done recently.
- Open the MFC pinch clamp. The pressure should rise but remain under 1 Torr.



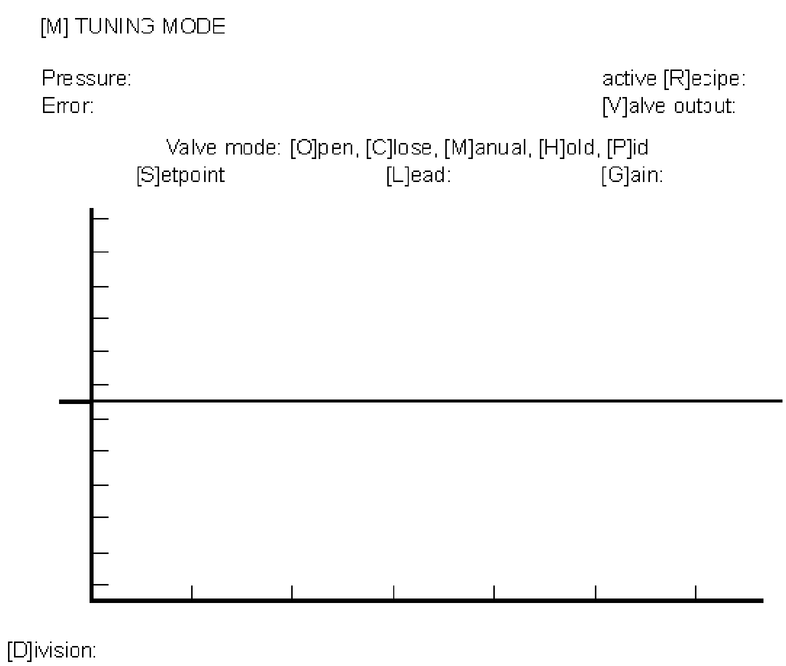
Note the Valve Output item in the top right corner of the screen. This represents how much the throttle valve is open (e.g. 100% means it is 100% open).

<u>If the throttle valve is closed, will pressure increase or decrease? Why?</u>

Enter the following parameters: [S]etpoint at 3 Torr, [L]ead at 5 and [G]ain at 100. Change to [P]ID mode. What does the throttle do (open or close)? Where and how does it stabilize? Does the valve position settle at a constant value?

Where does the pressure stabilize? Draw a sketch of the screen plot on the graph at the bottom of the page. What is the Pirani gauge reading?

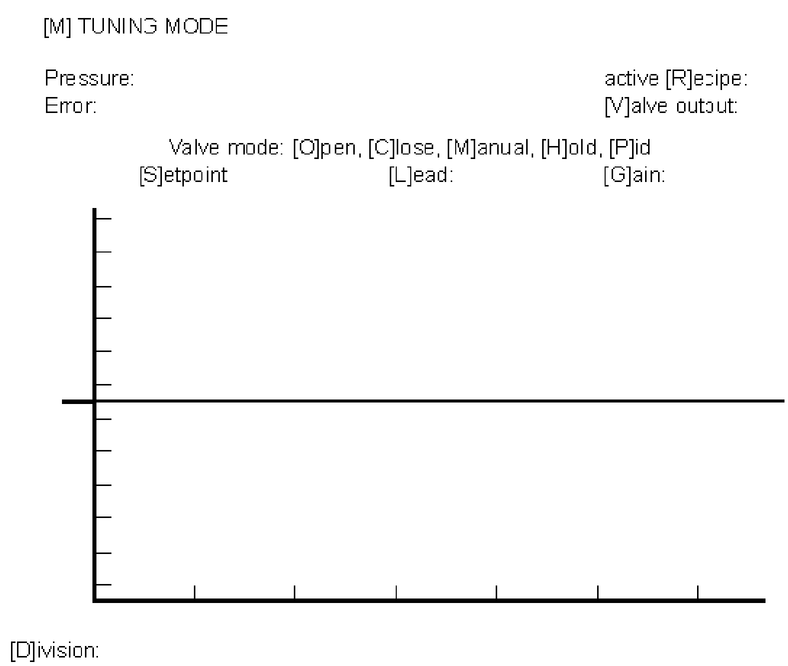
Now change the [S]etpoint to 10 Torr. Does the throttle valve open or close, and why? Where does the pressure stabilize? Was there overshoot or undershoot? Draw a sketch of the screen plot on the graph below. What is the Pirani gauge reading?



Change the [S]etpoint back to 3 Torr. Explain what the throttle valve must do to lower the pressure. Is there overshoot or undershoot? Does the system stabilize? Draw a sketch of the screen plot on the graph at the bottom of this page. What is the Pirani gauge reading?

Change the [G]ain to 900 and the [L]ead to 0.001. What does a high gain mean in terms of how fast the pressure will rise or fall to a new set point?

Now change the [S]etpoint back to 10 Torr. Does the system stabilize about the setpoint? Draw a sketch of the screen plot on the graph below and explain what the throttle valve is doing.



Now change the [G]ain back to 5 and the [L]ead to 100. What does the system do? Explain.

Change the [S]etpoint to 1 Torr. Can the throttle valve system control to the chamber to the pressure? At what pressure does the system stabilize? Explain why the set point pressure can or can not be reached (be specific). What is the Pirani gauge reading?

Explain the various readings that were taken with the Pirani gauge. To what degree were they similar or different? Explain.

You have completed this lab and you can bring the MKS trainer to atmospheric pressure. Prior to venting per the approved procedure (see Lab #1), set the throttle valve to [O]pen.

Lab written by M. Quirk and V. Ybarra, Jr., at Austin Community College, based on information from the VTS-1 equipment manual written by MKS Instruments, Inc. Comments may be submitted to S. Hansen at: MKS Instruments, Inc., Six Shattuck Rd., Andover, MA 01 or by email to hansens@mksinst.com.