Lab 2
System Time Constant

Name: _____

Purpose

The purpose of this lab is to explain and demonstrate the system time constant and how it varies with different conductances.

Review

The time constant of a vacuum system describes the rate at which the system will pump down. It is analogous to the time constant of an electrical RC (resistance-capacitance) circuit: the volume of the chamber is like the capacitor, and the effective pumping speed through the connecting lines is like the resistor. For a vacuum, the time constant is equal to the chamber volume (in liters) divided by the effective pumping speed (in liters/sec).

The pumpdown curve is exponentially declining in form. One time constant has passed when the pressure in the system has been reduced to about 37% of its original value. If the starting pressure is 760 Torr (standard atmospheric pressure), what will be the pressure after 1 time constant?

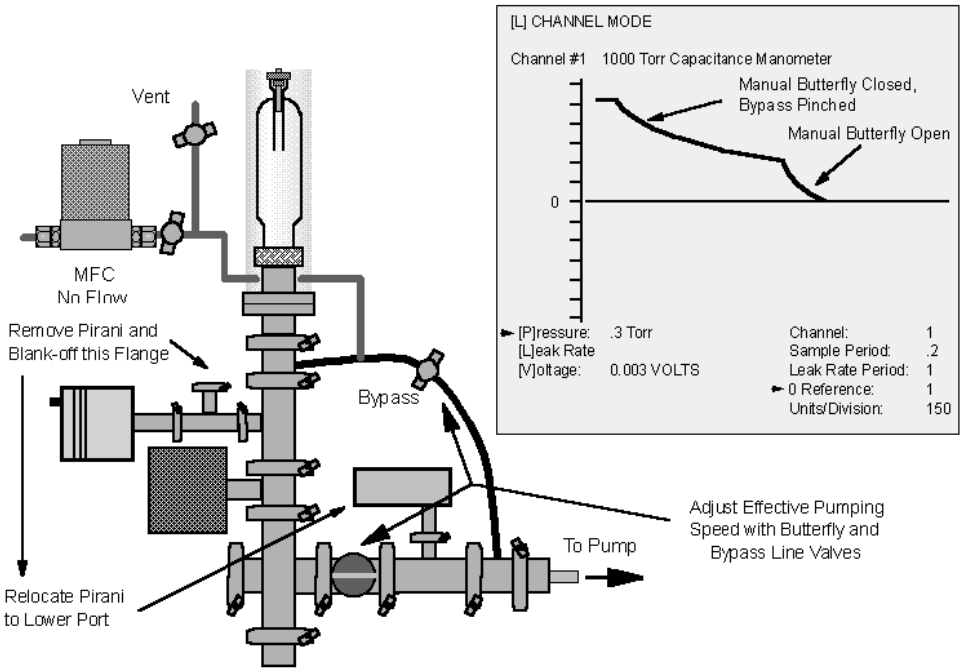
The time constant can be used to gauge the "health" of a system. Increasing time constants may indicate a poorly performing pump. Also, the time constant may be lengthened during initial pumpdown from atmospheric pressure to minimize turbulence and other contamination inducing effects. This is usually done by introducing elements into the pumping line that vary the conductance of the line. We will use the pressure plot on the screen to view the pumpdown and determine the time constant.

Based on the above information, will a larger chamber volume take a longer or shorter time to pump down? Explain.

Procedure

The figure on the next page shows the equipment set up and how the screen should look for this part of the experiment (Channel 1). You may have to try other parameters (Sample Period and Units/Division) in order to have the plot show up properly.

- With the system at atmospheric pressure, ensure that all of the pinch clamps are closed (Vent, MFC and Bypass).



- The manual butterfly valve should be fully open.
- The automatic throttle valve should be open (verify by looking at the indicator light on the back of the valve housing).

Turn on the vacuum pump and observe the pump down trace. What is the time constant (in seconds)? (You may have to try this several times to get an accurate number.) Sketch the curve on the graph on the last page.

If you put a longer hose on the inlet, what will this do to the conductance? Will the time constant increase or decrease? Will the system pump down faster or slower? Explain.

The conductance of the line may be changed by varying the position of the manual butterfly valve. Set the butterfly valve to a position where it is just barely open. What is the time constant? Sketch the curve on the graph on the last page.

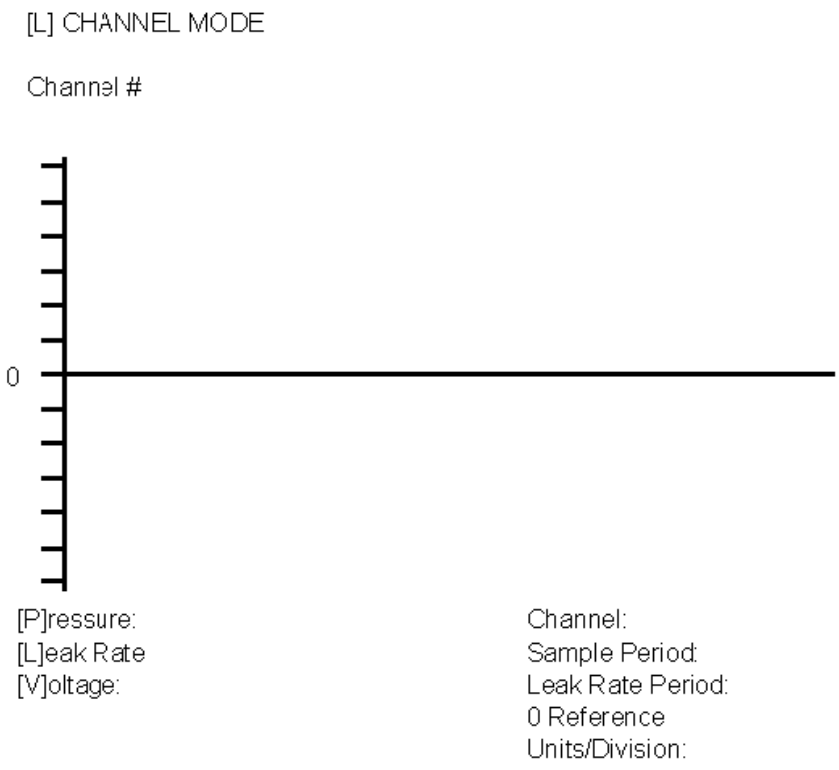
With the manual butterfly valve closed, the system can be pumped through the bypass line. The conductance of this line may be varied by constricting the line with the pinch clamp. With the

pinch clamp fully open, pump the system from atmospheric pressure and determine the time constant. Sketch the curve on the graph on the last page.

Now vent the system. With the manual butterfly valve still closed, fully close the pinch clamp on the bypass line. Turn on the pump and slowly open the pinch clamp until the pressure starts to fall. Observe the trace on the screen. Make some observations about the degree of control over the time constant with the bypass line and pinch clamp versus with what you observed with the butterfly valve. Think in terms of, for example, the fine and course potentiometers in an electrical circuit.

There is always a pressure drop across a conductance element when there is gas flow. With the gauges arranged as shown in the figure on the previous page it is possible to observe the pressure drop across the bypass line. With the pinch clamp set for a long time constant, observe the pressure readings from the upstream gauge (the capacitance manometer) and the downstream gauge (the convection Pirani). Now decrease the time constant and again observe the pressure readings. Under which condition was there a larger pressure differential? For a given time constant , how did the pressure differential vary through the pumpdown period? Explain your observation.

Relate what you have observed to how conductance control is useful in the pumpdown cycle of a vacuum process tool.



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.