Lab 3
Understanding Throughput and its Relationship to Speed and Pressure

Name: _____

Purpose

The purpose of this lab is to:

1) Be capable of converting between the common units of throughput (torr-liters/sec and std. cc/min [sccm]).
2) Understand the relationship between pumping speed (*S*) in liters/sec, pressure (*P*) in torr, and throughput (*Q*) in torr-liters/sec.
3) Calculate and verify pumping speed at a particular point in the system.
4) Interpret the pressure rate-of-rise for a vacuum system.

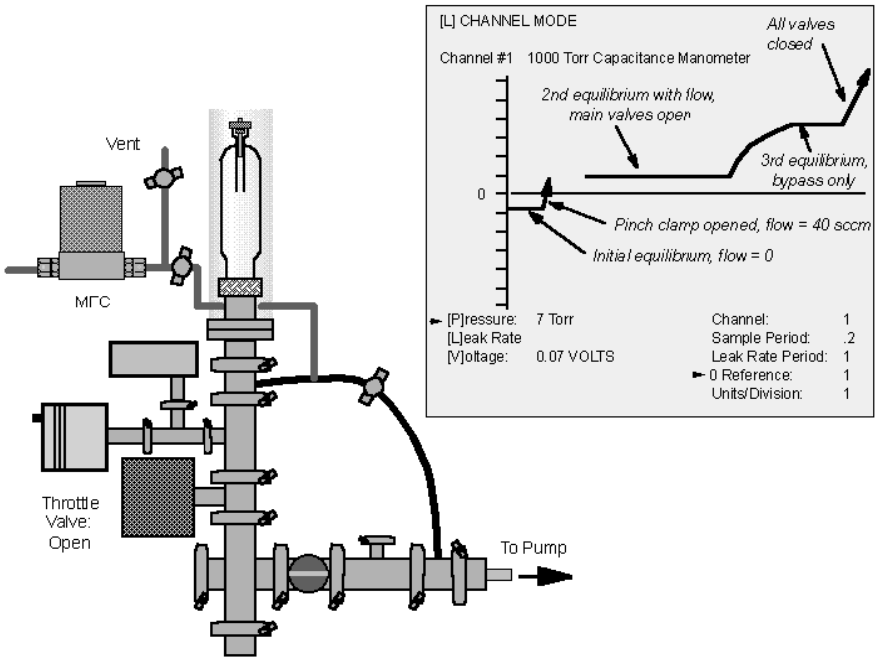
Procedure

The figure on the next page shows the equipment set up and how the Channel 1 screen should look for this experiment. Note that the scale is adjusted such that you will be observing the pressure in the range of 0.0 to a few Torr.You may have to try other parameters (Sample Period and Units/Division) in order to have the plot show up properly. Configure the system as follows:

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

Enter the Set-up Mode and adjust the mass flow controller for a throughput of 40 sccm. What is this throughput in torr-liters/sec?

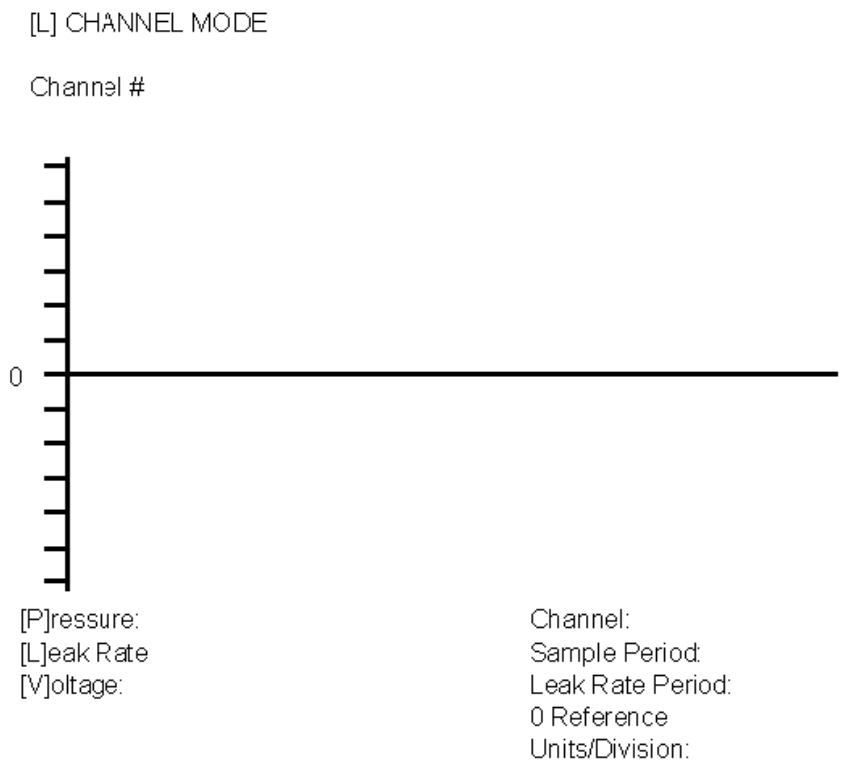
What is the purpose of a mass flow controller?



Turn on the pump and evacuate the system. When the system has stabilized at its base pressure, zero the capacitance manometer. What is the base pressure value as measured by the convection Pirani gauge? (The Pirani gauge is used because of its resolution in this pressure range.)

While monitoring the Channel 1 trace, quickly open the pinch clamp between the MFC and the chamber. What did you observe on the pressure plot? What is the new equilibrium pressure as measured by the convection Pirani? Sketch the curve on the graph on the next page.

The relationship between pumping speed (*S*) in liters/sec, pressure (*P*) in torr, and throughput (*Q*) in torr-liters/sec. is represented by the equation $Q = P \times S$. When the system was at base pressure with no gas flowing from the MFC, we only knew one parameter, the pressure at the point where the gauge is mounted. However, by admitting a known *Q*, the pressure also rose by a certain amount. Knowing the change in pressure resulting from a change in gas load then permits us to calculate speed. With the data gathered, determine the effective pumping speed in liters per second.



At what point(s) on this system is this speed valid?

Is this calculated speed the same as that of the pump manufacturer's data specification? If not, why? Where on the system is the manufacturer's rated speed valid?

Now that we know the effective pumping speed, what was the gas load, in torr-liters/sec, when the system was at its initial equilibrium base pressure (no flow from the MFC)?

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Name at least four possible sources of the gas load at base pressure.

Now close the manual butterfly valve and open the bypass pinch clamp slightly. Let the system stabilize at a new, 3rd, equilibrium pressure between 3 and 5 Torr. Record this third equilibrium pressure.

Using the difference in pressure from the initial equilibrium pressure (base pressure) and the 3rd equilibrium value, calculate the effective pumping speed. Is the speed different from the previous calculation? Why?

Finally, close the manual butterfly valve and the bypass pinch clamp. Note the linear pressure rise trace on the screen. Sketch the curve on the graph on the previous page. Using a watch with a second hand, calculate the rate-of-rise (that is, the slope of the curve) in units of torr/second.

What does the rate-of-rise represent (be specific)?

You have completed this lab and you can bring the MKS trainer to atmospheric pressure per the approved procedure (see Lab #1).

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.