Lab 1
Achieving Vacuum with the MKS Trainer

Name: ______________________

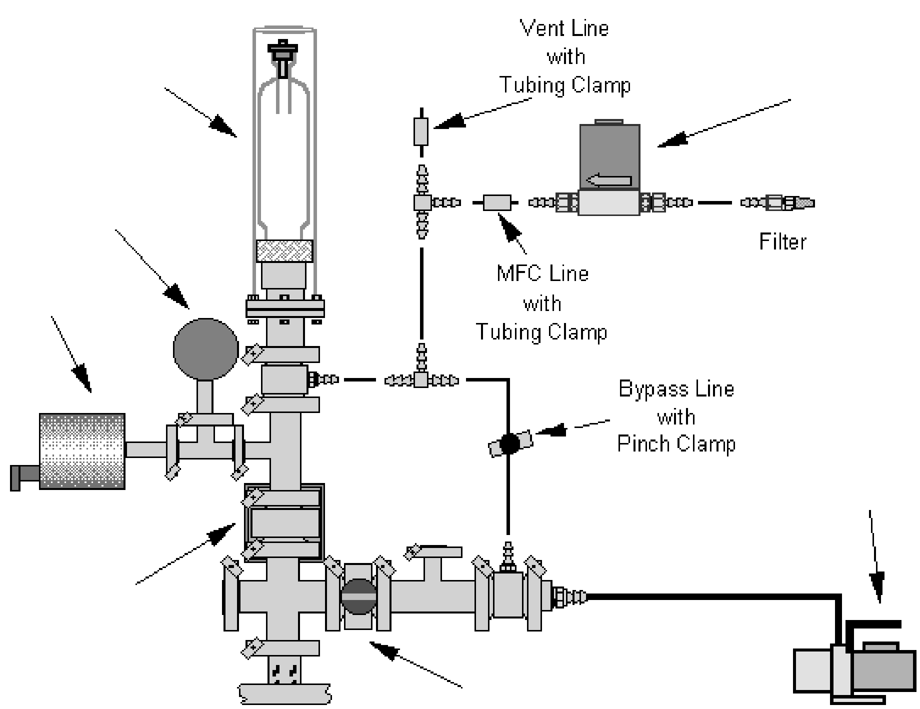
PURPOSE

The purpose of this lab is to:

1) Familiarize the student with the MKS vacuum trainer
2) Understand backstreaming and why oil pumps are not used in wafer-fabs
3) Bring the system to base pressure
4) Zero the MKS Baratron (capacitance manometer) pressure gauge and perform a pressure rate-of-rise leak check
5) Properly bring the vacuum trainer back to atmospheric pressure

Part I: Overview of the MKS VTS-1 Vacuum Training System

The MKS vacuum trainer operates in the medium and rough vacuum ranges and is pumped with an oil-sealed two-stage rotary-vane pump. Review the figures in this lab that describe the MKS trainer. Be sure that you can identify each part of the system. Identify each component highlighted by an arrow in the following figure:



Part II: The Oil-Sealed Rotary Pump

Describe the type of pump used with the MKS trainer (manufacturer and description of pumping technology – use information from the pump data sheet and in the book).

What base pressure is the pump capable of obtaining (use the data sheet, and specify this in milliTorr)? What type of vacuum is this (rough, medium, high)?

What is the speed rating of the pump? Describe what pumping speed means, and how it is related to pressure and throughput (give the equation and define the terms)?

Oil-sealed vacuum pumps are now infrequently seen in semiconductor manufacturing applications. One reason is that oil vapors, in some circumstances, will backstream. Explain what backstreaming is and under what conditions it will occur. How could you make backstreaming occur in the MKS trainer (give the specific steps)?

This vacuum pump is designed to only operate with safe (non-toxic, inert) gases. What problems, other than backstreaming, might be seen when this type of pump is used in a semiconductor process?

Where oil-sealed mechanical pumps are used, certain precautions are undertaken to minimize the effects discussed above. What might some of these precautions be?

Part III: System Software Control

Turn on the personal computer and MKS controller. Load the MKS control software (146_rti.exe). Follow the instructions to obtain the main menu screen.

There are 4 different channels. Enter into Set-up Mode to see which instrument is attached to each channel. List the instrument attached to each channel and give a short description of each instrument (use your book for information).

Channel 1:

Channel 2:

Channel 3:

Channel 4:

Part IV: Bringing the System to Base Pressure

At this point you are ready to start evacuating the vacuum chamber. **NOTE: Do not turn on the pump until the instructor or lab assistant has checked your equipment and approved your set-up**. Please check the following:

- Ensure all pinchcocks in the flexible tubes are closed.
- Open the manual butterfly valve.
- Ensure the Type 153 throttle valve is open. You have to look behind and check that the Open light is on when the top toggle switch is pushed to Open.
- Enter Channel Mode and use the convection Pirani gauge to monitor the system pressure (Channel 2).
- Turn on the vacuum pump.

NOTE: **Never turn off the pump unless the system is immediately evacuated by opening the vent pinchcock right after turning off the vacuum pump**. Make sure all pinchcocks are open except the vent pinchcock. The manual butterfly valve should be open. The instructor will review this with you prior to starting.

Make adjustments to the parameters on Channel 2 so that you can observe a graph of the decrease in pressure using the Pirani gauge (adjust Sampling Period and Units/Division). Over what pressure range is the convection Pirani gauge valid? Explain the difference between a convection Pirani gauge and a conventional Pirani gauge.

The MKS trainer is capable of achieving a vacuum less than 50 milliTorr. However, we are limited to the ultimate vacuum the pump is capable of achieving (you answered this in a previous question). Ideally we will achieve a pressure less than 50 milliTorr. We will call this the *system base pressure.*

You may have to add a pinchcock on the flexible tubing next to the vacuum chamber to achieve the lowest possible base pressure. At what pressure does the system stabilize at (express in milliTorr)? List at least 3 reasons why the system may not be able to achieve the rated base pressure of the pump (or why it might take a long time to reach this pressure). What could be done to improve the system base pressure?

Explain what types of gas flow occur in this system, and describe. Consider the entire pumpdown from atmospheric pressure to base pressure. Are there other types of gas flow? If so, describe.

Part IV: Zeroing the Capacitance Manometer

Note: Baratron is a trademark of MKS Instruments, Inc. The generic name for this type of gauge is capacitance manometer or capacitance diaphragm gauge (CDG).

Configure the system as follows:

- Throttle and butterfly valves open
- MFC setpoint at 0 (verify this by checking the MFC channel on the screen)
- The line from the MFC pinched closed
- Observe the pressure using the convection Pirani gauge

Pump the system to a pressure less than 50 milliTorr as measured by the convection Pirani gauge. It may be necessary to place pinchcocks at the beginning of each flexible tube (to isolate the tubes themselves, as there may be some leakage due to permeability of the tubes).

Display the capacitance manometer output on the screen. Locate the capacitance manometer's zero adjust pot, and with a small screwdriver, adjust the zero pot to give a reading of 0.0 Torr. The instrument is now zeroed.

Why do capacitance manometers have to be zeroed?

The general purpose capacitance manometer that is supplied with the VTS-1 has an accuracy specification of 0.5% of reading. Given this specification, what are the maximum reading errors (in Torr) at the following pressures?:

Pressure	Error	Error if zero is offset by +0.2 Torr
1000 Torr		
10 Torr		
1 Torr		

A typical capacitance manometer has a resolution of 1 part in 10,000 of the full scale rating. The capacitance manometer that is supplied with the VTS-1 has a full scale rating of 1000 Torr. What is its resolution (in Torr)?

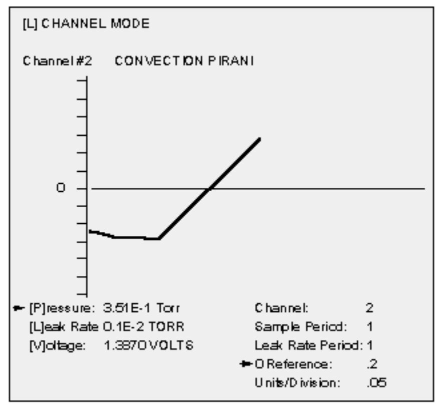
If you wanted to accurately measure a pressure in the range of 500 milliTorr, would you select a capacitance manometer with a full scale range of (circle one and explain your answer):

100 Torr? 10 Torr? 1 Torr? 100 milliTorr?

Pirani gauges are not supplied with accuracy specifications but they are generally repeatable to 5 or 10% and the accuracy of a new gauge will usually be in the same range. Why is it acceptable to use the Pirani gauge to zero the capacitance manometer?

Is the capacitance manometer a direct or indirect gauge and what do those terms mean? What type of gauge is the convection Pirani?

Part V: Leak Checking the System



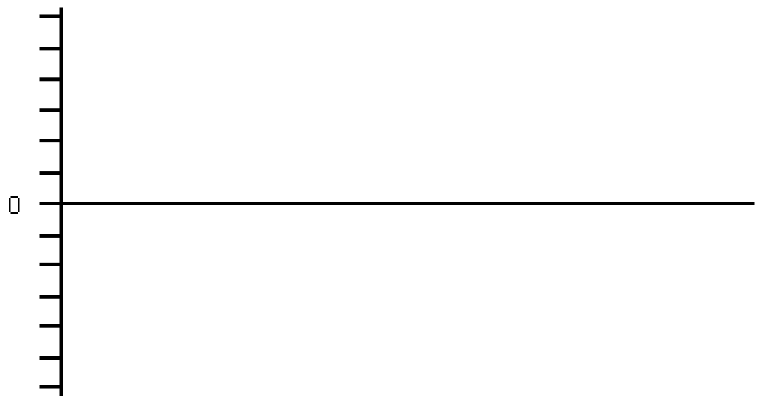
We will perform a simple "rate of rise" leak check by monitoring the pressure rise after the vacuum chamber is isolated from the pump. With the screen in Channel Mode and displaying the convection Pirani gauge, close the butterfly valve and observe the pressure rise. You should obtain a slow, linear (at least initially) rise in pressure.

Given the two gauges on the system, why is the Pirani the more appropriate gauge for this test?

What does the leak rate parameter on the screen specify? Ideally, this rise should be about 0.001 Torr/sec or less. If the rise is significantly greater than this, inspect the system for loose fittings, missing O-rings, etc. Calculate the rate of rise for this system using a watch and the pressure rise shown on the screen. Is it less than 0.001 Torr/sec? If it is not acceptable, check the system for a leak. You can plot your pressure rate-of-rise curve on the graph on the next page. Be sure to record the graph parameters.

[L] CHANNEL MODE

Channel #



[P]ressure:
[L]eak Rate
[V]oltage:

Channel:
Sample Period:
Leak Rate Period:
0 Reference
Units/Division:

Most of the pressure rise is probably due to virtual leaks. What is a virtual leak (refer to the book if necessary)? Give at least 2 virtual leak sources that could be contributing to the pressure rise.

Part VI: Returning the system to Atmospheric Pressure

Now we will return the system to atmospheric pressure. **NOTE: Please review these instructions with the instructor or lab assistant prior to starting this activity.**

- Make sure the butterfly valve is open.
- Open all pinchcocks except the vent pinchcock. Make sure you have direct access to the vent pinchcock.
- With one hand (or person) on the vent pinchcock, turn off the pump.
- Immediately after turning off the pump, open the vent valve with the pinchcock. You should hear air enter the vacuum chamber. Failure to vent the system quickly will result in oil from the mechanical pump backing up through the foreline into the manifold.

The system is now at atmospheric pressure. A final step is to check the Pirani gauge (Channel 2) to ensure it reads the same as the capacitance manometer (Channel 1). If it differs, then the Pirani gauge must be *spanned*. Spanning the gauge simply means that the top end of the Pirani's calibration curve gets locked to the same value as that of a gauge of known accuracy.

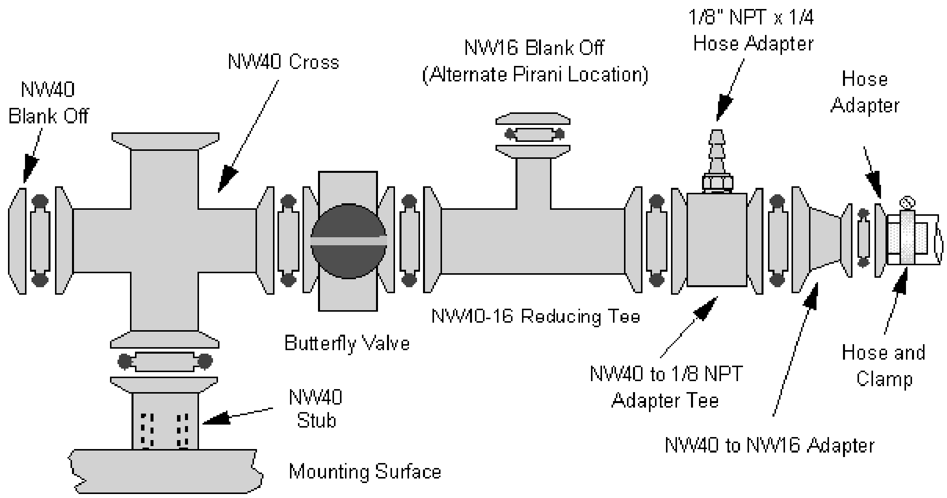
Span the pirani gauge to the capacitance manometer on the screen by doing the following:

- Return to the main menu and press [E] Span Channel.
- The screen will prompt you to enter the channel to be spanned. Enter "2" for the Pirani.
- The screen will then prompt you to enter the reference channel. Press "1" for the capacitance manometer.

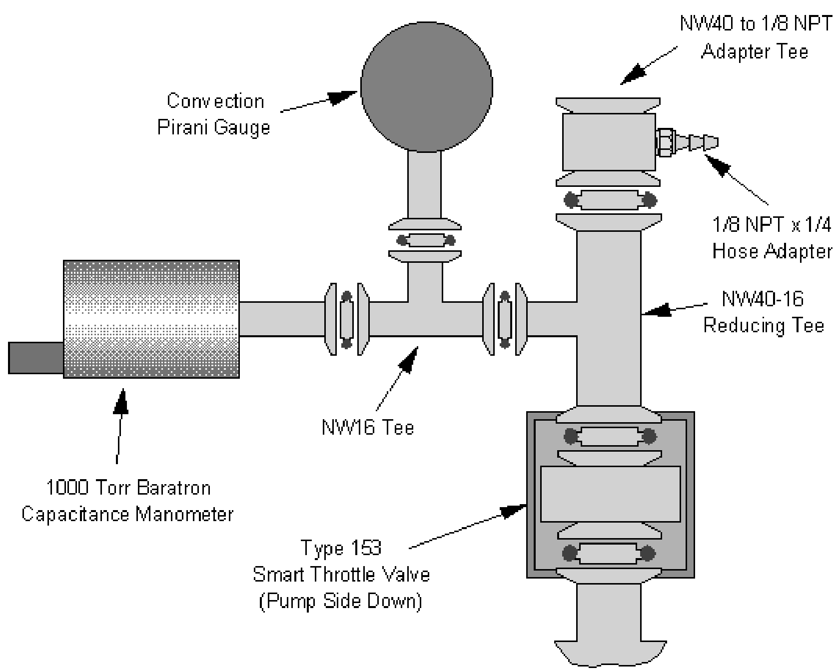
Now the pressure reading of the Pirani gauge will be matched to the reading of the capacitance manometer gauge.

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 01810-2449 or by email to hansens@mksinst.com.

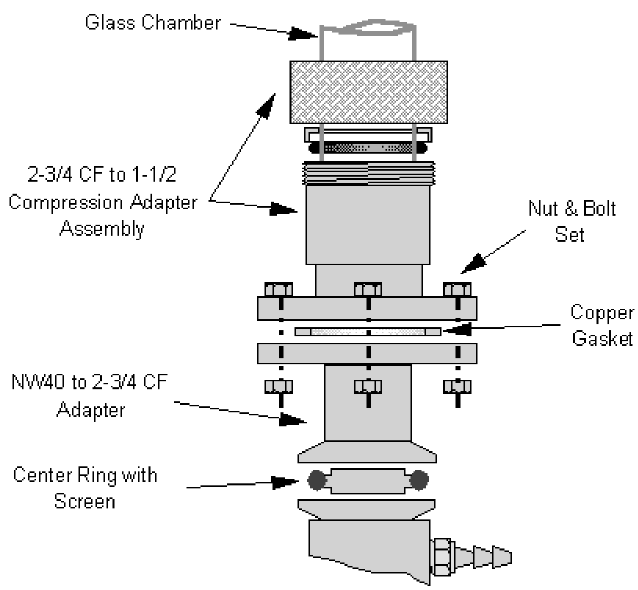
Lower Manifold



Throttle Valve and Gauging Section



CF & Compression Adapters and the Glass Chamber



Chamber Top End and Shield