

Vacuum Technology

(Continued)

Summary

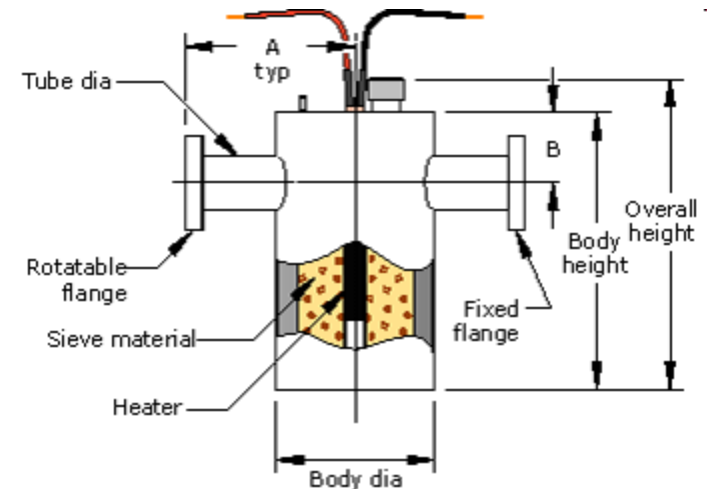
- Molecules sizes ($\sim 3 \text{ \AA}$)
- Distance between molecules ($\sim 30 \text{ \AA}$)
- Mean free path (inversely proportional to pressure, $\sim 10 \text{ cm}$ for 1 mT)
- Gas velocities ($\sim 500 \text{ m/s}$)
- Knudsen number = MFP/L
- Vacuum systems

Vacuum Pumps

	Mechanical	Diffusion	Turbo molecular	Ion	Ti Sublimation	Cryo
Type	Gas Transfer	Gas Transfer	Gas Transfer	Adsorption	Adsorption	Adsorption
Range	$10^3 - 10^{-3}$	$10^{-3} - 10^{-7}$	$10^{-4} - 10^{-10}$	$10^{-6} - 10^{-11}$	$10^{-6} - 10^{-11}$	$10^{-6} - 10^{-9}$
Pump Speed	Up to 300 lt/s	Up to 50K lt/s	50 – 3500 lt/s	Up to 1000 lt/s	Surface area dependent	Vapor dependent (~1000 lt/s)
Pros	Low vacuum workhorse, roughing pump	No vibrations	Clean	Clean, bakeable, no vibrations	Used as an addition to other UHV pumps	Clean
Cons	Vibrations, oil contamination	Hot oil	Vibrations	Lower pump speed	Not for inert gases	Vibrations, not for Helium

Foreline Traps

- Used to prevent hydrocarbons and water vapor from backstreaming.
- In a molecular sieve trap, a zeolite sieve acts as the trap.
- Water vapor can be baked out but trapped oil cannot. The sieve needs to be replaced periodically.
- Other types are coaxial and liquid nitrogen traps.



Vacuum Flanges

- Used to connect vacuum chambers, tubing and vacuum pumps to each other.
- Quick release flanges (QF, KF, LF)
 - up to 10^{-8} Torr, 150 °C
 - Flanges are connected by an elastomer ring and held together by a ring clamp.
- Con-Flat flanges
 - Knife edged rims inside create grooves on the gasket for the seal.
 - up to 10^{-13} Torr, 450 °C
 - Can use viton or copper gaskets



Vacuum Gaskets

- Viton Fluoroelastomer Rubber
 - Multiple uses
 - Oil resistant
- OFHC Copper
 - Single use
 - Use with CF flanges
 - Best solution for UHV



Vacuum Valves

- Used for:
 - Isolation
 - Flow control
 - Enabling access
- Valve parts:
 - Valve body
 - Flapper
 - Actuator

Valve Types

- Gate valves
 - Isolation
- Angle and inline valves
 - Pump switching, isolation
- Ball valves
 - Low vacuum, foreline trap isolation
- Butterfly valves
 - Suitable for large openings, conductance control
- Leak valves
 - Controlled gas flow

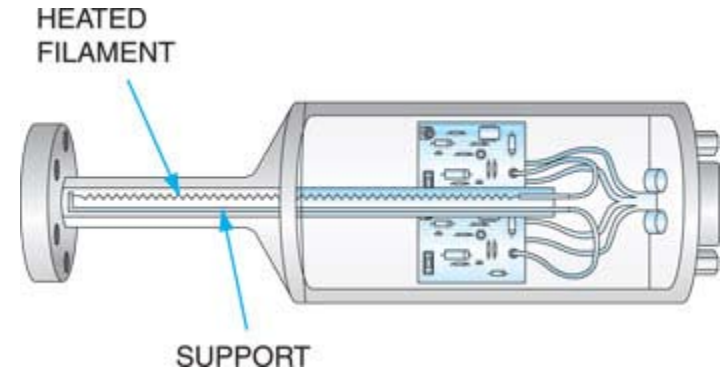


Pressure Gauges

- Absolute pressure
 - Referenced against perfect vacuum
 - 1 atm = 760 Torr = 14.7 psi
- Gauge pressure
 - Referenced against atmospheric pressure
- Differential pressure
 - Pressure difference between two points
- Different gauges measure different scales.
 - Combine various gauges in a single controller.

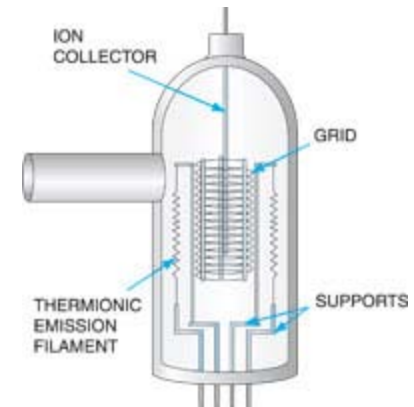
Pirani Gauge

- Operation is based on thermal conductivity.
- A filament is heated and its temperature is measured.
- The temperature depends on the heat loss to the environment which in turn depends on the vacuum level.
- Will work between $10 - 10^{-3}$ Torr



Ion Gauge

- A filament is used to emit electrons which are attracted to a positively charged grid.
- Inside the grid is a negatively charged collector.
- The electrons collide with gas molecules around the grid and ionize them.
- The positively charged ions are attracted to the collector and create an ionic current.
- Works between $10^{-3} - 10^{-10}$ Torr



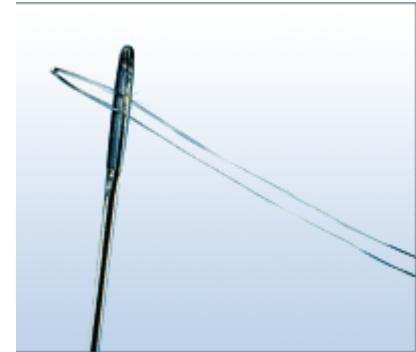
Feedthroughs

- Electrical
 - Power
 - Instrumentation
 - Thermocouple
- Optical
 - Viewports
 - Fiber optic
 - Glass-metal
- Motion
- Fluid



Thermocouples

- Thermal gradients will produce electrical voltage differences in conductors.
- Using two different conductors meeting at a point will generate a voltage difference that can be calibrated.
- The v vs. T relationship is non-linear and not very precise (not good around $\sim 0.1^\circ \text{C}$)





Crystal Monitor



- Monitors thin film deposition rate and calculates thickness
- Quartz crystal has an oscillating electrical current, oscillates at a fixed frequency
- Oscillation frequency changes with changing mass
- Must input material density for each material
- Quartz crystal must be changed frequently
- Position needs to be calibrated

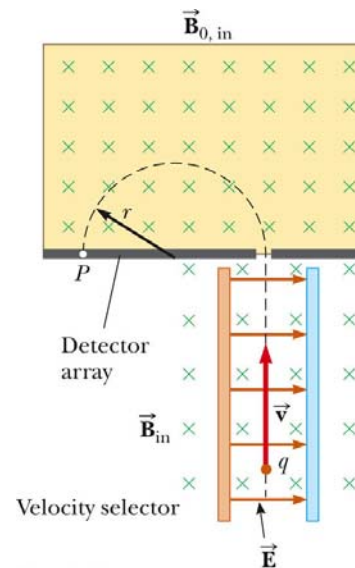


Mass Spectrometry

- Ions with a high charge to mass ratio are deflected more strongly in magnetic fields.
- Charge particles into ions.
- Accelerate them using an electric field.
- Deflect them using a magnetic field.
- Used to obtain chemical composition data.

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$

Mass Spectrometer



$$\frac{m}{q} = \frac{rB_0B}{E}$$

RHEED

- **R**eflection **H**igh-**E**nergy **E**lectron **D**iffraction
- A well formed crystal will have a well-defined diffraction pattern
- As successive layers are formed, the intensity of each spot will fluctuate.

