Vacuum equipment is used to generate, maintain, and manipulate pressures below that of the ambient atmosphere. Many common lab procedures require vacuum conditions, such as inert gas purging, cannulation, and solvent evaporation. Vacuum equipment often requires special care to maintain.

### Quality

Higher quality vacuum contains less matter, and therefore a lower pressure. A commonly used convention is:

- **Low vac**: 760 torr - 25 torr
- **Medium vac**: 25 - $10^{-3}$ torr
- **High vac**: $10^{-3}$ - $10^{-9}$ torr
- **Ultra high vac**: $10^{-9}$ - $10^{-12}$ torr

### Pumps

- **Diaphragm**: Diaphragm pumps use a flexible diaphragm and a set of check valves to produce pumping pressure and typically produce low to medium vac. They are often resistant to solvent and mildly corrosive vapors, making them useful for rotary evaporators, but their inability to produce high vacuum limits their utility. Diaphragm pumps often do not require oil.

- **Rotary Vane**: Rotary vane pumps use rotating sets of circular vanes in an elliptical cavity to create pumping pressure, and can achieve medium to high vacuum. If your pump requires oil changes, it is likely a rotary vane pump. Though they can achieve higher vacuum than diaphragm pumps, they are easily damaged by solvent or corrosive vapors. Steps must be taken to prevent harmful vapors from reaching this type of pump such as the implementation of a cold trap as contamination can significantly reduce a pump's efficiency and lifetime.

- **Diffusion**: Diffusion pumps have no moving mechanical parts; instead they use a high speed vapor jet to direct gases toward the exhaust. This type of pump can achieve high to ultra high vacuum, but can not discharge directly to the atmosphere and must use a secondary pump to maintain low pressure at the outlet. Diffusion pumps can also introduce oil vapors into the vacuum chamber.

- **Turbomolecular**: Turbomolecular pumps use sets of spinning blades to accelerate gases. They can achieve medium to ultra high vacuum. Higher vacuum requires faster rotational rates, so turbomolecular pumps must also be treated with care to avoid introducing particles or corrosive vapors. Some types of turbomolecular pump also require a secondary pump at the outlet.

### Schlenk Lines

A Schlenk line, often referred to as a vacuum manifold, is composed of a vacuum line connected by several valves to an inert gas line and a port. The valve position connects the port to either the vacuum line or the inert gas line. The inert gas line often has an oil-filled bubbler at its outlet to prevent atmospheric contamination.

### McLeod Gauge

A McLeod Gauge is an instrument for measuring pressure in high-vacuum systems. It is filled (typically) with mercury. When pressure is not being measured, the gauge should be held in the “evacuating” position; the mercury rests in a chamber connected to two capillary tubes, which should be (just past) horizontal. To make a measurement, the gauge
should be connected the line and opened to vacuum. Pressure should be allowed to equilibrate for a couple of minutes. Then the gauge should be rotated so that the capillaries are vertical (the "measuring" position); the mercury should flow from the chamber into the capillaries. One of these capillaries is open to the rest of the system, while the other is closed. The difference between the levels of the mercury when these are vertical gives the pressure of the system (the instrument should have its own scale, which should be zeroed to the level of mercury in the open capillary). For accurate measurements, the rotation from evacuating to measuring positions should be slow, to prevent discontinuities in the mercury.

Before disconnecting the gauge, it should be returned to the evacuating position and returned, slowly, to atmospheric pressure. Disconnecting the system while it is still under vacuum can cause splattering of mercury, potentially out of the gauge. Returning it to atmospheric pressure while it is in the measuring position can cause mercury to get stuck in the closed capillary.

**Safety**

Care should be used to avoid venting harmful vapors into the lab atmosphere. Pump exhaust should be either vented into a fume hood, or fitted with an appropriate scrubber or filter. When broken, evacuated glassware shatters and violently implodes, sending fragments flying at high velocity. Inspect your glassware for cracks and flaws before applying vacuum.