General Good Vacuum Practices

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Why do we need a good vacuum in the lab?

- To pump out the superconducting magnet jacket and in the cryogenic fridge jacket. Due to all gases, except helium, hydrogen and neon, will condense on surfaces cooled to below about 60 K. Therefore, once liquid helium at 4.2 K is introduced into the magnet or the fridge, all the residual gases that are normally present will condense, reducing the pressure in the vacuum space by one or two orders of magnitude. Therefore, the vacuum works as a thermal insulation to allow liquid helium to be held in the magnet and the fridge.
- To pump out the helium gas the separator line.
- To reduce the vapor pressure over the cryogenic fridge to get 1K.

Understanding vacuum

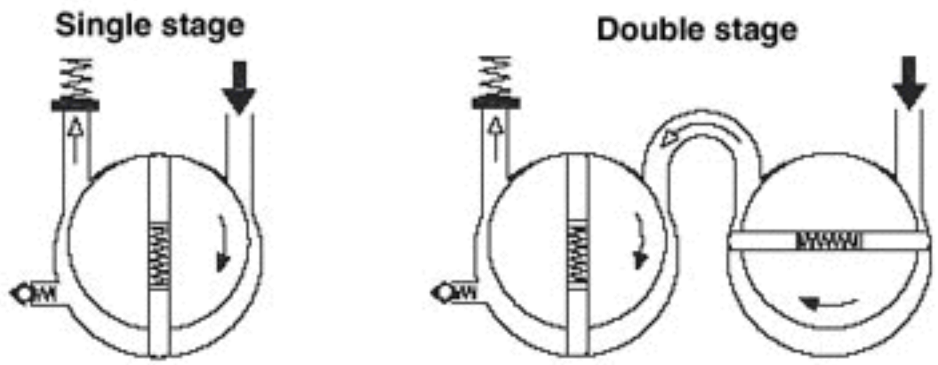
	Pressure (Torr)
Atmospheric Pressure	760
Low Vacuum	760 to 25
Medium Vacuum	25 to .001
High Vacuum	1×10^{-3} to 1×10^{-9}
Ultra high vacuum	$< 1 \times 10^{-9}$

Vacuum Pumps I

In our lab

Roughing pumps

Rotary pumps
oil required



[1]

In ideal conditions could get a base pressure of:

$10^{-4} Torr$ $10^{-5} Torr$

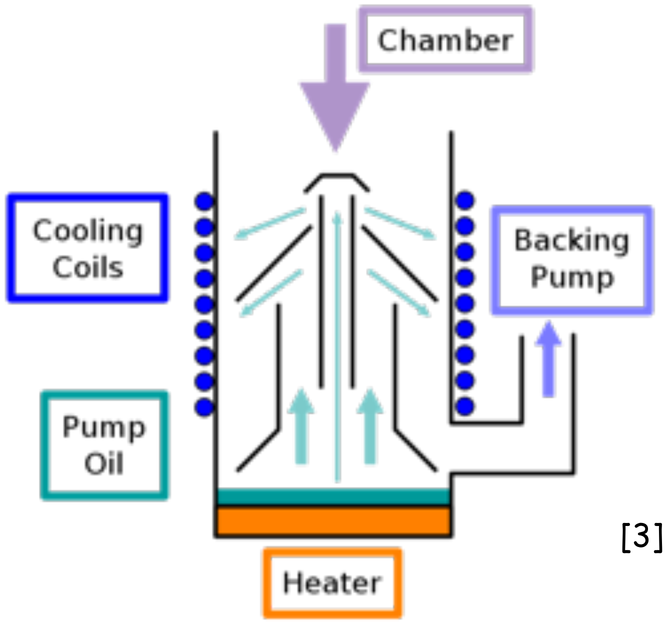
The inlet valve is always open during operation. The working chamber is located inside the housing and is restricted by the stator, rotor and the vanes. As the rotor turns, gas flows into the enlarging suction chamber until it is sealed off by the second vane. The enclosed gas is then compressed until the outlet valve opens against atmospheric pressure. The outlet valve is oil-sealed. When the valve is open, a small amount of oil enters the suction chamber and not only lubricates it but also seals the vanes against the housing. [2]

Ideal for rough pumping or as a backing pump for a diffusion or turbo pump. But, not good enough to produce thermal isolation.

Not in our lab

Diffusion pumps

oil required



[3]

In ideal conditions could get a base pressure of:

$10^{-8} Torr$

Diffusion pump is heated to its boil temperature. The vaporized oil moves up, traps the gas molecules in the chamber, as oil condensates on the cold surface, the gas gets free and is removed from the chamber with the pre-vacuum pump.

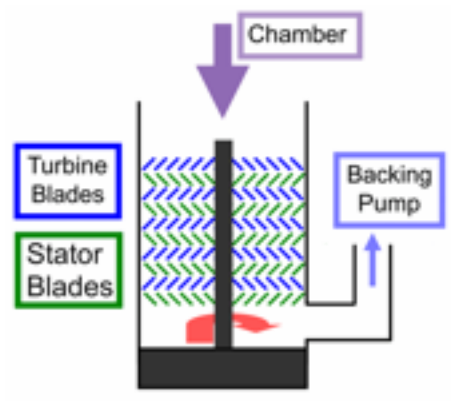
Ideal for pumping insulating high vacuum spaces in cryostats.

Vacuum Pumps II

In our lab

Turbomolecular pumps

Oil free



[4]

In ideal conditions could get a base pressure of: $10^{-9} Torr$

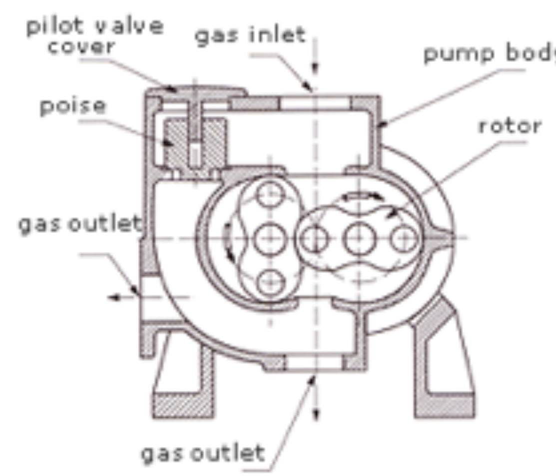
“The gas molecules enter through the inlet, the rotor, which has a number of angled blades, hits the molecules. Thus the mechanical energy of the blades is transferred to the gas molecules. With this newly acquired momentum, the gas molecules enter into the gas transfer holes in the stator. This leads them to the next stage where they again collide with the rotor surface, and this process is continued, finally leading them outwards through the exhaust.” [4]

Ideal for pumping insulating high vacuum spaces in cryostats. They should be vented from the high vacuum side, while they are still spinning slowly.

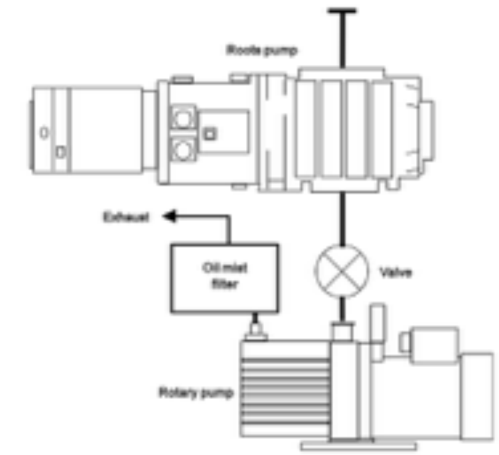
In our lab

Roots Pumps

oil required



[5]



[6]

In ideal conditions could get a base pressure of: $10^{-5} Torr$

Single-stage and multi-stage Roots known as roots blowers. Two synchronously counter-rotating rotors rotate contactlessly. The rotors have a figure-eight configuration and are separated from one another by a narrow gap. Four to six pairs of rotors are located on the rotor shafts. Each rotor cavity is separated from the others by stator disks with a gas orifice. The gas conveyed is pumped from the inlet port to the outlet port. One shaft is driven by a motor. The other shaft is synchronized by a timing gear in thew gear box. Lubrication is limited to the gear box and encapsulated low pressure and high pressure bearings, which are sealed off from the suction chamber by shaft seals. [7]
They can be reach rotation speeds of up to 6,000 rpm. Two (or more) pumps can be used in series with some advantage.

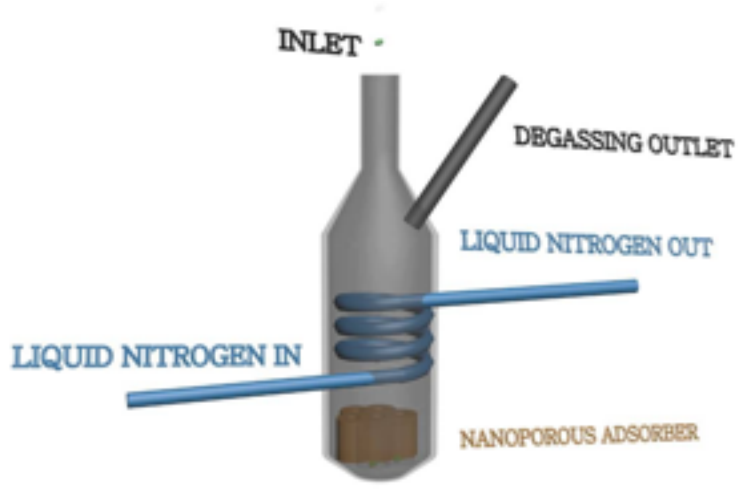
Ideal for reaching high vacuum range with very high gas throughputs (dilution refrigerators).

Vacuum Pumps III

Not in our lab

Sorption pumps

Oil free



[8]

In ideal conditions could get a base pressure of:

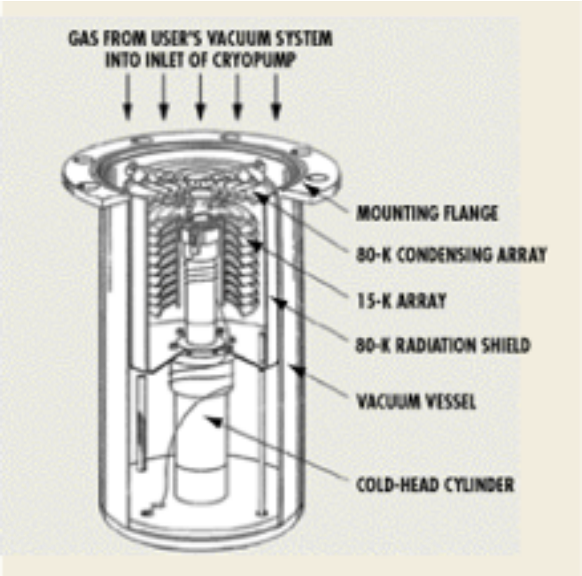
$10^{-2} Torr$

"The cylindrical shape is filled with an adsorbent material (activated charcoal or a molecular sieve). The canister is placed in a dewar cooled by liquid nitrogen. Zeolite is a poor heat conductor, so an array of aluminum fins inside the pump is used to improve thermal contact with the sieve material. The pump body and internal cooling fins are specially designed for maximum heat transfer. The pump neck and flange are made of stainless steel. The pumps are mounted and supported by the flanges and since stainless steel is a poor thermal conductor frosting of adjacent components is minimized." [9]

Ideal for pumping insulating high vacuum spaces in cryostats. They should be vented from the high vacuum side, while they are still spinning slowly.

Not in our lab

Cryopumps



[10]

In ideal conditions could get a base pressure of:

$10^{-4} - 10^{-9} Torr$

Trap gases and vapors by condensing them on a cold surface, but are only effective on some gases. It is made of a large number of metal plates cooled around to 4.2 K. It may also use dry ice, liquid nitrogen. The plates are attached to the cold head to expand the surface area available for condensation, but these also increase the radiative heat uptake of the cryopump. Over time, the surface eventually saturates with condensate and thus the pumping speed gradually drops to zero. It will hold the trapped gases as long as it remains cold, but it will not condense fresh gases from leaks or backstreaming until it is regenerated.

Used in high or ultra high vacuum systems.

O-rings

Choosing the right one!


Butyl rubber is not a possible choice, because it permeates to gasses (helium). It works until -60°C.


PTE (Teflon) may break when is compressed, but it is also used as vacuum seals.


Viton (Fluoroelastometer) is more expensive that Buna N and deforms more after being compressed.
It works from -20°C to 200°C, but after being exposed to temperatures bigger than 200°C, the residues may contain hydrofulic acid.


Buna N (Nitrile rubber) is the most common for vacuum applications. It is cheap and works from -40°C to 120°C.

They need to be clean!

You can check with the latex glove for impurities. But, always clean them gently with a wipe before to use them.

Avoid to use any solvent because they reduce the workalike f the o-ring and it remains outgassing for several days.

Apeizon L or N is recommended to clean and conditioning: Using gloves, put a Appeizon (a little) in your finger, pu it between your fingers to warm it up and thin it out. Rub it in thoroughly, going around the entire o-ring several times. Now, clean your gloves with a clean, lint free cloth. Attempt to remove as much as you can with a your gloved fingers. Repeat the procedure again. Clean your gloves repeatedly, and each time try to remove as much grease as you can.

Discard any broken or damaged o-ring

O-ring may fail because of abrasion, over-compression, degradation, extrusion, installation damage, among others. Those o-rings need to be disposal and never used for high vacuum purposes.

All the lines in the vacuum system are important!

The pumping lines need to be all leak checked,

The throughput of the lines must be at least as high as that of the pump affect the amount of time required to pump down to the required pressure.

Clean Surfaces are vital importance in the vacuum system, because the may outgas. Clean and polish all the surfaces.

Make sure the clamps are well positioned and clamped.

Use the recommended number of clamps for the flanges. For example, the most common size in the lab is ISOK-200 and it requires 12 clamps.

Flange Size	Flange O.D. (In)	Thickens (In)	Optimal Number of clamps
Iso K-63	3.74	0.47	4
Iso K-80	4.33	0.47	8
Iso K-100	5.12	0.47	8
Iso K-160	7.09	0.47	8
Iso K-200	9.45	0.47	12
Iso K-250	11.42	0.47	12
Iso K-320	14.57	0.67	12
Iso K-400	17.72	0.67	16
Iso K-500	21.65	0.67	16
Iso K-630	27.17	0.86	18

[11]

More…

Use gloves when you touch vacuum equipment, your finger prints may outagas and avoid to get ultra high vacuum.

Check all the bellows or equipment before to use. They may be contaminated and you may break the equipment. For example, if you use an oil contaminated bellow. It may break the pump if the oil gets to it.

Don't leave the equipment running without supervision, any failure may happen at any time.

Pumps

Make sure to use the pump when you get familiar with its system (read the manual and check it of any possible failure before starting). It is always good to check the oil level (if the pump requires oil), before to use it. Change the oil regularly.

The roughing pumps may contaminate with oil the vacuum lines or the pump may be contaminated, use the foreline trap in the rotary pump to reduce the amount of oil backstreaming the oil. Remember to change the filter regularly. Specially, in the Pfeiffer DUO 65 M. Don't use silicone rubber as o-ring because it is not leak tight to helium gas.

Using the turbopumps require a backing pump (roughing pump). First, start the roughing pump and when it gets got a pressure of the bellow 1 Torr, start the turbo pump.

For more information about the pumps in the lab check here.

Don't forget to use the appropriate pressure gauge for your job.

References

[1] http://www.vacuumpumpsuk.com/2SOLRV.html
[2] https://www.pfeiffer-vacuum.com/en/know-how/vacuum-generation/rotary-vane-vacuum-pumps/
[3] http://www.globalspec.com/learnmore/manufacturing_process_equipment/vacuum_equipment/vacuum_pumps/high_vacuum_pumps
[5] http://www.china-vacuum-pumps.com/vac/roots-vacuum-pumps.htm
[6] Book
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