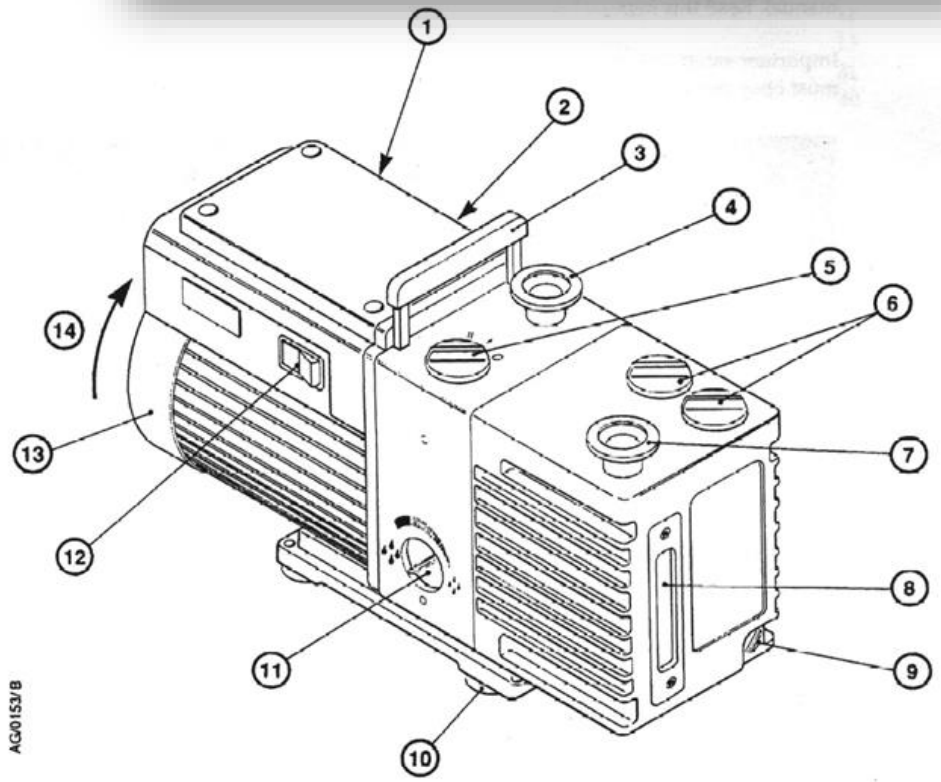
SOP: ROTARY VACUUM PUMP USAGE

ROTARY VACUUM PUMP PARTS



1. Electrical inlet-connector
2. Voltage indicator
3. Lifting handle (lifting bracket on RV8 and RV12 pumps and Bareshaft)
4. NW25 inlet-port
5. Gas-ballast control
6. Oil filler-plug
7. NW25 outlet-port
8. Oil-level sight-glass
9. Oil drain-plug
10. Rubber feet (4 off)
11. Mode selector
12. On/off switch (single-phase pumps only)
13. Motor fan-cover
14. Correct direction of rotation

MAINTENANCE & TESTING

Routine operation maintenance is necessary to maintain pump in normal use.

Operation	Frequency
1. Check the Oil level	Monthly
2. Replace Oil	Every 3000hours/4months
3. Pump Seals	Yearly
4. Inspect and clean Inlet-filter	Yearly
5. Inspect and clean gas-ballast control	Yearly
6. Clean Oil-level sight-glass	Yearly
7. Clean the Motor Fan-cover and enclosure	Yearly
8. Clean and overhaul the pump	Every 15000 hours/2 years
9. Fit new blades	Every 30000 hours/4 years
10. Test motor condition	Every 15000 hours/2 years

YAASIEN MUST CHANGE OIL ONCE EVERY 6 MONTHS OR EVERY 3000HOURS OF OPERATION

YAASIEN MUST SERVICE PUMPS ONCE A YEAR

In case of pump failure or a need for oil top-up or oil change inform:
Yaasien Ely at Ely.Ely@uct.ac.za or x2533

Place a **WARNING: OUT OF ORDER TAG** on RVP.
See Annexure 1!

PROCEDURES FOR CORRECT USE

In the **High Vacuum Mode** pressurized oil is fed to the low vacuum stage only and thus provides the best possible ultimate vacuum.

In the **High Throughput Mode** pressurized oil is fed to the high vacuum and low vacuum stages and the pump can thus sustain long-term high inlet pressures.

HOW CHECK THE OIL-LEVEL?

Oil level can be checked while pump is operating

- Check the level of the oil in the sight-glass (8), it must be between the MAX and MIN level marks on the bezel of the sight-glass
- If the oil-level is near to or below the MIN level mark, remove one of the filler-plugs (6) and pour more oil into the reservoir until the oil reaches the MAX level mark
- If the oil-level goes above the MAX mark, remove the drain-plug (9) and drain the excess oil from the pump
- Refit the filter-plug
- If the oil is contaminated, drain and refill the pump with clean oil as described below

WHEN MUST OIL BE REPLACED?

- Pale yellow or clean vacuum pump oil – indicates a good condition

REPLACE WHEN:

- Dark oil – indicates acid contamination

- Cloudy gray oil – indicates water contamination

HOW TO REPLACE OIL?

1. Operate the pump for approximately 10 min to warm the oil, then switch off the pump (this lowers the viscosity of the oil and enables it to be drained from the pump more easily)
2. Isolate pump from the electrical supply and disconnect it from your vacuum system
3. Remove one of the oil filter plugs (6)
4. Place a suitable block under the pump-motor to tilt the pump and place a suitable container under the drain plug (9)
5. Remove the drain plug and allow the oil to drain into the container
6. If the oil is contaminated, pour clean oil into the filler-hole and allow it to drain out of the pump
7. Repeat this step until the oil reservoir in the pump has been thoroughly cleaned

8. Refit the drain-plug, remove block and reconnect pump to system
9. Fill a suitable container with clean oil and pour the oil into the filler hole until the oil-level reaches the MAX level mark on the bezel of the sight-glass (8)
10. Allow a few minutes for the oil to drain the pump
11. If necessary add more oil
12. Refit the filler-plug

USE OF GAS-BALLAST CONTROL

The gas-ballast control is used to change the amount of air introduced into the low vacuum stage of the pump. The use of the ballast will prevent the condensation of vapours in the pump, which contaminates the oil. When choosing low or high flow gas-ballast positions “I or II” there will be an increased loss of oil.

Closed position “0”

- To achieve ultimate vacuum
- To pump dry gases

Low flow “I” position

- To pump low concentrations of condensable vapours
- To decontaminate oil

High flow “II” position

- To pump high concentrations of condensable vapours

TO ACHIEVE ULTIMATE VACUUM

1. Isolate the pump from the vacuum system by closing the isolation-valve
2. Turn the **Mode Selector** (usually on side of pump) to **High Throughput mode**
3. Set the gas-ballast control to low flow (position “I”)
4. Operate the pump for at least 1 hour (or overnight) to thoroughly purge the oil from contaminants
5. Turn the mode selector to select High Vacuum mode
6. Close gas-ballast control (“0” position)
7. Open the vacuum system isolation-valve and pump down to ultimate vacuum

TO PUMP CONDENSABLE VAPOURS

1. Close the vacuum system isolation valve
2. Turn the **Mode Selector** (usually on side of pump) **to High Vacuum mode or High Throughput mode** as required
3. Turn the **gas-ballast** control to **position “II”** and operate the pump for 30 min to warm the oil (this helps to prevent vapor condensation)
4. Set gas-ballast control to the position required for your application
5. Open the vacuum system isolation-valve

After having pumped off condensable vapour the oil can be decontaminated as described below.

TO DECONTAMINATE OIL

1. First pump off condensable vapours as described in point above
2. If oil in pump is cloudy or discolored it is contaminated – it should be clear
3. To proceed with decontamination close the vacuum system isolation-valve
4. Turn the **Mode Selector** (usually on side of pump) to select **High Throughput mode**
5. Set gas-ballast to the “I” position
6. Operate pump until oil is clear

FAULT-FINDING

The Pump Fails To Start

- The pump has been left to stand after contaminants have been pumped and has seized
- The oil is too viscous
- The oil is contaminated
- The oil temperature is below 12ºC
- The pump has seized after long storage
- The electrical supply fuse has blown
- The electrical supply voltage does not match that of the motor
- The outlet pipeline or the outlet-filter (if fitted) is blocked
- The motor is faulty

The Pump Fails To Achieve Specific Performance

- The mode selector and gas-ballast control are set incorrectly
- The oil-level is below the minimum level
- The oil is contaminated
- The vacuum fittings are dirty or damaged
- The inlet-filter is blocked
- The pump has not warmed up
- The pressure measurement technique or gauge head is unsuitable or gives an incorrect indication of pressure
- The pump is filled with the wrong type of oil
- There is a leak in the vacuum system

The Vacuum Is Not Fully Maintained After the Pump Is Switched Off

- The gas-ballast control is open (thus in the “I or II” position)
- The inlet-valve pad is damaged
- The inlet-valve has not closed

The Pump Is Noisy

- The oil is contaminated with solid particles
- The motor bearings are worn
- The motor fan-cover is damaged

The Pump Surface Temperature Is Above 100ºC

- The oil-level is below minimum level
- The oil is contaminated
- The process gas is too hot or the throughput is too high
- The outlet-filter or the outlet pipeline is blocked
- The pump is filled with the wrong type of oil
- The ambient temperature is too high
- The cooling-air supply is insufficient or is too hot
- The electrical supply voltage is too high

The Pumping Speed Is Poor

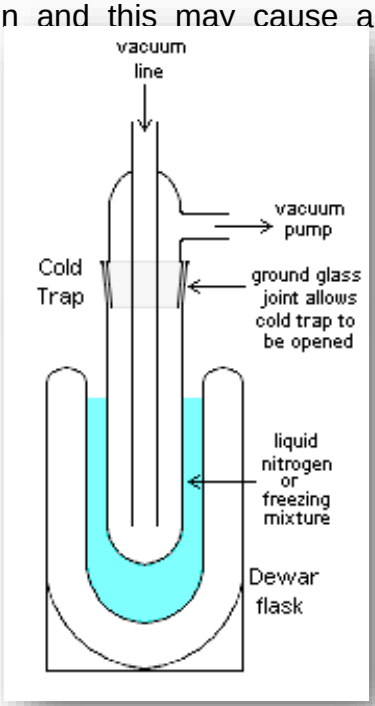
- The inlet-filter is blocked
- The connecting pipelines are too small in diameter
- The connecting pipelines are too long

There Is an External Oil Leak

- The outlet shaft-seal is worn or damaged
- The oil-box gaskets have deteriorated
- There is an oil leak from the gas-ballast control
- There is an oil leak from the drain-plug
- There is an oil leak from the sight-glass

COLD TRAP

- A cold trap should be placed between the pump and the experiment to *minimize* the amount of volatile chemicals from reaching the pump oil. Pump oil will break down if exposed to high concentrations of solvents from the vacuum line. This can result in pump damage.
- It also prevents the vacuum system form materials backstreaming from the pumps & increasing potential vacuum.
- The trap must be adequately sized and cold enough to condense vapours in the experiment.
- Extreme care must be exercised to prevent the introduction of room air into a trap containing liquid nitrogen. Liquid Nitrogen condenses oxygen and this may cause an explosion.
- If you observe blue crystals in the trap disconnect the trap from the system and shield the trap if possible.
- Remove reagents from the hood close the sash and allow the condensed material to evaporate.
- Maintain trap during the experiment.
- Check frequently for blockage.



- ❖ Cold traps should be assembled such that the down tube is connected to the source of gas whilst the cap is connected to the source of vacuum.
- ❖ Reversing this, connecting the down tube to the source of vacuum, places the inlet of the vacuum directly above the condensate, increasing the chances of vapour phase condensate moving up the (uncooled) down tube (towards the pump) or, should the trap begin to fill to an appreciable volume, liquid phase condensate being pulled into the pump.

USE WITH HAZARDOUS CHEMICALS

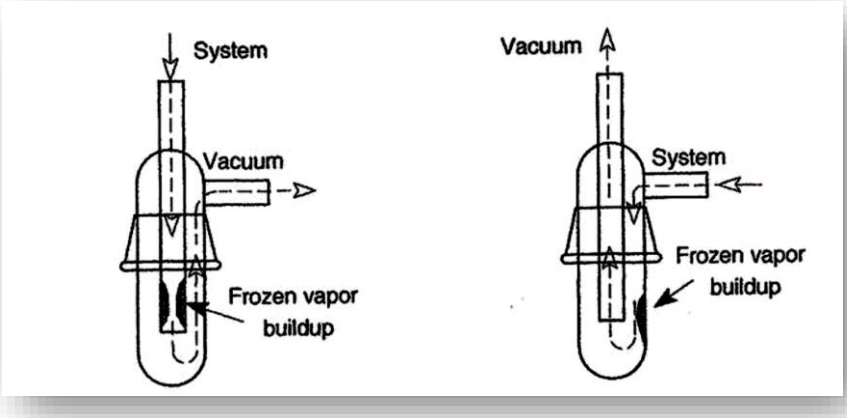
- Vacuum pumps which are used to evacuate systems containing toxic, corrosive or volatile substances must be vented into the building's exhaust system.
- Failure to properly vent the pump can result contamination of the lab with hazardous chemical vapours.

VENTED VACUUM PUMP

Exhaust gases always carry a certain quantity of oil mist. This is extremely unpleasant, and even harmful, for those working nearby.

- Use an oil mist separator (purchased from the pump vendor) to prevent oil mist loss.
- Connect the exhaust line to the exhaust port in the vacuum cabinet (if one is present) using a thimble connection *or* run the hose into the fume hood.
- Note that some oil mist separators may not fit into your vacuum pump cabinet. Measure before you order.

If a liquid nitrogen trap is attached the one way the can be a build-up of excess frozen materials in the center tube resulting in the reduction of the trap's throughput and can eventually lead to a complete cutoff of all gas flow through the trap. By orientating the trap the other way the buildup of frozen vapours collects on the outer wall leaving the center tube free for gas transport. This also allows one to remove the condensate whilst frozen and moved to a fume hood to prevent it from drifting back into the system. It lso assists to ensure a constant temperature at any vacuum.



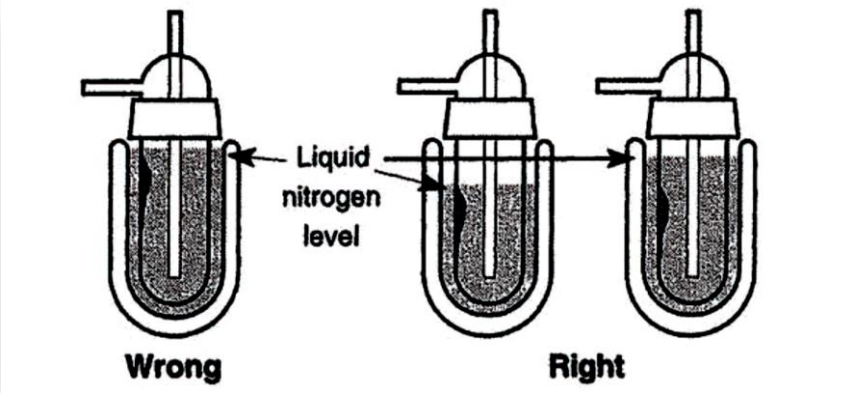
Trapped material must constantly be removed.

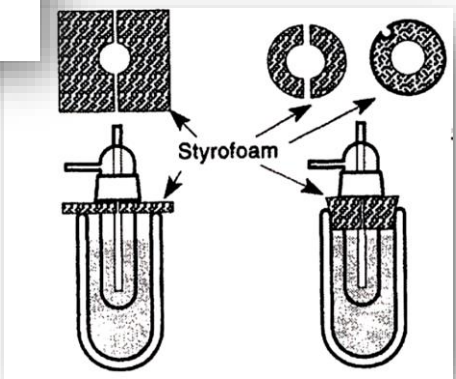
It is claimed that the best and efficient throughput will be obtained when the inside diameter of the inside tube divided by the inside diameter of the outer tube to obtain a ratio of 0.62.

Improper selection of coolant for a cold trap may artificially limit the potential vacuum of your system. The vapour pressure of water as coolant is quite high without any cold trapping, moderate at dry ice temperatures & negligible at liquid nitrogen temperatures. If your vacuum needs are satisfied within a vacuum of 5×10^{-4} torr you can use dry ice. Another coolant is a slush bath.

1) Prevent air (oxygen) from condensing within the cold trap – can occur especially with liquid nitrogen. Once LN is removed the condensed air vaporizes and excess pressure created by the frozen air can result in stopcock plugs being blown across a room to an explosion of the line. Thus to prevent this incident ensure there is no air in trap when filling it with LN. If you suspect air condensed – ensure it has room to expand. To prevent explosions
   a. Leave that section constantly under vacuum – do not bring it to room pressure. This is not always possible
   b. Let pump run for a few minutes to make sure the trap is below 1 torr before filling it with LN. Once the pumps noise has dropped that is usually when it is safe to place the trap in the LN.
   c. Leave a stopcock open to the atmosphere at the experiment end to vent the system after the work is completed. IMPORTANT remove the LN from trap before opening vent.

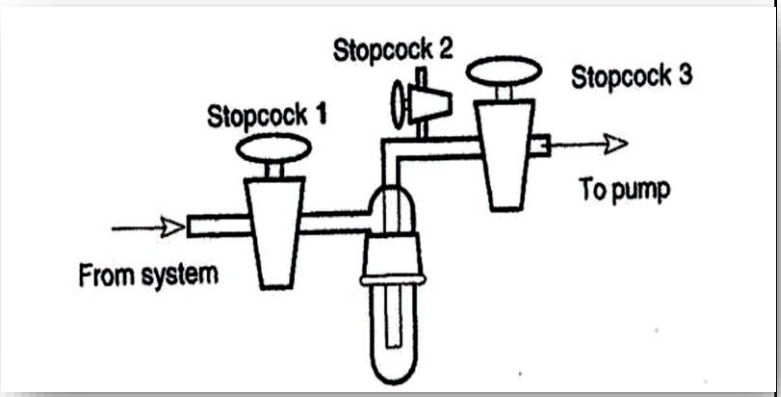
2) Limit the amount of moisture near or the top of the cold trap
   a. **DO NOT** overfill the Dewar at the early startup stage – the LN will initially boil off quickly & can limit the potential vacuum of system and create pressure blips





3) Maintenance of Cold Traps
   a. Maintain the LN or coolant of choice at a proper level while the trap is in use
   b. Maintain a clean trap to ensure best throughput
   c. Use a good-quality Dewar that is larger in radius than the cold trap by +/- 2cm on all sides
   d. Wrap Dewars in tape to prevent flying glass when implosion takes place
   e. If there is frost on outside of Dewar – chances are good that the void is filled with atmosphere. This is caused by a poor quality tip-off of Dewar when evacuated
   f. Insulate LN by placing something simple such as cardboard or Styrofoam corkscrew shape on top of Dewar with a cutout for cold trap.

4) Use various stopcocks within your system to assist maintaining a vacuum in the rest of the system.
5) When closing a system start closing from the trap section – thus prevents compounds vapours when warming up to drift into the rest of the line & to prevent oil to be drawn into the system.
   a. Close stopcock 1
   b. Remove coolant
   c. Turn off pump
   d. Open stopcock 2



6) When you temporarily need to remove trap:
   a. Close stopcocks 1 & 3
   b. Open stopcock 2
   c. Remove base of cold trap
   d. Replace base of cold trap
   e. Close stopcock 2
   f. Open stopcock 3
   g. When pump quiets down, replace Dewar under cold trap
   h. Open stopcock 1

HEALTH & SAFETY

1. Ensure that pumps have belt guards in place during operation to prevent hands or loose clothing from getting caught in the belt pulley.
2. Ensure that electrical cords and switches are free from defects.
3. Do not place pumps in an enclosed, unventilated cabinet allowing heat and exhaust to build up.
4. Do not operate pumps near containers of flammable chemicals, flammable chemical wastes, or combustible materials such as paper or cardboard.
5. Use correct vacuum tubing (thick walls) not thin Tygon-type hoses.
6. Replace old tubing; crumbly tubing can degrade performance.
7. Use the shortest length of tubing that reaches where needed.
8. Do not use solvents which might damage the pump.
9. Always close the valve between the vacuum vessel and the pump before shutting off the pump to avoid sucking vacuum oil into the system.
10. Place a pan under pumps to catch oil drips.
11. Check oil levels and change oil when necessary. Replace and properly dispose of vacuum pump oil that is contaminated with condensate. Used pump oil must be disposed as hazardous waste.
12. With oil rotary pumps many vapours condense in the pump oil. Solvents in the oil degrade its performance (and eventually ruin the pump), create a chemical hazard when the oil is changed, and are emitted in an oil mist vented from the system. Other vapours pass directly into the exhaust stream. To avoid these problems:
    a) Trap evaporated materials with a cold trap before they reach the pump. Depending on the material that is to be trapped, this can be a filtration flask either at room temperature or placed in an ice bath. For more volatile solvents more sophisticated options exist (e.g. dry ice trap).
    b) Vent the pump exhaust properly.
13. Conduct all vacuum operations behind a table shield or in a fume hood and always wear safety glasses, lab coat, and gloves.
14. Keep a record for each pump to record oil change dates and to keep track of the maintenance schedule.
15. Use an inert gas to dilute flammable and pyrophoric gas to safe levels.
16. Leak test systems and equipment before use.
17. Ensure that the cold trap is of sufficient size and cold enough to condense vapours present in the system.
18. Check frequently for blockages in the cold trap.
19. Use isopropanol/dry ice or ethanol/dry ice instead of acetone/dry ice to create a cold trap. Isopropanol and ethanol are less expensive, less toxic, and less prone to foam.
20. Use gloves when handling the dry ice.
21. Do not use dry ice or liquefied gas refrigerant bath as a closed system. These can create uncontrolled and dangerously high pressures.
22. Liquid nitrogen should only be used with sealed or evacuated equipment, and then only with extreme caution. If the system is opened while the cooling bath is still in contact with the trap, oxygen may condense from the atmosphere and react vigorously with any organic material present.
23. Maintain a cold trap between a vacuum pump and the apparatus - do not use liquid nitrogen as trap coolant when pumping organic compounds (liquid oxygen may condense in the trap, leading to explosive oxidation).

HEALTH & SAFETY

24. Container Selection
    a) Do not apply a vacuum to a flat-bottomed flask. Use only containers that can withstand vacuum operations - heavy-walled round-bottomed glassware or specifically-designed glassware (e.g., Erlenmeyer filtration flasks).
    b) Wrap exposed glass with tape to prevent flying glass if an implosion occurs.
    c) Carefully inspect vacuum glassware before and after each use. Dispose of any glass that is chipped, scratched, broken, or otherwise stressed.
25. Desiccators

    It is important to use properly designed equipment for experiments carried out under reduced or elevated pressure.

    a) Vacuum desiccators should be enclosed in approved shielding device or protected with a framework of wire, nylon or other suitable material.
    b) Glass desiccators often have a slight vacuum due to contents cooling. When possible, use moulded plastic desiccators with high tensile strength. For glass desiccators, use a perforated metal desiccator guard.
    c) Air admittance should be carried out gradually. When opening, make sure atmospheric pressure has been restored.
    d) Never carry an evacuated desiccator.

ANNEXURE 1: OUT OF ORDER TAG

DO NOT USE OUT OF ORDER

Authorised by.....

Date.....