Vacuum System (VS) and Schlenk Line (*SL*) Safety

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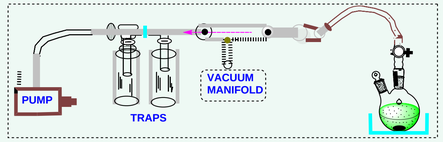
INTRODUCTION

Vacuum System (VS) & Schlenk Line (SL; Fig. 1) are effective and common devices in research laboratories for various chemical manipulations. Generally in a laboratory set-up two types of vacuum systems are used—water aspirators and mechanical pumps. Water aspirators are common in chemistry labs for filtration purposes, however water aspirators consume plenty of water (**11 lit/min**). **Mechanical pumps are more useful** for providing high vacuum for SL and many other laboratory instruments.

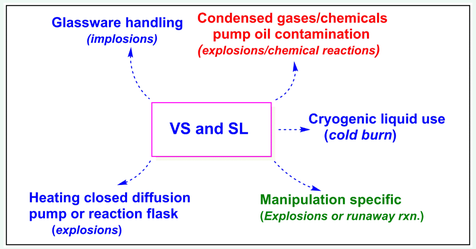
Fig. 1: Vacuum and Schlenk Line system



Hazards

Explosions and product/chemical related hazards (Fig. 2) are associated with **VS** and **SL** operation. Cryogenic liquid and glassware handling hazards (**explosions and implosions**) are also possible.

Fig. 2: Hazards attributed to the VS and SL



Glassware Selection for VS and SL

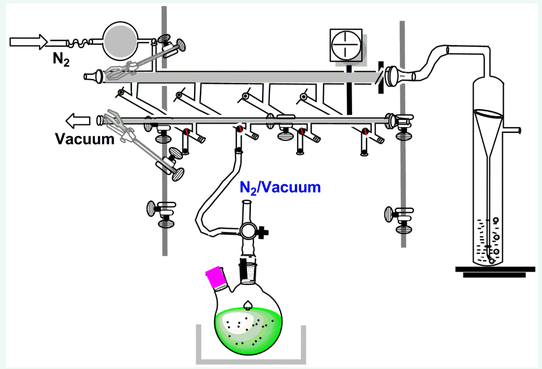
- Never use defective glassware that is cracked or chipped for vacuum use. Cracked glassware is more prone to explode or implode under vacuum while heated.
- If possible use **plastic coated glassware or taped flasks** for vacuum system to avoid injury from flying glass in case of an explosion.
- Apply a thin layer of grease before assembling reaction set-up for high- vacuum, to avoid freezing of the joints.
- When removing frozen glassware joints, slightly warm the joint. Never use excess force.

Schlenk Line and Vacuum Pump Set-up

Schlenk lines (SLs) are effective and common devices in research laboratories for controlling the reactivity of various chemical manipulations. Hydrogenations, Grignard reactions, pyrophoric manipulations, air and/or moisture sensitive chemicals are easily handled using SL techniques.

SL in laboratories should be installed in a safe location, preferably inside a chemical fume hood, to avoid impacts from glass implosion and chemical exposures (Fig. 3).

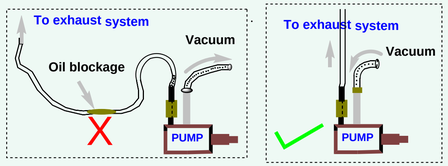
Fig 3. Schlenk line set-up



Safety Considerations and Best Practices for Working with VS & SL

- Use **cold traps** (liquid nitrogen or dry ice traps) to protect pumps from corrosive and flammable solvents, and vent pump exhaust into an exhaust system.
- **Flexible tubes (**Fig. 4) should not be used for venting vacuum pumps, to ensure that vacuum pump exhaust obstruction does not occur during operation. Also, check the exhaust pipe regularly for presence of oil. If the exhaust pipe is exhausted inside a chemical fume hood, it should not hinder the operation of chemical fume hood sash.
- Always support vacuum flasks and joints, and **avoid stress** caused by overtightening clamps.
- Never use high vacuum pumps for a rotary evaporator evaporation of **low volatile solvents** without controlling vacuum.
- Never run vacuum pumps near flammable and temperature sensitive chemicals. Avoid placing vacuum pumps inside a closed cabinet to avoid the overheating**.** **FIRE HAZARDS!**
- Vacuum pump oil **contaminated with hazardous chemicals and flammable solvents** should not be operated to prevent pump system damage.
- If possible, use a secondary containment for the pump to contain **any oil leaks**.
- Check the trap after each manipulation for condensed material, and moisture, and empty it if the trap is completely filled. Never allow **the bypass tubing to become clogged.**
- An oil spill on the floor should be cleaned properly using soap solutions. An **oil leak** on a laboratory floor can pose serious **slipping hazards**.
- Belt-driven mechanical pumps must have protective guards to prevent physical injuries.
- Ensure that electrical cords and switches are free from defect.

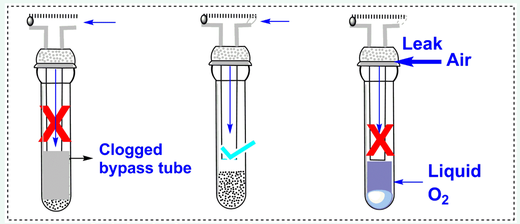
Fig. 4: Vacuum pump exhaust system



Schlenk Line Cold Trap Safety (Liquid Oxygen Condensation)

- Extreme care should be taken if liquid nitrogen is used for the trap to avoid the condensation of oxygen from air.
- Oxygen has a higher boiling point (-297 ºF) than nitrogen (-320 ºF) and will condense out of the atmosphere and collect in a liquid-nitrogen cooled container open to the air (**EXPLOSION HAZARD**).
- Make sure the system is not open to atmosphere while any part of manifold is under liquid nitrogen to prevent the condensation of liquid oxygen. Many organic materials can react explosively with liquid oxygen.
- **If you ever see a deep blue color in a trap** (Fig. 5), seek assistance from experienced laboratory staff or Environment, Health and Safety.
- Allow the trap to warm up slowly then put an explosion shield and close the hood sash first. Warn everyone of the potential hazard before you consult someone else in lab for help.
- If help is not available, keep the vacuum on the system to pump the trap, and slowly warm up the trap (e.g., leave the trap on but do not add more liquid nitrogen).
- If you're not sure that liquid oxygen has condensed in a cold trap, then shield the trap (with an explosion shield, closed hood window, etc.), post a sign indicating the danger, and allow the trap (vented to the atmosphere) to slowly warm to room temperature.

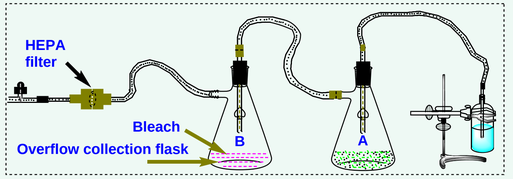
Fig. 5: Proper use of cold traps



Aspiration of Biological Materials using VS

Utilization of local or central vacuum systems for biological materials in a laboratory can contaminate vacuum lines, pumps and laboratory equipment. Using vacuum line traps and filters can prevent **infectious material** from entering vacuum lines (Fig. 6). Therefore, aspiration of culture media or other fluids with a suction or aspirator flask **A** should be connected to an overflow collection flask and **B** contain an appropriate disinfectant. Connect the flasks to an inline filter followed with a **HEPA** filter designed to protect the vacuum system. The HEPA filter must be inspected and replaced if clogged or if liquid makes contact with the filter.

Fig. 6: Vacuum set-up for biological material aspiration



Vacuum Pump Maintenance (Oil Change)

- Regularly monitor the condition of the pump oil and filters. Pumps used for conducting corrosive chemical manipulations are more prone to damage and require frequent oil change.
- Use sight-glass to check the oil-level which should be between the **Max** and **Min** level marks on the groove of the sight-glass.
- Frequent use of water samples and volatile compounds requires frequent oil changes.
- Pump oil contaminations with residual water and corrosive chemicals will damage the pump quickly.
- Maintain a record for pump oil change dates, and keep track of the maintenance schedule.

CONCLUSIONS

1. Hazards identification and their mitigations are critical for any chemical manipulations associated with VS & SL use.
2. Extreme care should be taken if liquid nitrogen is used for the trap to avoid the condensation of oxygen from air.
3. First time users of SL system should practice SL operations without using any hazardous chemicals or difficult chemical manipulations. This will provide confidence and hands on experience with the system.
4. Proper PPE including goggles, a lab coat, and gloves must be worn during SL manipulations.

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ACKNOWLEDGMENT

1. Dr. Paul Umbeck (Director EH&S).
2. Dr. Rob McClain & Department of Chemistry, UW-Madison.
3. Dr. Neal Langerman, Advanced Chemical Safety.