Physical Hazards -Recognition, Evaluation and Control

1. RECOGNITION OF PHYSICAL HAZARDS

There is a lot more to laboratory safety than protecting yourself from chemical hazards. Physical hazards are the most common hazard in labs and in any work place. Physical hazards are often related to the release of stored energy, i.e. the energy stored in a pressure or vacuum vessel, electrical energy or the energy in moving mechanical parts.
Physical hazards include but are not limited to:

- compressed gases
- vacuum operations
- distillations/extractions
- electrical
- machinery equipment
- centrifuges
- research animals
- glassware
- oil and sand baths

2. EVALUATION OF PHYSICAL HAZARDS - "Examples"

A. Compressed Gases

The following safety precautions should be taken for all types of cylinder usage.

- Be sure the contents are marked on the cylinder; never use cylinder paint colors as an indicator.
- Storage areas must be well ventilated.
- Keep the main cylinder valves closed when not in use.
- The valve-protection cap should always be kept on until the cylinder is ready for use.
- Always transport cylinders using a suitable hand truck with a tie-down chain; NEVER roll, pull, or drag cylinders.
- Always double chain compressed gas cylinders separately to the wall to prevent falls.
- Wear appropriate personal protective equipment (PPE), such as safety goggles or face shield, gloves and steel-toed safety shoes, as necessary.
- Clearly mark "EMPTY" cylinders and store separately from full ones.
- Always use pressure-reducing regulators.
- Install shut-off valves and check valves. Assure flashback arrestor is used for flammable gases.
- Do not allow grease or oil on oxygen regulators.
- Store flammables and oxidizers apart by at least 20 feet or separated by a wall.
- Always wear safety glasses when handling tubing on compressed gases.
- Gas cabinets: These cabinets offer added protection from toxic, flammable and corrosive gases by enclosing the cylinder(s) in a cabinet, which is equipped with an exhaust system located at the top of the cabinet.
  - ✓ Should have perforated plate floor air inlet to ensure complete air distribution throughout the cabinet.
  - ✓ Should have a smooth top-to-stack transition at the top of the cabinet exhaust area to prevent possible air channeling.

1. Cryogenic Liquids and solids

- Avoid skin contact, and clothing like knitted mitts that can trap spilled liquid. Use only well insulated gloves designed for the handling of super cold materials.

- Be alert for the condensation and displacement of oxygen from air.
- Use in a well ventilated area.
- Use eye protection.
- Do not use standard "thermos" bottles. Use high quality Dewars wrapped with cloth backed tape, like duct tape, to contain flying pieces in event of an implosion.

2. Highly Toxic Gases (i.e. fluorine, ETO, and arsine)
   - Always handle in a well-ventilated area such as inside a chemical fume hood or gas cabinet.
   - Should a leak be detected, leave the cylinder inside a fume hood, close the sash, evacuate the area immediately, and report to EH&S office.
   - NEVER attempt to move any leaking cylinder.
3. Corrosive Gases
   - Stored for the shortest possible periods before use, preferably less than 6 months.
   - Storage area should be dry as possible.
   - Do not store near instruments or devices sensitive to corrosion.
4. Acetylene
   - Acetylene forms explosive compounds with copper, silver, and mercury.
   - Avoid contact with these metals or their salts.
   - Never exceed the pressure limit indicated by the warning red line of an acetylene pressure gauge.
   - Ensure outlet line of the cylinder is protected with a flash arrestor.
   - Do not use a cylinder that has been stored in a non-upright position until it has remained in an upright position for at least 30 minutes.

Please refer to SafetyNets #509 (https://safetyservices.ucdavis.edu/safetynet/compressed-gas-cylinders) and #60 (https://safetyucd.sf.ucdavis.edu/safetynet/compressed-gas-safety) for further information.

B. Vacuum Operations

An operation involving an evacuated system where there exists a higher pressure on the outside rather than on the inside. These operations must be regarded as having an implosion hazard, which may result in flying glass, spattered chemicals and possibly fire.

- Always wear eye and/or face protection (i.e. face shields, safety goggles).
- Check all glass vessels and equipment for visible defects and ensure that they are specifically designed for such operations.
- Use glassware specially designed with heavy walls.

1. Vacuum Desiccators
   - Should be enclosed in a shield or wrapped with friction tape (i.e. vinyl electrical tape).
   - Whenever possible, use plastic desiccators (i.e. polycarbonate).
2. Vacuum Pumps
   - Use a cold trap to protect the pump oil from getting contaminated with volatile substances.
   - The output of each pump should be vented to an exhaust hood.

C. Electrical Safety

Shock injuries are caused by the flow of electric current (amperage), not the voltage (i.e. 60/100 of an ampere, just enough to light an ordinary Christmas tree light, may kill if it passes through the chest).

- Grounding should be provided for all electrical equipment, machinery, portable tools, extension cords and other electrical systems; grounding provides a safe path for electricity to the ground, preventing leakage of current in circuits or equipment.
- Maintain three-foot clearance around electrical switches and panels.
- All electrical equipment must have UL approval.
- Inspect all equipment periodically for defects or damage.
- Maintain all equipment in proper operating condition; see that necessary repairs are carried out.
- Be sure to de-energize all electrical equipment before inspecting or making repairs. (Call EH&S at 752-1493 for Lockout/Tagout procedures).
- Do not overload circuits and wiring.
- All cords that are worn, frayed, abraded, corroded or otherwise damaged must be replaced.
- Do not yank cords to disconnect them; keep all cords away from heat, oil and sharp edges.
- Ensure live parts of electrical equipment operating at 50 volts or more is guarded against accidental contact.
- Be sure that ground-fault circuit interrupters (GFCI) are used in high-risk areas such as wet locations (GFCI's are designed to shut off electrical power within as little as 1/40 of a second).

D. Machinery Equipment

Examples: Rotating equipment or apparatus that can trap clothing, hair, or body parts; vacuum pumps, centrifuges, mechanical stirrers and rotary evaporators; hazardous grinding, drilling, and cutting equipment in shops.

- Do not use a piece of equipment until you are instructed in its proper use.
- Do not remove guards or safety interlocks devices.
- Use the appropriate personal protective devices: glasses, gloves, goggles or face shield.

Please see Safety Net # 115 for further information:
https://safetyservices.ucdavis.edu/safetynet/machine-guarding

E. Research Animals

- Keep cages clean and rooms well ventilated.
- Maintain a high standard of personal hygiene.
- Wear gloves to avoid diseases and to protect against bites.
- Follow guidelines for animal handling in "Guide to the Care and Use of Laboratory Animals", NIH (National Institute of Health) No. 78-23 (1978).
- Follow UCI Animal Research Committee Policy and Procedures for handling animals.

Please see the UCD IACUC website for further information:

https://research.ucdavis.edu/policiescompliance/animal-care-use/iacuc/

F. Glassware Safety

- Inspect glassware for cracks and defects before using.
- For heating and pressurize operations, ensure that appropriate glass is used. Borosilicate glassware is recommended for all laboratory glassware except for special experiments that use UV or other light sources.

1. Cutting glass
   - Place tubing on a hard surface and nick glass surface with a triangular file.
   - Always wrap the glass tubing in a cloth before attempting to break it.
   - If the tubing doesn't easily break, the nick is to shallow; try again.
2. Broken glass
   - Clean all broken glass using a broom and pan; do not pick up broken glass with your hands.
   - Dispose of broken glass properly in a plastic lined, hard-walled container and label "Broken Glass".
   - Contaminated glass must be place in appropriate durable chemical waste container.

G. Oils and Sand Baths

- Avoid spilling water and other volatile substances.
- Silicone oil should be used for temperatures.
- Oil baths left unattended should be fitted with thermal sensing devices that will turn off the electric power of the bath overheats.
- Care must be taken to keep salt baths dry because they are hygroscopic.

H. Distillations and Extractions

1. Distillations
   - Do not distill or evaporate organic solvents to dryness unless they are known to be free of peroxides
2. Extractions
   - Do not attempt any extraction until the solution is cooler than the boiling point of the extractant.
   - Do not vent the separatory funnel near a flame or other ignition source.

I. Centrifuges

Centrifuging presents the possibility of two serious hazards:

- mechanical failure - i.e., broken drive shaft, faulty bearing, disintegrated rotor all these can produce aerosols and hazardous fragments moving at great velocity.
- creation of aerosols.

1. General Safety Procedures
   - Before centrifuging, inspect tubes for crack, inspect the inside of the trunnion cup for rough walls caused by erosion of adhering matter, and carefully remove bits of glass from the rubber cushion.
   - Screw caps or a cap that fit over the rim outside the centrifuge tube is safer than plug-in closures. Fluid collects between plug-in closure and tube rim.
   - Aluminum foil should not be used to cap centrifuge tubes containing infectious materials because they often become detached or rupture during or centrifuging.

- When centrifuging is done in a ventilated glove box, the glove panel should be in place with the glove ports covered. A centrifuge in operation creates a reverse air currents that may cause escape of agent from an open cabinet.
- For flammable/highly hazardous materials, the centrifuge should be under negative pressure to a suitable exhaust system.

2. Centrifuge and Biohazardous Material
   - When used with biohazardous materials, centrifuge tubes, rotors, and accessories should be filled and opened in a biological safety cabinet (BSC).
   - If centrifuging of biohazardous material is to be performed outside a containment cabinet, a sealed safety bucket/tube should be used.
   - After safety bucket/tube is filled and sealed, it should be considered contaminated and wiped with cloth soaked in disinfectant. (Some disinfectants are corrosive to centrifuge rotors/buckets, rinse with water after appropriate contact time elapsed.)
   - Minimize the amount of aerosol created by using a swirling, rotary motion rather than shaking to resuspend sediment after centrifuging.
   - Avoid decanting centrifuge tubes. If you must do so, wipe outer rim with a disinfectant; otherwise, the infectious fluid will spin off as an aerosol.
   - Avoid filling the tube to the point that the rim outside becomes wet with culture.
3. Low Speed/Small Portable Centrifuges (centrifuges that do not have aerosol- tight chambers)
   - Outside of bucket should be decontaminated before bucket is removed for centrifuging.
   - Bucket should be returned or opened in a BSC.
   - Small centrifuge could be placed in BSC.
4. High Speed Centrifuges (chamber is connected to a vacuum pump)
   - Filter should be placed between chamber and pump.
   - Prone to metal fatigue, therefor keep a record of use, one record for each rotor and an instrument log.
   - To prevent corrosion or other damage, conduct frequent inspections, proper cleaning, and timely drying of rotors.
   - Rubber "O" rings and tube closures must be examined for deterioration and coated with a lubricant recommended by manufacturer.
5. Continuous Flow Centrifuges (allow continuous harvesting of product while centrifuge operates at full speed) and Zonal Centrifuges (separates product according to its density or buoyancy under centrifugal force.
   - Enclose in especially designed ventilated safety cabinet.
   - Conditions that can lead to production of aerosols during zonal centrifuging:
   - leaky rotor seals due to nicks, damage to seals, improper assembly and over-pressurization.
   - drops of culture in chamber or on rotor.
   - snagging tubing or tubing connections
   - disassembly or decontamination.

3. CONTROL METHODS FOR PHYSICAL HAZARDS

Many control methods outlined for chemical hazards can also be applied for physical hazards. These methods include designated area, engineering controls (i.e. gas cabinets, fume hoods), work practice controls, PPE, and SOP's (Standard Operating Procedures).

Sources:

Prudent Practices in the Laboratory - Handling and Disposal, National Academy of Sciences, 1995.

Safety in Academic Chemistry Laboratories, American Chemical Society, Wash. DC, 1990

Handbook of Compressed Gases, Compressed Gas Association, Inc. 2nd Ed., Van Nostrand Reinhold Company, 1981

Safety in Academic Chemistry Laboratories, American Chemical Society, Washington D.C., 1990