C1. Handling Hazardous Gases

BACKGROUND

The purpose of this guideline is to provide UBC lab personnel with general guidance on how to safely work with hazardous gases in the workplace. Hazardous gas storage and handling requirements are governed by WorkSafeBC, BC Occupational Health and Safety Regulation, the BC Fire Code and the Gas Safety Act.

“Hazardous gases” includes gases classified as toxic, corrosive or flammable. Additional regulations apply to their use and storage.

The handling of compressed gases must be considered more hazardous than the handling of liquid and solid materials because of the following properties unique to compressed gases:

- pressure
- low flash points for flammable gases
- low boiling points
- no visual and/or odor detection of many hazardous gases

Hazards may arise because of equipment failure and leakage from systems that are not pressure-tight. Diffusion of leaking gases may cause rapid contamination of the atmosphere, giving rise to toxicity, anesthetic effects, asphyxiation, and rapid formation of explosive concentrations of flammable gases.

The flash point of a flammable gas under pressure is always lower than ambient temperature, and leaking gas can therefore rapidly form an explosive mixture with air. Low-boiling-point materials can cause frostbite on contact with living tissue. This is common among the cryogenic liquids such as nitrogen and oxygen, but it also can result from contact of the liquid phase of liquefied gases such as carbon dioxide, fluorocarbons, and propylene. Other hazard properties of compressed gases are similar to other chemicals in that they may be corrosive, irritating, and highly reactive.

Examples of highly toxic gases found in UBC laboratories include, but are not limited to:

- hydrogen cyanide (HCN)
- hydrogen sulfide (H_2S)
- sulfur dioxide (SO_2)
- chlorine (Cl_2)
- fluorine (F_2)
- bromine (Br_2)
- carbon monoxide (CO)
- hydrogen chloride (HCl)
- hydrogen bromide (HBr)
- hydrogen fluoride (HF)
- ammonia (NH3)

SCOPE

This procedure applies to all UBC faculty and staff who may use hazardous gases in their laboratories for research purposes. SOPs must be developed and applicable to specific substances. Written SOPs are the responsibility of the Principal Investigator.

PROCEDURE

Hazard Assessment

Perform detailed hazard assessment of all the steps of the experiment. Understand the properties of the compressed gas that represent hazards (such as flammability, toxicity, chemical activity, and corrosive effects). Include safety precaution and hazard controls as part of the experiment protocol. Employees should be trained on: the health risk and additional hazards posed by the gases in use, the proper handling procedures, the use of designated areas, and emergency response, evacuation and notification procedures in the event of gas release.

Storage of Gas Cylinders

Compressed gas cylinders must be individually stored and securely fastened in an upright position. Cylinders should be stored in an upright position and secured to a wall or laboratory bench using chains or straps. Cylinder and tanks gases shall be protected against mechanical damage. All flammable, poisonous, corrosive or oxidizing gas cylinders shall be located in a room that is separated from the remainder of the building by a gas-tight fire separation having a fire resistance of at least 2 hours.

- Store lecture bottles and small cylinders in special holders or racks
- Keep the protective cap in place while moving the cylinder
- Keep cylinder valves closed when not in use
- Fittings must be compatible and withstand cylinder pressures
- Store away from heat, sun and source of moisture
- Store hazardous gases outside in a protected enclosure
- Store the smallest size that is available & practical
- Never mix gases in cylinder. This may result in explosion, contamination, corrosion and other hazards
- Do not drop cylinders or otherwise permit them to strike each other
- Store according to compatibility groups
- Use the proper regulator for a particular gas
- Check for regulator maintenance requirements and service regulator per manufacturer recommendations
- Review SDS for gas specific information
- Hazardous gases with poor warning properties should be stored in an exhausted enclosure
- Corrosive gases should be stored for the shortest possible periods before use, preferably less than three months. Storage areas should be as dry as possible. Corrosive gases should not be stored in areas containing instruments or other devices sensitive to corrosion.
- Cylinders containing flammable gases must be grounded

HANDLING

- All work with hazardous gases must be conducted in a certified fume hood.
- Pyrophoric gases must be handled in a way that prevents contact with air
- Keep flammable gases away from ignition sources

- When corrosive gases are being used, the cylinder valve stem should be periodically opened and closed to prevent “freezing.” The valve should be closed when the cylinder is not in use. Regulators and valves should be closed when the cylinder is not in use and flushed with dry air or nitrogen after use. Such control devices should not be left on a cylinder, except when it is in frequent use. When corrosive gases are to be discharged into a liquid, a trap, check valve, or vacuum break device should always be employed to prevent dangerous reverse flow.
- Proper PPE must be worn at all times to prevent eye and skin contact.
- A second person shall be present when working with these materials.
- Always use a hand truck/cylinder cart for transport. Chain cylinders to hand truck.
- Do not drag, roll, or slide a cylinder; never attempt to lift a cylinder.
- Discontinue using a high-pressure cylinder when the pressure approaches 30 psi, clearly label the container “EMPTY”, and move to disposal location.
- Regulators: gases from full sized gas cylinders must be dispensed using a two-stage regulator that is both compatible with the gas and the intended use. The maximum pressure of the second stage of the regulator should be a low as is practical for the intended experimental work. Do not select or reuse existing regulators with very high second stage pressure ranges unless needed since this will require the entire experimental setup (tubing, connections) to be engineered to withstand high pressures. Regulators for "fuel” gases (H_2, acetylene, etc.) generally have a left-hand thread. Control of flow can be regulated by means of a valve supplied in the regulator outlet or by a supplementary valve put in a pipeline downstream from the regulator.

Flow control valves: A mechanical flow control valve (needle valve) that is compatible and properly cleaned for the hazardous gas must be attached directly to the gas out port of the gas regulator. This is required even if other flow control devices are present in the experimental device. Flow control must not be attempt through use of the gas regulator.

Flow restricting orifices: where feasible flow restricting devices must be installed after the regulator. Select the appropriate flow restricting orifice based on gas used and the flow rate required for the research.

Tubing and piping: hazardous gases must be dispensed using systems that are properly cleaned and compatible with the gas in use. Bust pressure of tubing and piping must be twice the maximum pressure on the second stage regulator. Exceptions to this requirement may be made for short sections of tubing when it and the compressed gas cylinder are completely enclosed in a fume hood and low pressures and flow rates are used.

Purge assembly: required for all hazardous gas systems that are not used in a fume hood or other ventilated enclosure. Purge assemblies must exhaust into a fume hood or other approved exhaust system. Exceptions may be made for laser systems that contain small quantities of hazardous gas that will be effectively filtered when exhausted. Exemptions must be approved by RMS.

FLAMMABLE, TOXIC AND CORROSIVE GASES

Highly toxic gases are kept and used in a continuously operating fume hood or in a specialized gas storage cabinet with an exhaust to the outside. A sign must be located on the outside door of any room and adjacent to equipment where a hazardous gas is being used, advising occupants of potential hazards and emergency procedures to follow if a leak or other incident occurs. Gas detectors and alarm systems must be installed where cylinders of compressed toxic gases are being used, or an equivalent means of managing an accidental release is implemented (please contact Health, Safety & Environment at hse.ok@ubc.ca).

FUEL GAS CLYINDERS (IE PROPANE, HYDROGEN, ACETYLENE, ETC)

(BC Gas Safety Act)

- Fuel cylinders of 20 pounds (9 kilograms) capacity or more must not be stored inside UBC buildings. Gas should be piped into the working area using piping material and procedures permitted by UBC Regulatory Services.
- Fuel cylinders must be stored in a secure area protected from vandalism and the weather. This area should be fire-proof and well ventilated.
- Where large quantities of fuel gas are being used, Risk Management Services must be consulted on the requirements for detector and alarm systems.
- Warning signs identifying this hazard must be on the cage or room protecting the cylinder as well as on the piping entering the building.

SPECIAL CONSIDERATIONS

- Do not use oily regulators with oxygen. Oxygen under pressure will rapidly oxidize oil or grease, resulting in an explosion hazard.
- Acetylene under pressure can decompose with explosive force. It can explode with extreme violence if ignited. Copper or brass with more than 65% copper can form explosive compounds in contact with acetylene.
- Corrosive compressed gases, such as hydrogen bromide, should not be stored, unused, for extensive periods. There is a danger of the valves corroding and leaking, as well as the potential for the cylinder pressure to exceed its limits to explode. The pressure excess may be due to production of hydrogen where moisture is present causing hydrogen bromide to react with the cylinder wall.

INSPECTIONS

When hooking up cylinders to other systems, there is a chance of leaks. (Use snoop or equivalent solution for leak check). Perform leak checks regularly. A regular inspection log must be maintained to check for leaks periodically, and after any modifications have to the system have been made. Appropriate PPE must be worn during the leak tests; in case there is a leak present, emergency procedures must be implemented.

Audible alarms for atmospheric testing may installed to alert all laboratory staff of accidental release.

PERSONAL PROTECTIVE EQUIPMENT

Eye protection in the form of safety glasses must be worn at all times when handling hazardous gases. Depending on the state of the toxic substance, for adequate protection from splashes, splash guards must be used, refer to MSDS. Lab coats must be worn at all times when in the laboratory. Extra precaution must be taken for gases with skin absorption properties.

Gloves should be worn when handling hazardous gases. Disposable nitrile gloves provide adequate protection against accidental hand contact with small quantities of most laboratory chemicals, check gloves compatibility charts for proper glove selection. Work gloves must be worn when handling the cylinders.

ENGINEERING CONTROLS

Fume hood: Work with hazardous gases should be carried out in a fume hood. All areas where acutely toxic gases are stored or manipulated must be labeled as a designated area. Some work with toxic gases may be performed in a properly vented glove box rather than a fume hood.

Safety shielding is required any time there is a risk of explosion, or a highly exothermic reaction. All manipulations of hazardous gases, which pose this risk, should occur in a fume hood with the sash in the lowest feasible position. Portable shields, which provide protection to all laboratory occupants, are acceptable.

Signs and labels

Doorways: The door sign must contain a WHMIS hazard class indicating that the lab contains carcinogens, reproductive hazards, and/or other hazardous property.
Containers: All hazardous gas cylinders must be clearly labeled with:

- Name of gas
- Name of supplier
- Date of purchase
- Date of hydrostatic testing (by supplier)

Handwritten labels are acceptable; chemical formulas and structural formulas are not acceptable.

EMERGENCY PROCEDURES

- An emergency plan must be developed addressing the release of all the different gases stored and used in the lab. Emergency procedures must address response actions to fires, explosions, injury to staff, accidental release or the development of sign and symptom of overexposure. Consult the MSDS for gas specific emergency response instructions and procedures
- Lab personnel must be trained in proper handling of gas cylinders, and the procedures to be followed in cases of gas release.

- In the event of gas release alert personnel in the area that a release has occurred. Asses the situation, area evacuation may be required. If you initiated area or building evacuation, arrange to meet the hazmat team at the entrance to the building.

- Emergency equipment such as escape respirator may be required for handling toxic gases or for handling asphyxiating gases in close confine
- Emergencies involving flammable gases must be managed with the utmost care in order to prevent ignition. After any gas release the area must be adequately vented before the restoration of power.
- Areas contaminated by corrosive gases must be adequately vented and completely washed down to prevent subsequent degradation of delicate instruments, electrical contacts, etc.
- On rare occasions, emergency action may be necessary in order to move a leaking cylinder to a location where it can vent safely, or it may have to be removed from a building and brought outdoors.
- In such instances, an emergency plan should be put into effect (to properly warn all personnel required to evacuate, shut off electrical power to prevent ignition of a leaking flammable gas, and determine the shortest route to the point of gas disposal.)

The emergency procedures should also indicate:

- **Who to contact:** Hazmat - 911, RMS, Principal investigator of the laboratory including evening phone number, and Campus Security (250-807-8111).
- The **location** of all safety equipment (showers, eyewash, fire extinguishers, etc.)
- A means of **communication** used to alert personnel in nearby areas of potential hazards

WASTE DISPOSAL

All empty or partially filled hazardous gas cylinders should be returned to the supplier. If the supplier does not accept empty or partially filled cylinders, contact Health, Safety & Environment to arrange for special disposal. The cost of disposal of non-returnable gas cylinders is borne by the generator/purchaser.