Guideline	UBCV-RMS-OHS-GDL 14-004
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Hydrogen Gas use in the Laboratory

1. Scope

This guideline applies to all UBC faculty and staff who may use hydrogen gas in their laboratories for research purposes. Lab-specific SOPs must be developed and applicable to specific processes. Written SOPs are the responsibility of the Principal Investigator and all users of this chemical must carefully read and sign the SOP.

2. Introduction

Hydrogen (H2) is a highly flammable gas. Hydrogen gas forms explosive mixtures with air if it is 4–74% concentrated and forms explosive mixtures with chlorine if it is 5–95% concentrated. The mixtures spontaneously explode by spark, heat or sunlight. Auto-ignition temperature of Hydrogen: The temperature of spontaneous ignition in air, is 500 °C (932 °F). The detection of a burning hydrogen leak may require a flame detector; such leaks can be very dangerous. Hydrogen reacts with every oxidizing element.

Hydrogen poses a number of hazards to human safety, from potential detonations and fires when mixed with air to being an asphyxiant in its pure, oxygen-free form. Hydrogen dissolves in many metals. In addition to leaking out, may have adverse effects on metals, such as hydrogen embrittlement, leading to cracks and explosions. Hydrogen gas leaking into external air may spontaneously ignite. Moreover, hydrogen fire, while being extremely hot, is almost invisible, and thus can lead to accidental burns.

Even interpreting the hydrogen data (including safety data) is confounded by a number of phenomena. Hydrogen detonation parameters, such as critical detonation pressure and temperature, strongly depend on the container geometry.

If not handled and stored properly, Hydrogen gas can pose a serious threat to the health and safety of laboratory personnel & emergency responders and also to the property. This guideline helps to understand how to properly store & handle hydrogen.
Common Uses (but not limited to):

- Used to process ('upgrade') fossil fuels.
- Used to produce ammonia- used in common household cleaning products.
- Hydrogen is used as a hydrogenating agent to produce methanol and convert unhealthy unsaturated fats and oils to saturated fats and oils.
- The triple point of hydrogen (the temperature where all 3 phases- gas, solid and liquid- are in equilibrium) can be used to calibrate some thermometers.
- Tritium, a radioactive isotope of hydrogen, is produced in nuclear reactions. It can be used to make hydrogen bombs and acts as a radiation source in luminous paints. In the biosciences, tritium is sometimes used as an isotopic label.
- Hydrogen (either used on its own or combined with nitrogen) is used in many manufacturing plants to determine whether there are any leaks. It is also used to detect leaks in food packages.
- Hydrogen is used as a rotor coolant in electrical generators.
- Hydrogen gas is used as a shielding gas in atomic hydrogen welding (AHW).
- Used in the production of hydrochloric acid- used widely in chemical industries.
- Hydrogen gas is used to reduce many metallic ores.
- Can be used to make water
- Used as a carrier gas

3. 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.

Physical & Chemical Properties / Definition of Chemical Group:

Class:	2.1 - Flammable gas
Color:	Colorless
Phase:	Gas
Density:	(0 °C, 101.325 kPa)
Melting point:	14.01 K, -259.14 °C, -434.45 °F
Boiling point:	20.28 K, -252.87 °C, -423.17 °F
Molar Heat Capacity:	28.836 $J \cdot mol^{-1} \cdot K^{-1}$

Potential Hazards/Toxicity

Hydrogen (H2) is a highly flammable gas. Hydrogen gas (dihydrogen or molecular hydrogen) is highly flammable and will burn in air at a very wide range of concentrations between 4% and 75% by volume.

Basic Training Requirements

- Lab personnel working with Hydrogen gas must have taken the RMS Chemical Safety course. Please refer to the following link to register for the online course and scheduled practical sessions: http://www.hse2.ubc.ca/moodle/
- To work with hydrogen gas, the lab personnel must have had *hands-on training provided by the lab PI/Supervisor*. This training must be documented in the form of a log sheet with name of the trainer, name of the trainee, UID, date of training and signature of both trainer & trainee.
- Lab personnel working with hydrogen must read this guidance document.
- Lab personnel working with hydrogen must read know the location of the MSDS.

Personal Protective Equipment (PPE):

Eye protection
Safety goggles.

Skin and body protection
Fire/flame resistant lab coat (100% cotton based)
Cotton based clothing/attire.
Full length pants or equivalent
Close toed shoes

Storage Requirements
British Columbia Fire Code (2006) Section 3.2.7.6 and Table 3.2.7.6 requires that Class 2.1, Flammable Gases like hydrogen cannot be stored in the same fire compartment as oxidizing substances.

**** In simple words, DO NOT store Hydrogen & Oxygen/other oxidizing gases, or oxidizing materials together.***

Hydrogen Safety
Safety can be achieved while handling hydrogen gas by adhering to the below mentioned protocols, *but not limited to the following*;

- Compressed gas cylinders should be double chained or strapped (chains are preferred) to a stable structure such as a wall. The first chain must be one third from the bottom of the cylinder and the second chain should be one third from the top of the cylinder. Secure cylinders of equal sizes together to avoid chaining problems.

- If a compressed gas cylinder holding metal rack is used to restrain the cylinders, the rack must be bolted to the floor and the chains or rods must be at 1/3rd from the bottom and 1/3rd from the top of the cylinders. Clam shell (a cylindrical metal casing bolted to the floor) can be used to secure cylinders that need to be stored and used next to the experimental set-up.
- Always use Stainless Steel (SS) tubing to convey hydrogen gas. Teflon tubing is okay *if* specified by the manufacturer.
- Remove the regulator and place the safety cap on, when the cylinder is not in constant use.
- Hydrogen gas leak detector installation is recommended.
- Prevent hydrogen leaks by meticulously connecting gas regulator and tubing. Leak test equipment regularly – piping can develop cracks and leaks over time and from repeated use.
- Prevent accumulations of leaked hydrogen by ensuring adequate ventilation. Vent into fume hood where possible.
- Eliminate likely ignition sources, and suspect unknown ignition sources.
- Store hydrogen gas cylinders away from electrical panels and emergency eyewash & safety shower.
- Always assume hydrogen is present, and verify the system has been purged to less than 1 percent when performing system maintenance on a hydrogen system. Inert gases such as Nitrogen & Argon can be used for purging.
- Always assume oxygen is present, and verify the system has been purged to the appropriate level when reintroducing hydrogen into a system.
- WorkSafeBC regulation 5.31 Flammable gas or vapour, part (c) states, "*the concentration of the flammable gas or vapour must not exceed 20% of the lower explosive limit*". The lower explosive limit for hydrogen is 4%, therefore the concentration of the gas in the air should not be above 0.8%(V). Calculate expected concentrations from your experiment to ensure that these limits are being met.
- Have lab buddy system when working with highly flammable gases such as Hydrogen, Ethane, Methane, Acetylene etc.
- All users must have had documented hands-on training to work with highly flammable gases.
- Lab personnel handling highly flammable gases must have easy access to an Emergency Eyewash & Safety Shower.

Repair operations Involving Hydrogen Gas Related Equipment

- The system shall be verified safe according to proper procedures before any type of maintenance is attempted
- Includes all repairs, alterations, cleaning, or other operations performed in confined spaces in which hydrogen vapors or gases are likely to exist.
- The personnel engaged in the operations shall be advised of the hazards that may be encountered, and an attendant (lab buddy) shall be immediately available for emergency rescue if necessary

Types of Emergencies

- The principal danger from a leak is the potential burns and fires
- When a leak occurs, the area shall be completely roped off and caution signs shall be posted
- Leaks can occur near the valve/regulator/tubing/tubing bends or joints or a pumping system.
- Catastrophic fires can occur
- High-pressure gas leaks can occur

Procedures to be followed during uncontrollable leaks

- The supply source shall be shut-off immediately *if possible*
- The area shall be evacuated
- Call **911** from campus phone or call **UBC Campus Security** at **604-822-2222** immediately.

Handling Gas Leaks from Cylinders

- Only an acceptable, approved solution shall be used when testing for leaks.
- If a cylinder safety device leaks, personnel shall not attempt to correct the leak by tightening the safety device cap while the cylinder is under pressure. The contents of the cylinder shall be emptied in a safe location. The cap shall be removed to examine the condition of the threads, correct the damage, pressurize and leak test.
- Leaking commercial cylinders should be safely vented, tagged as defective, and returned to the supplier ASAP.

Accidental release / fire

Dial 911 or **UBC Campus Security** at **604-822-2222 immediately for assistance.** Hardcopy or electronic copy of the MSDS must be available for Hydrogen.

Online MSDS can be accessed at http://riskmanagement.ubc.ca/health-safety/chemical-safety/materials-safety-data-sheets