Standard Operating Procedure

**Hydrogen Gas (H2)**

*This is an SOP template and is not complete until: 1) lab specific information is entered into the box below 2) lab specific protocol/procedure is added to the protocol/procedure section and
3) SOP has been signed and dated by the PI and relevant lab personnel.*

 Print a copy and insert into your
*Laboratory Safety Manual* and *Chemical Hygiene Plan*.
Refer to instructions for assistance.

|  |  |
| --- | --- |
| **Department:** | Click here to enter text. |
| **Date SOP was written:** | Click here to enter a date. |
| **Date SOP was approved by PI/lab supervisor:** | Click here to enter a date. |
| **Principal Investigator:** | Click here to enter text. |
| **Internal Lab Safety Coordinator/Lab Manager:** | Click here to enter text. |
| **Lab Phone:** | Click here to enter text. |
| **Office Phone:** | Click here to enter text. |
| **Emergency Contact:** | Click here to enter text. |
| *(Name and Phone Number)* |
| **Location(s) covered by this SOP:** | Click here to enter text. |
| *(Building/Room Number)* |

**Type of SOP:** ☐ Process ☒Hazardous Chemical ☒ Hazardous Class

**Purpose**

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 SOP helps to understand how to properly store & handle hydrogen.

**Uses 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

**Physical & Chemical Properties/Definition of Chemical Group**

**Class:** Highly flammable gas

|  |  |
| --- | --- |
| **Color** | colorless |
| **Phase** | Gas |
| **Density** | (0 °C, 101.325 kPa)0.08988 g/L |
| **Liquid density at m.p.**  | 0.07 (0.0763 solid) g·cm−3 |
| **Liquid density at b.p.**  | 0.07099 g·cm−3 |
| **Melting Point**  | 14.01 K, -259.14 °C, -434.45 °F |
| **Boiling Point**  | 20.28 K, -252.87 °C, -423.17 °F |
| **Triple Point**  | 13.8033 K (-259°C), 7.042 kPa |
| **Critical Point**  | 32.97 K, 1.293 MPa |
| **Heat of Fusion**  | (H2) 0.117 kJ.mol -1 |
| **Heat of Vaporization** | (H2) 0.904 kJ·mol−1 |
| **Molar Heat Capacity** | (H2) 28.836 J·mol−1·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.

**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

Lab personnel intending to use/wear a respirator mask must be trained and fit-tested by ORS and should contact occhealt@uga.edu. This is a UGA requirement described in more detail in the [UGA Respiratory Protection Plan](https://esd.uga.edu/sites/default/files/respiratoryprotection.pdf) and supported by the [Office of Research Occupational Health and Safety Program](https://research.uga.edu/ohsp/).

**Storage Requirements**

*In simple words, DO NOT store Hydrogen & Oxygen/other oxidizing gases, 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*;

* If 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.
* Keep constant vigilance to immediately detect accidental leaks.
* Prevent accumulations of leaked hydrogen using plentiful ventilation.
* 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.
* Have lab buddy system when working with highly flammable gases such as Hydrogen, Ethane, Methane, Acetylene etc.
* All users must have had hands-on training to work with highly flammable gases. The training must be documented.
* Lab personnel handling highly flammable gases must have easy access to an Emergency Eyewash & Safety Shower within 10 seconds (i.e., travel distance no greater than 100 feet).

**Repair operations**

* 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

**Controllable leaks**

* Controllable leaks are relatively small leaks that would not result in significant release before shut-off and relief valves can be made operational.

**Uncontrollable leaks**

* Uncontrollable leaks may be large and involve major release.
* Large fire and explosions may occur.

**Procedures to be followed during uncontrollable leaks**

* The supply source shall be shut-off immediately *if possible*
* The area shall be evacuated to 152 m (500ft) from the release point
* Call 911 from campus phone or call Office of Research Safety at 706-542-5288 from cell phone immediately.
* Adjacent equipment shall be cooled down in case of fire.

**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.

**Spill and Accident Procedure**

**Chemical Spill Dial 911**

**24-7 On-Call Response to Research, Environment, Health or Safety Concerns Dial 2-5561 from a campus phone or 706-542-5561 from a non-campus line.**

**Spill** – Follow the procedures set out in the [UGA Chemical and Laboratory Safety Manual.](http://research.uga.edu/docs/units/safety/manuals/Chemical-Laboratory-Safety-Manual.pdf)

[If there are any chemical-specific protocols for responding to a spill, insert them here or mark “none”:]

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**Medical Emergency Dial 911**

**Life Threatening Emergency, After Hours, Weekends And Holidays** – Dial **911** or the emergency phone numbers listed at the beginning of the UGA Chemical and Laboratory Safety Manual

*Note: All incidents that result in an injury or property damage must be reported to ORS / ESD using a University Incident/Accident Report.*

**Non-Life Threatening Emergency** – Follow the instructions in the UGA Chemical and Laboratory Safety Manual.

*Note: All incidents that result in an injury or property damage must be reported to ORS / ESD using a University Incident/Accident Report.*

**Decontamination/Waste Disposal Procedure**

**For general hazardous waste disposal procedures, see Appendix H of the UGA Chemical and Laboratory Safety Manual.**

**Chemical Specific Procedures: [to be inserted or marked as “none”]**

**Safety Data Sheet (SDS) Location**

UGA personnel can access Online SDS through a link in the upper left corner of the ESD home page (<https://esd.uga.edu>) and logging in by using their UGA email user name and password.

**Protocol/Procedure**

***(Add specific description of procedure)***

**Any deviation from this SOP requires approval from PI.**

**Documentation of Training** *(signature of all users is required)*

* Prior to conducting any work with hydrogen gas, designated personnel must provide training to his/her laboratory personnel specific to the hazards involved in working with this substance, work area decontamination, and emergency procedures.
* The Principal Investigator must provide his/her laboratory personnel with a copy of this SOP and access to the SDS provided by the manufacturer.
* The Principal Investigator must ensure that his/her laboratory personnel have attended appropriate laboratory safety training or refresher training within the last 12 months

**Principal Investigator SOP Approval**

Print name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Signature\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Approval Date:

I have read and understand the content of this SOP:

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| --- | --- | --- |
| **Name** | **Signature** | **Date** |
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