



# Chemical Safety Summary

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## Hydrogen

*This is chemical safety summary should be used to complete the process SOP template located on the EH&S Website.*

Print a copy and insert into your  
*Laboratory Safety Documents.*  
Refer to instructions for assistance.

### **Purpose**

The purpose of this document is to establish a safety summary for handling, storage, and disposal of Hydrogen gas, AKA Dihydrogen and Molecular Hydrogen.

Hydrogen (H<sub>2</sub>) is a highly flammable gas. Hydrogen gas forms explosive mixtures with air if it is 4–76% 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.

Gas mixtures that contain >5.5% of Hydrogen in Nitrogen, >2.94% Hydrogen in Argon, or >3.9% hydrogen in Helium are classified as flammable.

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

The Department of Environmental Health and Safety reserves the right to cease operation and use upon observing non-compliant activities.

## Physical & Chemical Properties/Definition of Chemical Group

CAS#: 1333-74-0

Class: **Flammable Gas**

Molecular Formula: H<sub>2</sub>

Form (physical state): Gas

Color: Colorless

Boiling point: -253°C(-423.4°F)

NFPA: Health: 0 Flammable: 4 Reactive: 0 Special:

## Potential Hazards/Toxicity

Hydrogen gas is **extremely flammable**, colorless, odorless, and tasteless gas and it can form explosive mixtures with air. Explosive Limits: 4 – 76%

May displace oxygen and cause rapid suffocation

Compressed gas cylinders contain gas under pressure. May explode if heated.

Contact with rapidly expanding gas may cause burns or frostbite.

A fireball may form if ignited immediately after release.

Burns with invisible flame.

Incompatible with oxidizers, halogens, lithium, and ignition sources. Contact with metals may cause hydrogen embrittlement.

## Personal Protective Equipment (PPE)

### Respirator Protection

Use a full-face respirator with multi-purpose combination (US) respirator cartridges.



Respirators should be used only under any of the following circumstances:

- As a last line of defense (i.e., after engineering and administrative controls have been exhausted).
- When Permissible Exposure Limit (PEL) has exceeded or when there is a possibility that PEL will be exceeded.
- Regulations require the use of a respirator.
- An employer requires the use of a respirator.
- There is potential for harmful exposure due to an atmospheric contaminant (in the absence of PEL)
- As PPE in the event of a chemical spill clean-up process

Lab personnel intending to use/wear a respirator mask must be trained and fit-tested by EH&S. This is a regulatory requirement.

### **Hand Protection**

Gloves must be worn. Use proper glove removal technique to avoid any skin contact. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with Hydrogen.

Refer to glove selection chart from the links below:

<https://www.ansellpro.com/specware/>

OR

<https://www.allsafetyproducts.com/asp-glove-selection-chart-chemical-break-through-times.html>

OR

<https://www.coleparmer.com/safety-glove-chemical-compatibility>

OR

[http://www.ansellpro.com/download/Ansell\\_8thEditionChemicalResistanceGuide.pdf](http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf)

### **Eye Protection**

ANSI approved, tight-fitting safety glasses/goggles. Face shields are recommended.

### **Skin and Body Protection**

Flame resistant lab coats must be worn and be appropriately sized for the individual and buttoned to their full length. Laboratory coat sleeves must be of sufficient length to prevent skin exposure while wearing gloves. As outlined in the Chemical Hygiene Plan personnel should also wear full length pants, or equivalent, and close-toed shoes. Full length pants and close-toed shoes must be worn at all times by all individuals that are occupying the laboratory area. The area of skin between the shoe and ankle should not be exposed.

### **Hygiene Measures**

Wash thoroughly and immediately after handling. Remove any contaminated clothing and wash before reuse.

### **Engineering Controls**



Handle using a chemical fume hood with good ventilation and electrically grounded lines and equipment. Hydrogen gas at 5% and above is required to be stored and/or used in a chemical fume hood, glove box, gas cabinet, or other exhaust system. An oxygen sensor or gas monitor may also be required. Please contact the Department of Environmental Health and Safety for more details at 215-895-5919 or [safeheal@drexel.edu](mailto:safeheal@drexel.edu). A hydrogen leak detector may be required.

## First Aid Procedures

### If inhaled

Move person into fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

### In case of skin contact

In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid immediately. Wash clothing before reuse.

### In case of eye contact

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical aid immediately.

### If swallowed

Do not induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Give a cup of water if fully conscious. Get medical attention immediately.

## Special Handling and Storage Requirements

### Precautions for safe handling:

1. The laboratory's principal investigator must develop specific written experimental procedures for the use of Hydrogen in the laboratory before any work can be permitted to begin. These are to be included in this Standard Operating Procedure (SOP) (see *Protocol/Procedure section below*). The written procedures must be approved by the Department of Environmental Health and Safety.
2. Compressed gas cylinders may only be handled by experienced and properly trained personnel. Lab personnel may not work with or near compressed gas cylinders until both they and the Principal Investigator (PI) have completed the appropriate online training on BioRAFT, <https://drexel.bioraft.com/>. The principal investigator must provide proper training to the laboratory personnel specific to the hazards involved in working with this substance, work area decontamination, and emergency procedures. Records of the training must be uploaded to BioRAFT.
3. Work in an open, well-ventilated location.
4. Never work alone in the laboratory.
5. Use the local laboratory exhaust, such as the chemical fume hood or gas cabinet, with Hydrogen to prevent exposure.
6. Hydrogen gas greater than or equal to 5% requires the use of a ventilated compressed gas cabinet or fume hood. Ventilation monitors, gas detection systems with visible and audible alarms, automatic shut systems, and flash back arrestors. Check the monitors and alarms before and during compressed gas use.
7. Hydrogen gas mixtures that are >5.5% hydrogen in nitrogen, >2.94% hydrogen in argon, and >3.9% hydrogen in helium are considered flammable. Use of these gas mixtures requires ventilated cabinet, ventilation monitors, gas detection systems with visible and audible alarms, automatic shut systems, and flash back arrestors.
8. Always wear personal protective equipment when handling and using compressed gases.



9. Check the label and confirm it is the correct type and purity you require. Always check the label – there is no universal means of identification (such as color coding) in use. All gas cylinders must be labeled according to US DOT and OSHA regulations.
10. Do not use the gas if unable to confirm the contents by its label.
11. Do not remove, alter, or deface the label applied by the supplier to identify the cylinder.
12. If the label is damaged or the contents cannot be positively identified, return the compressed gas cylinder to the supplier.
13. Examine containers and valves for signs of defect, such as damage, leaks, neglect, or unauthorized modifications. Never use a container that has defects or if the hydrostatic test date, if present, is past due. Ask the vender for assistance with questions on compressed gas equipment and valves, and return to the vender if damaged.
14. Ensure that all equipment and containers are free of oil, grease, dirt, or other materials which may lead to flammability hazard upon contact with oxygen. Dirt may also cause valves to seize up.
15. Select working materials and equipment carefully and make sure that they are compatible with the gas being used.
16. When transporting the cylinder, use a hand truck, cart, or dolly designed for this purpose. Securing chains or straps must be present on the hand truck, cart, or dolly. Only one cylinder should be moved at a time, unless a two cylinder cart where each cylinder is restrained by its own chain is available. Use such a device to move the gas cylinder into position.
17. Always move the compressed gas cylinder with the safety cap on.
18. When moving a compressed gas cylinder avoid banging or striking it into other cylinders or objects.
19. Never roll a compressed gas cylinder on its sides or along the bottom rim. The cylinder may fall and rupture. Avoid dragging and sliding cylinders as well.
20. Do not lift the cylinders by the safety cap or valve.
21. When transporting compressed gas cylinders, use the freight elevator when possible. If there is not freight elevator, do not use an elevator with people in it and do not allow other people to enter the elevator when transporting the cylinders.
22. Compressed gas cylinders must always be properly secured at all times. The use of chains, straps, or a suitable stand to prevent them from falling is an acceptable practice. Stands or a frame casing must be used for lecture bottles and other small compressed gas cylinders.
23. Be aware that a rapid release of a compressed gas will cause an unsecured gas hose to flail dangerously, and may also build up a static charge that could ignite a combustible gas.
24. Valve outlets must be pointed away from all personnel when the valve is being opened. Never direct gas at a person.
25. The manually operated container valves shall be opened slowly.
26. Never force (i.e. use a wrench, lubricant, or a screwdriver through the cap) or modify any knob or valve on the container. Some lubricants may react violently with the gas.
27. Some gas cylinders do not come with hand wheels. For these, use only the wench provided by the gas supplier. The wrench must remain on the valve while the container is in use.
28. If you experience any difficulty in operating a container valve or with the container connections, discontinue use and contact your supplier.
29. Use only the appropriate regulator and tubing for each gas. The threads of the regulators are designed to avoid improper use. Using the wrong regulator may compromise the gas' purity. It is recommended to label the regulators to prevent misuse. NEVER use adaptors or homemade modifications.
30. Always use stainless steel tubing to convey hydrogen gas. Teflon tubing is okay only if specified by the manufacturer.
31. Gas lines containing oxygen, oxidizing gases, air, or flammable gases must not run above the tiles of a dropped ceiling.
32. Always purge a hazardous gas line with an inert gas, such as argon or nitrogen, before opening the cylinder valve. Always assume the hazardous gas is present unless you can confirm a purge has been done previously.
33. Purchase hazardous gases (flammable, corrosive, toxic, etc.) in minimum quantities. Do not purchase more than you need to do the required work. Fire codes may limit the quantities of hazardous gases you may be able to keep in your lab. Please contact EHS for more information.



34. Use a trap or suitable check valve when discharging gas into a liquid to prevent backflow into the regulator or cylinder.
35. Compressed gas cylinders must not be placed where they might become part of an electrical circuit. When compressed gas cylinders are used in conjunction with electrical welding, they shall not be grounded or used for grounding.
36. Never strike and electric arc on a cylinder.
37. Avoid any sparks, open flame, heat sources, or other sources of ignition. Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.
38. Spark proof tools shall be used when working with flammable gas cylinders.
39. No work with Hydrogen gas will be performed alone. A second person familiar with the dangers and emergency procedures for handling hydrogen must be present at all times within the laboratory while operations with hydrogen gas are being carried out.
40. Always include compressed gases on your laboratory's chemical inventory. Include the size of the compressed gas cylinder and/or volume of gas in addition to the number of tanks.
41. Always practice good laboratory hygiene. Wash hands, face, neck, and forearms frequently. Wash hands before eating.
42. Do not eat, drink, or smoke in the laboratory.
43. Use equipment rated for cylinder pressure. Pressure requirements should be considered when selecting materials and designing systems.
44. Only use hydrogen gas approved regulators and valves. Consult you gas supplier for approved regulators and valves.
45. Treat any release of Hydrogen as a **major spill event**.
46. Repair operations:
  - a. The system shall be verified safe according to proper procedures before any type of maintenance is attempted
  - b. Includes all repairs, alterations, cleaning, or other operations performed in confined spaces in which hydrogen vapors or gases are likely to exist.
  - c. 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

#### **Conditions for safe storage:**

1. Store compressed gas cylinders in dry, well-ventilated areas.
2. Hazardous gases (flammable, toxic, corrosive, etc.) must be stored in the laboratory, never in the hallway.
3. Do not store compressed gases in locations where they may block doors or corridors leading to emergency exits. Flammable gases must never be stored near an exit or in any location where it may block an exit.
4. Store away from incompatible materials such as oxidizers and ignition sources.
5. Avoid any sparks, open flame, heat sources, or other sources of ignition. Ignition sources are not permitted near oxygen or flammable compressed gases.
6. Avoid storing compressed gases in environmental rooms or other rooms with insufficient ventilation.
7. Compressed gases of all sizes, whether full or empty, must be properly secured at all times.
8. The use of chains, straps, or a suitable stand to prevent them from falling is an acceptable practice. Cages may be used to store unused gas cylinders. Stands or a frame casing must be used for lecture bottles and other small compressed gas cylinders. In areas where earthquakes are likely to occur, gas cylinders are often required to be double chained and bolted to a secure surface.
9. Never secure or store a compressed gas cylinder on its side. They must be stored and used upright. An upright position shall include conditions where the cylinder is inclined as much as 45°



from the vertical. Gas cylinders, particularly lecture bottles, are more susceptible to damage, corrosion, and leaks when stored on their side.

10. Avoid securing cylinders below their center of gravity as this does not ensure that they will not tip over.
11. Store hazardous gas cylinders away from electrical panels, safety showers, and eyewashes.
12. Use signage to identify the hazards of the compressed gases in the gas storage area. Include hazard class or name of the gas stored. No smoking signs shall be posted where appropriate.
13. Combustible materials, corrosives, and uncontrolled ignition sources must not be stored near the compressed gas storage area.
14. Flammable compressed gas cylinders must be stored 20 feet from oxidizing compressed gas cylinders. Alternatively, flammable and oxidizing cylinders can be stored next to each other as long as there is a 1/2 hour fire rated wall between the cylinders.
15. Fire extinguishers or other fire suppression systems must be present in a flammable gas storage area.
16. No smoking signs must be posted where flammable gases are used or stored.
17. Never expose gas cylinders to heat sources, such as storing near a heating vent or an ignition source. Exposing cylinders to temperatures above 130°F (50°C) could result in excessive cylinder pressure.
18. Keep away from sunlight when ambient temperatures exceed 52°C (125°F).
19. Gas cylinders generally have rupture devices that will release at 149°F (65°C). Small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode at high temperatures.
20. When securing a compressed gas cylinder, please make sure the label is positioned to be easily readable. Do not have the label facing the wall.
21. Compressed gas cylinders not in use or not hooked up to equipment must have their regulators removed, valves closed, and be capped at all times to protect the valve stem.
22. Empty compressed gas cylinders must be marked "EMPTY" and stored apart from full cylinders while waiting to be removed. This will help avoid confusion. Serious suck-back may result when an empty cylinder is attached to a pressurized system.
23. Due to the hazardous nature of the material, only minimal quantities of material should be purchased and stored.

Appropriate hazard warning information must be located on the entrances to the lab and the chemical storage area.

**NOTE:** Hazardous gases may be required to be stored and used in either a chemical fume hood, glove box, gas cabinet, or other exhaust system. Do not modify existing chemical fume hoods, glove boxes, gas cabinets, or other exhaust systems before consulting Environmental Health and Safety. An oxygen sensor or gas monitor may also be required. Please contact the Department of Environmental Health and Safety for more details at 215-895-5919 or [safeheal@drexel.edu](mailto:safeheal@drexel.edu).

## Spill and Accident Procedure

### Chemical Spill Dial 215-895-2222

**Spill/Release** – The Department of Environmental Health and Safety defines the release of any amount of hazardous gas into the environment that could threaten the safety and health of the building occupants as a **Major Spill Event**. Upon identifying a release, laboratory occupants must immediately implement the major spill procedures.

1. Notify persons in the immediate area that a release has occurred
2. Avoid breathing vapors, fumes, mists, dusts, or gases



3. If it can safely be done, turn off all ignition sources
4. If injured or contaminated, immediately proceed with decontamination procedures
5. Evacuate and close the door
6. From a safe area, contact the 24-hour help line, 215-895-2222
7. Please provide the following information:
  - a. Name and Call back number
  - b. Location of the release (Campus, building, room number)
  - c. Type of material released
  - d. Amount released
8. If there is a life-threatening injury, contact 911 or 215-895-2222
9. Remain on or near the phone until you have received instructions from the emergency operator, Public Safety, Security, or the Department of Environmental Health and Safety
10. The MSDS sheet for hydrogen gas should be brought to the hospital to aid in treatment.

### **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.

### **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 by EHS. 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.

**Chemical Spill on Body or Clothes** – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. *Notify supervisor and EH&S at 215-895-5919 immediately.*

**Chemical Splash Into Eyes** – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. *Notify supervisor and EH&S at 215-895-5919 immediately.*





## Medical Emergency Dial **911** or 215-895-2222

**Life Threatening Emergency, After Hours, Weekends And Holidays** – Dial **911**, then Public Safety at 215-895-2222. *Note: All serious injuries must be reported to EH&S at 215-895-5919 within 8 hours.*

**Non-Life Threatening Emergency** – Notify your supervisor, who will contact Public Safety at 215-895-2222. Seek medical attention, if necessary, at Work Net; Hours: M – F, 8:00 a.m. to 5:00 p.m. Located at Hahnemann Hospital, Bobst Building, room 113, or One Reed Street, Philadelphia, PA. Public Safety can arrange transportation to Worknet facilities for employees. All other times, report to nearest emergency room.

**Needle stick/puncture exposure** (as applicable to chemical handling procedure) – Wash the affected area with antiseptic soap and warm water for 15 minutes. For mucous membrane exposure, flush the affected area for 15 minutes using an eyewash station. Seek medical attention, if necessary, at Work Net; Hours: M – F, 8:00 a.m. to 5:00 p.m. Located at Hahnemann Hospital, Bobst Building, room 113, or One Reed Street, Philadelphia, PA. Public Safety can arrange transportation to Worknet facilities for employees. All other times, report to nearest emergency room. *Note: All needle stick/puncture exposures must be reported to EH&S at 215-895-5919 within 8 hours.*

## Decontamination/Waste Disposal Procedure

Use proper personal protective equipment and properly dispose chemical. Contact vender to return old, unused, unneeded, or empty compressed gas cylinders. Please note that not all vendors have a return policy for lecture bottles. Please only purchase lecture bottles from sources with a return policy or if there are no other options. Contact Drexel EHS if you need assistance in disposal of unwanted gas cylinders. Compressed gas cylinders must be properly secured at all times, even if believed to be empty.

*General hazardous waste disposal guidelines:*

### Label Waste

- Follow the labeling guidelines in the Chemical Hygiene Plan and the Hazardous Waste Management Plan
- Drexel EHS can supply waste labels upon request, if needed.

### Store Waste

- Store hazardous waste in a designated location
- Segregate waste from incompatible materials.
- Waste must be under the control of the person generating & disposing of it

### Dispose of Waste

- All waste of Hydrogen, including solutions and by-products, must be collected in a sealable compatible container and disposed as hazardous waste as per University Hazardous Waste Guidelines if unable to be returned to the vender.
- All residual materials and rinse water from empty containers of this material must be collected and disposed as hazardous waste.
- The rinse water from decontamination of all non-disposable equipment must be collected and disposed as hazardous waste.
- All disposable materials contaminated with this material must be disposed as hazardous waste.
- Submit chemical pick-up requests when have unused containers that cannot be returned to the vender:  
<http://www.drexel.edu/facilities/healthSafety/serviceRequests/ChemicalPickupRequest/>
- Do not release unwanted hazardous gases into the air.



## **Safety Data Sheet (SDS) Location**

Online SDS can be accessed at <http://hq.msdsonline.com/drex3646/Search/Default.aspx>.