

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid	SDS No. P-4603-H March 2012
---	--------------------------------

1. Chemical Product and Company Identification

Product Name: Hydrogen, Refrigerated Liquid (MSDS No. P-4603-H)	Trade Names: Liquid Hydrogen
Chemical Name: Hydrogen	Synonyms: Hydrogen (cryogenic liquid)
Chemical Family: Permanent gas	Product Grades: None assigned.
Emergency Telephone Numbers: *	
Onsite emergencies:	1-800-645-4633
CHEMTREC:	1-800-424-9300
Company Name: Praxair, Inc. 39 Old Ridgebury Road Danbury, CT 06810-5113	

* Call emergency numbers 24 hours a day only for spills, leaks, fire, exposure, or accidents involving this product. For routine information, contact your supplier, Praxair sales representative, or call 1-800-772-9247.

2. Hazard Identification

EMERGENCY OVERVIEW

DANGER! Extremely cold, flammable liquid and gas under pressure.

Can form explosive mixtures with air.

Can cause severe frostbite.

Burns with invisible flame.

Liquid or cold gas can freeze air in vent lines.

May cause dizziness and drowsiness.

Self-contained breathing apparatus and protective clothing may be required by rescue workers.

Under ambient conditions, this is a colorless, odorless, cryogenic liquid.

OSHA REGULATORY STATUS: This material is considered hazardous by the OSHA Hazard Communications Standard (29 CFR 1910.1200).

POTENTIAL HEALTH EFFECTS:

Effects of a Single (Acute) Overexposure

Inhalation. Asphyxiant. Effects are due to lack of oxygen. Moderate concentrations may cause headache, drowsiness, dizziness, excitation, excess salivation, vomiting, and unconsciousness. Lack of oxygen can kill.

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

Skin Contact. No harm expected from vapor. Cold gas or liquid may cause severe frostbite.

Swallowing. An unlikely route of exposure, but severe frostbite of the lips and mouth may result from contact with the liquid.

Eye Contact. No harm expected from vapor. Cold gas or liquid may cause severe frostbite.

Effects of Repeated (Chronic) Overexposure. No harm expected.

Other Effects of Overexposure. Hydrogen is an asphyxiant. Lack of oxygen can kill.

Medical Conditions Aggravated by Overexposure. The toxicology and the physical and chemical properties of hydrogen suggest that overexposure is unlikely to aggravate existing medical conditions.

CARCINOGENICITY: This product is not listed by NTP, OSHA, or IARC.

POTENTIAL ENVIRONMENTAL EFFECTS: None known. For further information, see section 12, Ecological Information.

3. Composition/Information on Ingredients

See section 16 for important information about mixtures.

COMPONENT	CAS NUMBER	CONCENTRATION
Hydrogen	1333-74-0	>99%*

* The symbol > means "greater than."

4. First Aid Measures

INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, qualified personnel may give oxygen. Call a physician.

SKIN CONTACT: For exposure to cold gas, liquid, or solid, immediately warm frostbite area with warm water not to exceed 105°F (41°C). In case of massive exposure, remove contaminated clothing while showering with warm water. Call a physician.

SWALLOWING: An unlikely route of exposure. This product is a gas at normal temperature and pressure.

EYE CONTACT: For exposure to cold gas, liquid, or solid, immediately flush eyes thoroughly with warm water for at least 15 minutes. Hold the eyelids open and away from the eyeballs to ensure that all surfaces are flushed thoroughly. See a physician, preferably an ophthalmologist, immediately.

NOTES TO PHYSICIAN: There is no specific antidote. Treatment of overexposure should be directed at the control of symptoms and the clinical condition of the patient.

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

5. Fire Fighting Measures

FLAMMABLE PROPERTIES: Highly flammable, extremely cold cryogenic liquid and gas. Flame is nearly invisible. Escaping gas may ignite spontaneously. Hydrogen has a low ignition energy. Fireball forms if gas cloud ignites immediately after release. Forms explosive mixtures with air and oxidizing agents.

SUITABLE EXTINGUISHING MEDIA: CO₂, dry chemical, water spray, or fog

PRODUCTS OF COMBUSTION: Water (H₂O)

PROTECTION OF FIREFIGHTERS: DANGER! Extremely cold, flammable liquid and gas under pressure. Evacuate all personnel from danger area. Immediately spray containers with water from maximum distance until cool, taking care not to direct spray onto vents on top of container. Do not discharge sprays into liquid hydrogen. Liquid hydrogen will freeze water rapidly. Shut off flow of gas if without risk, while continuing cooling water spray. Remove ignition sources if without risk. If flames are accidentally extinguished, explosive re-ignition may occur. All personnel including, fire and rescue workers, should leave the area immediately. Re-approach with extreme caution. When containers have cooled, move them away from fire area if without risk. Self-contained breathing apparatus and protective clothing may be required by rescue workers. On-site fire brigades must comply with OSHA 29 CFR 1910.156 and applicable standards under 29 CFR 1910 Subpart L—Fire Protection.

Specific Physical and Chemical Hazards. Liquid causes severe frostbite, a freezing injury resembling a burn. Liquid will solidify air, concentrating oxygen and creating a potential explosion hazard. Heat of fire can build pressure in container and cause it to rupture. Liquid hydrogen containers are equipped with pressure relief devices. No part of a container should be subjected to a temperature higher than 125°F (52°C). If venting or leaking hydrogen catches fire, do not extinguish flames. Flammable gas may spread from leak, creating an explosive re-ignition hazard. Vapors can be ignited by pilot lights, other flames, smoking, sparks, heaters, electrical equipment, static discharge, or other ignition sources at locations distant from product handling point. Explosive atmospheres may linger. Before entering area, especially confined areas, check atmosphere with approved explosion meter.

Protective Equipment and Precautions for Firefighters. Firefighters should wear self-contained breathing apparatus and full fire-fighting turnout gear.

6. Accidental Release Measures

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:

DANGER! Extremely cold, flammable liquid and gas under pressure.

Personal Precautions. Forms explosive mixtures with air. (See section 5.) Immediately evacuate all personnel from danger area. Liquid hydrogen will condense moisture in the atmosphere, producing a vapor cloud. The zone of flammability may extend beyond this cloud,

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

so personnel should be evacuated well beyond any visible moisture. Avoid contact with cold liquid, vapor, or frosty condensation. Liquid hydrogen can freeze air, oxygen, and other gases. Contact with liquid or solid gases can cause severe frostbite, a burn-like injury. (See section 2.) Flammable gas may spread from leak. Approach suspected leak area with caution. Before entering area, especially confined areas, check atmosphere with an appropriate device. Self-contained breathing apparatus and protective clothing may be required by rescue workers. Remove all sources of ignition if without risk. Reduce gas with fog or fine water spray. Shut off flow if without risk. Ventilate area or move container to a well-ventilated area.

Environmental Precautions. Prevent waste from contaminating the surrounding environment. Discard any product, residue, disposable container, or liner in an environmentally acceptable manner, in full compliance with federal, state, and local regulations. If necessary, call your local supplier for assistance.

7. Handling and Storage

PRECAUTIONS TO BE TAKEN IN HANDLING: Do not get liquid in eyes, on skin, or on clothing. **Keep away from heat, flame, and sparks.** Never allow any unprotected part of your body to touch uninsulated pipes or vessels containing cryogenic fluids. Flesh will stick to the extremely cold metal and will tear when you try to pull free. For liquid withdrawal, wear face shield and cryogenic gloves (see section 8). **Air will condense on exposed liquid or cold-gas surfaces such as vaporizers and piping.** Nitrogen, which has a lower boiling point than oxygen, will evaporate first, leaving oxygen-enriched condensation on the surface. To prevent possible ignition of grease, oil, or other combustibles, keep all areas of potential condensation free of these substances. Use only spark-proof tools and explosion-proof equipment.

Use a suitable hand truck for container movement. Cryogenic containers must be handled and stored in an upright position. Do not drop or tip containers, or roll them on their sides.

Hydrogen is the lightest known gas. It may leak out of systems that are air-tight for other gases and may collect in poorly ventilated upper reaches of buildings. **All piped hydrogen systems and associated equipment must be grounded.** Electrical equipment must be non-sparking or explosion-proof. Leak check system with soapy water; never use a flame. If valve is hard to open, discontinue use and contact your supplier. For other precautions in using hydrogen, see section 16.

PRECAUTIONS TO BE TAKEN IN STORAGE: Store and use with adequate ventilation.

Store only where temperature will not exceed 125°F (52°C). Post "No Smoking or Open Flames" signs in storage and use areas. There must be no sources of ignition. Separate packages and protect against potential fire and/or explosion damage following appropriate codes and requirements (e.g., NFPA 30, NFPA 55, NFPA 70, and/or NFPA 221 in the U.S.) or according to requirements determined by the Authority Having Jurisdiction (AHJ). Always secure cylinders upright to keep them from falling or being knocked over. Install valve protection cap, if provided, firmly in place by hand when the cylinder is not in use. Store full and empty cylinders separately. Use a first-in, first-out inventory system to prevent storing full cylinders for long periods.

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

Cryogenic containers are equipped with a pressure relief device and a pressure controlling valve. Under normal conditions, these containers will periodically vent product. Use adequate pressure relief devices in systems and piping to prevent pressure buildup; entrapped liquid can generate extremely high pressures when vaporized by warming.

RECOMMENDED PUBLICATIONS: For further information on storage, handling, and use, see Praxair publication P-14-153, *Guidelines for Handling Gas Cylinders and Containers*. Obtain from your local supplier. For further information specific to hydrogen, see NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, published by the National Fire Protection Association, www.nfpa.org.

8. Exposure Controls/Personal Protection

COMPONENT	OSHA PEL	ACGIH TLV-TWA (2012)
Hydrogen	Not Established	Simple Asphyxiant

IDLH = Not available.

ENGINEERING CONTROLS:

Local Exhaust. An explosion-proof local exhaust system is acceptable. See SPECIAL.

Mechanical (General). Inadequate; see SPECIAL.

Special. Use only in a closed system.

Other. See SPECIAL.

PERSONAL PROTECTIVE EQUIPMENT:

Skin Protection. Wear loose-fitting, cryogenic gloves, metatarsal shoes for container handling, and protective clothing where needed. Cuffless trousers should be worn outside the shoes. Select in accordance with OSHA 29 CFR 1910.132, 1910.136, and 1910.138.

Eye/Face Protection. Safety glasses and a full face shield are recommended. Select in accordance with OSHA 29 CFR 1910.133.

Respiratory Protection. None required under normal use. An air-supplied respirator must be used in confined spaces. Respiratory protection must conform to OSHA rules as specified in 29 CFR 1910.134. Select per OSHA 29 CFR 1910.134 and ANSI Z88.2.

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid	SDS No. P-4603-H March 2012
---	--------------------------------

9. Physical and Chemical Properties

APPEARANCE:	Colorless liquid
ODOR:	Odorless
ODOR THRESHOLD:	Not applicable.
PHYSICAL STATE:	Cryogenic liquid
pH:	Not applicable.
MELTING POINT at 1 atm:	-434.56°F (-259.2°C)
BOILING POINT at 1 atm:	-422.97°F (-252.76°C)
FLASH POINT (test method):	Not available.
EXPANSION RATIO for liquid at boiling point to gas at 70°F (21.1°C):	1 to 850.3
EVAPORATION RATE (Butyl Acetate = 1):	Not available.
FLAMMABILITY:	Flammable
FLAMMABLE LIMITS IN AIR , % by volume:	LOWER: 4.0% UPPER: 75.0%
LIQUID DENSITY at boiling point and 1 atm:	4.43 lb/ft ³ (70.96 kg/m ³)
VAPOR PRESSURE at 68°F (20°C):	Not applicable.
VAPOR DENSITY at 70°F (21.1°C) and 1 atm:	0.0052 lb/ft ³ (0.083 kg/m ³)
SPECIFIC GRAVITY (H ₂ O = 1) at 19.4°F (-7°C):	Not available.
SPECIFIC GRAVITY (Air = 1) at 32°F (0°C) and 1 atm:	0.07
SOLUBILITY IN WATER , vol/vol at 60°F (15.6°C) and 1 atm:	0.019
PARTITION COEFFICIENT: n-octanol/water:	Not available.
AUTOIGNITION TEMPERATURE:	1051°F (566°C)
DECOMPOSITION TEMPERATURE:	Not available.
PERCENT VOLATILES BY VOLUME:	100
MOLECULAR WEIGHT:	2.016
MOLECULAR FORMULA:	H ₂

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

10. Stability and Reactivity

CHEMICAL STABILITY: ☐ Unstable ☒ Stable

CONDITIONS TO AVOID: None known.

INCOMPATIBLE MATERIALS: Oxidizing agents, lithium, halogens

HAZARDOUS DECOMPOSITION PRODUCTS: None.

POSSIBILITY OF HAZARDOUS REACTIONS: ☒ May Occur ☐ Will Not Occur

Flammable gas. Forms explosive mixtures with air and oxidizer agents.

11. Toxicological Information

ACUTE DOSE EFFECTS: Hydrogen is a simple asphyxiant.

STUDY RESULTS: None known.

12. Ecological Information

ECOTOXICITY: No adverse ecological effects expected.

OTHER ADVERSE EFFECTS: Hydrogen does not contain any Class I or Class II ozone-depleting chemicals.

13. Disposal Considerations

WASTE DISPOSAL METHOD: Do not attempt to dispose of residual or unused quantities. Return container to supplier.

14. Transport Information

DOT/IMO SHIPPING NAME:		Hydrogen, refrigerated liquid					
HAZARD CLASS:	2.1	PACKING GROUP/Zone:	NA*	IDENTIFICATION NUMBER:	UN1966	PRODUCT RQ:	None
SHIPPING LABEL(s):		FLAMMABLE GAS					
PLACARD (when required):		FLAMMABLE GAS					

*NA—Not applicable.

SPECIAL SHIPPING INFORMATION: Cylinders should be transported in a secure position, in a well-ventilated vehicle. Cylinders transported in an enclosed, nonventilated compartment of a vehicle can present serious safety hazards.

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

Shipment of compressed gas cylinders that have been filled without the owner's consent is a violation of federal law [49 CFR 173.301(e)].

MARINE POLLUTANTS: Hydrogen is not listed as a marine pollutant by DOT.

15. Regulatory Information

The following selected regulatory requirements may apply to this product. Not all such requirements are identified. Users of this product are solely responsible for compliance with all applicable federal, state, and local regulations.

U.S. FEDERAL REGULATIONS:

EPA (ENVIRONMENTAL PROTECTION AGENCY)

CERCLA: COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT OF 1980 (40 CFR Parts 117 and 302):

Reportable Quantity (RQ): None

SARA: SUPERFUND AMENDMENT AND REAUTHORIZATION ACT:

SECTIONS 302/304: Require emergency planning based on Threshold Planning Quantity (TPQ) and release reporting based on Reportable Quantities (RQ) of Extremely Hazardous Substances (EHS) (40 CFR Part 355):

TPQ: None

EHS RQ (40 CFR 355): None

SECTIONS 311/312: Require submission of MSDSs and reporting of chemical inventories with identification of EPA hazard categories. The hazard categories for this product are as follows:

IMMEDIATE: Yes

DELAYED: No

PRESSURE: Yes

REACTIVITY: No

FIRE: Yes

SECTION 313: Requires submission of annual reports of release of toxic chemicals that appear in 40 CFR Part 372.

Hydrogen is not subject to reporting under Section 313.

40 CFR 68: RISK MANAGEMENT PROGRAM FOR CHEMICAL ACCIDENTAL RELEASE PREVENTION: Requires development and implementation of risk management programs at facilities that manufacture, use, store, or otherwise handle regulated substances in quantities that exceed specified thresholds.

Hydrogen is listed as a regulated substance in quantities of 10,000 lb (4536 kg) or greater.

TSCA: TOXIC SUBSTANCES CONTROL ACT: Hydrogen is listed on the TSCA inventory.

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

OSHA: OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION:

29 CFR 1910.119: PROCESS SAFETY MANAGEMENT OF HIGHLY HAZARDOUS CHEMICALS: Requires facilities to develop a process safety management program based on Threshold Quantities (TQ) of highly hazardous chemicals.

Hydrogen is not listed in Appendix A as a highly hazardous chemical. However, any process that involves a flammable gas on site in one location in quantities of 10,000 lb (4536 kg) or greater is covered under this regulation unless the gas is used as a fuel.

STATE REGULATIONS:

CALIFORNIA: Hydrogen is not listed by California under the SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT OF 1986 (Proposition 65).

PENNSYLVANIA: Hydrogen is subject to the PENNSYLVANIA WORKER AND COMMUNITY RIGHT-TO-KNOW ACT (35 P.S. Sections 7301-7320).

16. Other Information

Be sure to read and understand all labels and instructions supplied with all containers of this product.

OTHER HAZARDOUS CONDITIONS OF HANDLING, STORAGE, AND USE: *Extremely cold, flammable liquid and gas under pressure. Use only in a closed system. Use piping and equipment adequately designed to withstand pressures and temperatures to be encountered.* Avoid materials incompatible with cryogenic use; some metals such as carbon steel may fracture easily at low temperature. Use insulated hoses and piping to avoid condensation of oxygen-rich liquid air. See container manufacturer's operating instructions to avoid freezing air in vent lines. Do not change or force fit connections.

Use only transfer lines designed for cryogenic liquids. **Prevent liquid or cold gas from being trapped in piping between valves.** Equip the piping with pressure relief devices. Use a backflow prevention device in the piping.

Gas can cause rapid suffocation due to oxygen deficiency. Store and use with adequate ventilation. Close container valve after each use; keep closed even when empty. Praxair recommends piping all vents to the exterior of the building. **Never work on a pressurized system.** If there is a leak, close the container valve. Blow the system down in a safe and environmentally sound manner in compliance with all federal, state, and local laws; then repair the leak. **Never place a compressed gas container where it may become part of an electrical circuit.**

Mixtures. When you mix two or more gases or liquefied gases, you can create additional, unexpected hazards. Obtain and evaluate the safety information for each component before you produce the mixture. Consult an industrial hygienist or other trained person when you evaluate the end product. Remember, gases and liquids have properties that can cause serious injury or death.

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid	SDS No. P-4603-H March 2012
---	--------------------------------

HAZARD RATING SYSTEMS:

NFPA RATINGS:

HEALTH = 3
FLAMMABILITY = 4
INSTABILITY = 0
SPECIAL = None

HMIS RATINGS:

HEALTH = 3
FLAMMABILITY = 4
PHYSICAL HAZARD = 1

STANDARD VALVE CONNECTIONS FOR U.S. AND CANADA:

THREADED:

CGA-795 (cryogenic liquid withdrawal, for pressures up to 140 psig)

PIN-INDEXED YOKE:

Not applicable.

ULTRA-HIGH-INTEGRITY CONNECTION:

Not applicable.

Use the proper CGA connections. **DO NOT USE ADAPTERS.** Additional limited-standard connections may apply. See CGA pamphlet V-1 listed below.

Ask your supplier about free Praxair safety literature as referred to in this MSDS and on the label for this product. Further information can be found in the following materials published by the Compressed Gas Association, Inc. (CGA), www.cganet.com

AV-1 *Safe Handling and Storage of Compressed Gases*
G-5 *Hydrogen*
G-5.3 *Commodity Specification for Hydrogen*
P-1 *Safe Handling of Compressed Gases in Containers*
P-12 *Safe Handling of Cryogenic Liquids*
SB-2 *Oxygen-Deficient Atmospheres*
V-1 *Compressed Gas Cylinder Valve Inlet and Outlet Connections*
— *Handbook of Compressed Gases*

Last revised 28 Mar 2012.

Praxair Material Safety Data Sheet

Product: Hydrogen, Refrigerated Liquid

SDS No. P-4603-H
March 2012

Praxair asks users of this product to study this MSDS and become aware of product hazards and safety information. To promote safe use of this product, a user should (1) notify employees, agents, and contractors of the information in this MSDS and of any other known product hazards and safety information, (2) furnish this information to each purchaser of the product, and (3) ask each purchaser to notify its employees and customers of the product hazards and safety information.

The opinions expressed herein are those of qualified experts within Praxair, Inc. We believe that the information contained herein is current as of the date of this Material Safety Data Sheet. Since the use of this information and the conditions of use of the product are not within the control of Praxair, Inc., it is the user's obligation to determine the conditions of safe use of the product.

Praxair MSDSs are furnished on sale or delivery by Praxair or the independent distributors and suppliers who package and sell our products. To obtain current MSDSs for these products, contact your Praxair sales representative or local distributor or supplier. If you have questions regarding Praxair MSDSs, would like the form number and date of the latest MSDS, or would like the names of the Praxair suppliers in your area, phone or write the Praxair Call Center (**Phone:** 1-800-PRAXAIR; **Address:** Praxair Call Center, Praxair, Inc., PO Box 44, Tonawanda, NY 14151-0044).

Praxair, *Making our planet more productive*, and the *Flowing Airstream* design are trademarks or registered trademarks of Praxair Technology, Inc. in the United States and/or other countries.

Praxair, Inc.
39 Old Ridgebury Road
Danbury, CT 06810-5113