

**Section 1. Material Identification**

Hydrogen (H₂) Description: The most abundant element on earth, present as free hydrogen in air at ~ 1 ppm. Produced by reacting steam with natural gas and subsequent purification, dissociation of ammonia, passing steam over iron, electrolysis of water (simplest process and used when a high degree of purity is needed but because of high energy consumption is seldom produced in large quantities), or the most economical, the conversion of hydrocarbon gases (i.e. interaction of methane with water vapor). Used in production of ammonia, metals that resist fusion (molybdenum and bismuth), and methyl alcohol; in reducing metal oxides at high temperatures, welding and cutting steel, hydrogenation of liquid fuels and plant oils, extraction of liquid fuel from coal, and organic synthesis for reduction reactions. Liquid H₂ is used as a coolant, in balloons and airships, thermonuclear reactions, and to study subatomic particles in bubble chambers.

Other Designations: CAS No. 1333-74-0, protium.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*⁽⁷³⁾ for a suppliers list.

Cautions: Hydrogen is highly flammable and explosive when exposed to heat, flame, oxidizers. The gas is relatively inert although it becomes a simple asphyxiant at high concentrations by replacing oxygen. Rapid release of compressed gas or contact with the liquid may cause frostbite or severe burns.

		Gas	NFPA
R	1	HMIS	
I	-	H 0	
S	-	F 4	
K	4	R 0	
		PPE*	
		* Sec. 8	
		Liquid	
R	1	HMIS	
I	-	H 3	
S	3	F 4	
K	4	R 0	

Section 2. Ingredients and Occupational Exposure Limits

Hydrogen, ca 100%

1991 OSHA PEL
None established

1992-93 ACGIH TLV
Classified as 'inert'; a simple asphyxiant at high concentrations.

1990 NIOSH REL
None established

1985-86 Toxicity Data*
None reported

1990 DFG (Germany) MAK
None established

* Monitor NIOSH, RTECS (MW8900000), for future toxicity data.

Section 3. Physical Data

Boiling Point: -423 °F (-253 °C)

Freezing Point: -434 °F (-259 °C)

Critical Pressure: 12.8 atm

Vapor Density (Air = 1): 0.069

Ionization Potential: 13.59 eV

Molecular Weight: 2.02

Density (liquid): 0.07 at -423 °F (-253 °C)

Water Solubility*: Slightly, 1:50 parts water at 32 °F (0 °C).

Other Solubilities: Slightly soluble in alcohol and ether.

Critical Temperature: -399.8 °F (-239 °C)

Expansion Ratio, liquid to gas at b.p. to 70 °F: 1 to 851.33

Appearance and Odor: Colorless, tasteless, odorless gas which is much lighter than air.

* Contact with water at ambient temperatures will cause vigorous hydrogen vaporization.

Section 4. Fire and Explosion Data

Flash Point: None reported | **Autoignition Temperature:** 752 °F (400 °C) | **Explosion Range:** 4 to 75% v/v | **Detonation Range:** 20 to 65% v/v

Extinguishing Media: Use flooding quantities of water as fog and apply from as far away as possible. If possible without risk, stop flow of gas before extinguishment.

Unusual Fire or Explosion Hazards: Liquefied or compressed gas has a low ignition energy and burns with a light blue to nearly invisible flame. Container may explode in heat of fire. Hydrogen has a burning rate of 9.9 mm/min.

Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Approach fire with caution since high temperature flame is practically invisible. Approach release from upwind as flame can flash back easily. Use water spray to cool fire-exposed containers. Structural firefighter's protective clothing provides only limited protection. Stay away from ends of tanks. For massive fire in cargo area use monitor nozzles or unmanned hose holder; if impossible, withdraw and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Hydrogen is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Under normal temperatures hydrogen is not very chemically reactive, but as temperatures increase so does reactivity. "Explodes on contact with bromine trifluoride, fluorine, chlorine trifluoride, hydrogen peroxide + catalysts, and acetylene + ethylene. Explodes when heated with 3,4-dichloronitrobenzene + catalysts, calcium carbonate + magnesium, vegetable oil + catalysts, ethylene + nickel catalysts, difluorodiazene (> 90 °C), 2-nitroanisole (> 250 °C/34 bar + 12% catalyst), copper (II) oxide, nitryl fluoride, (> 200 °C), or polycarbon monofluoride (> 500 °C). Forms shock sensitive compounds with bromine, chlorine, iodine heptafluoride (heat or spark sensitive), chlorine dioxide, dichlorine oxide, dinitrogen oxide, dinitrogen tetraoxide, and oxygen (gas). Reacts with liquid nitrogen and heat to create an explosive product. A violent reaction or ignition occurs with air + catalysts (platinum or similar metals containing absorbed O₂ and H₂), iodine, dioxane + nickel, lithium, nitrogen trifluoride, oxygen difluoride, palladium + isopropyl alcohol, lead trifluoride, nickel + oxygen, fluorine perchlorate (ignition on contact), xenon hexafluoride (violent reaction), nitrogen oxide + oxygen (ignition above 360 °C), palladium powder + 2-propanol + air (spontaneous ignition). Produces a vigorous exothermic reaction with benzene + Raney nickel catalyst, metals (lithium, calcium, barium, strontium, sodium, and potassium above 300 °C), palladium (II) oxide, palladium trifluoride, and 1,1,1-tris(hydroxymethyl)-nitromethane + nickel catalyst. Some metals are susceptible to hydrogen attack or embrittlement.

Conditions to Avoid: Exposure to heat, flame, and incompatibles.

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Section 6. Health Hazard Data

Carcinogenicity: The IARC,⁽¹⁶⁴⁾ NTP,⁽¹⁶⁹⁾ and OSHA⁽¹⁶⁴⁾ do not list hydrogen as a carcinogen.

Summary of Risks: Hydrogen gas is generally inert but can cause asphyxiation at high concentrations by replacing air. Symptoms of exposure depend on the degree and duration of oxygen deficiency and are characterized by air hunger, fatigue, decreased vision, mood disturbances, numbness of extremities, headache, decreased coordination and judgement, cyanosis, and unconsciousness. Hydrogen can also be narcotic at elevated pressures.

Medical Conditions Aggravated by Long-Term Exposure: None reported

Target Organs: Respiratory and nervous systems.

Primary Entry Routes: Inhalation.

Acute Effects: Asphyxia. Skin exposure to liquid hydrogen or rapid bursts of compressed air can cause frostbite.

Chronic Effects: None reported.

FIRST AID *Rescuers should protect against asphyxiation and possible fire/explosion when entering areas having potentially dangerous H₂ levels.*

Eyes: Do not allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: For frostbite; immerse exposed area in 107.6 °F (42 °C) until completely rewarmed. Do not use dry heat.

Inhalation: Remove exposed person to fresh air and support breathing and administer 100% humidified-supplemental oxygen as needed.

Note to Physicians: Treatment is symptomatic and supportive.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel. Isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. If possible without risk, stop gas flow. Use water spray to reduce gas. Small leaks can be detected by bubbles that form when a suspected leak area has been painted with soapy water. Because hydrogen ignites readily and burns with a nearly invisible flame in daylight, leaks must be approached in a manner to protect against a jet flame. Remove leaking cylinder to a safe, outdoor area and repair or allow to empty. If impossible, place in a fume hood with good forced ventilation. Allow gas to be discharged at a slow rate. Tag the empty cylinder to reflect the defect, close the valve and return it to the supplier. Follow applicable OSHA regulations (29 CFR 1910.120).

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

SARA Toxic Chemical (40 CFR 372.65): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [*per RCRA, Sec. 3001]

OSHA Designations

Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA *using air, not pure oxygen! Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear cryogenically (extreme cold) protective gloves, boots, aprons, and gauntlets to prevent skin contact with liquid hydrogen. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations low enough to prevent oxygen displacement (O₂ levels should not go below 18% by volume). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.⁽¹⁰³⁾ **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from heat, sun, flame, and oxidizers. Store and transport in labeled, steel containers under pressure of not more than 150 atm. Outside or detached storage is preferred. Install electrical equipment Class I, Group B. Use only non-sparking tools when opening and closing H₂ containers. "A compact portable ultrasafe unit for hydrogen for laboratory use has been developed based on a lanthanum-nickel alloy hydride storage capsule, to eliminate hazards associated with use of high-pressure storage of hydrogen".⁽¹⁴⁹⁾ Comply with handling, use, storage, and inspection procedures (29 CFR 1910.103).

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Never allow air or oxygen to enter a liquid hydrogen system as fractionation can produce a spark causing an explosion. See NFPA (Sec. 50B, 1989) for complete coverage of construction, siting, piping, components and safety devices in consumer systems for liquid hydrogen. Electrically ground and bond piping.

Administrative Controls: Train employees on safe handling of liquid H₂ and follow procedure in the Confined Space Standard (29 CFR 1910.146) when work requires entry into confined spaces. Consider replacement and periodic medical exams of exposed workers.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Hydrogen, compressed

DOT Hazard Class: 2.1

ID No.: UN1049

DOT Packing Group: --

DOT Label: Flammable Gas

Special Provisions (172.102): --

Packaging Authorizations

a) Exceptions: 173.306

b) Non-bulk Packaging: 173.302

c) Bulk Packaging: 173.302, 173.314

Vessel Stowage Requirements

a) Vessel Stowage: E

b) Other: 40, 57

Quantity Limitations

a) Passenger, Aircraft, or Railcar: Forbidden

b) Cargo Aircraft Only: 150 kg

MSDS Collection References: 73, 103, 124, 126, 127, 132, 136, 139, 149, 153, 159, 163, 164

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