

Module 1

General Hydrogen Awareness



www.htec.ca

Disclaimer

Thank you for your interest in hydrogen! Hydrogen is a key driver in Canada's transition to clean energy. Like any fuel, it must be handled responsibly, with a strong understanding of its properties and well-established safety protocols. At HTEC, we prioritize safety at every level—from infrastructure design to fuel storage and refueling operations—ensuring hydrogen is integrated safely and effectively into our energy system.

Disclaimer

This module is intended as a compendium of information to support training and awareness for first responders. The guidance provided should be interpreted in the context of applicable national, regional, and local regulations, protocols, and operational procedures.

This document is for general informational purposes only and does not replace official emergency response protocols or professional judgment. It reflects current knowledge and best practices at the time of publication and may be updated as new information becomes available.

While the content has been developed with care and input from industry professionals, HTEC accepts no liability for how this information is used.

Users are encouraged to provide feedback and consult with their respective agencies before applying any of the guidance in practice.

If you have comments or questions, please contact: info@htec.ca



www.htec.ca

CONTENTS

WHAT IS HYDROGEN

WHY HYDROGEN

HYDROGEN COLOURS

HYDROGEN AS A FUEL

GASEOUS HYDROGEN

LIQUID HYDROGEN

SAFETY CHARACTERISTICS

MITIGATION OF HYDROGEN HAZARDS

What is Hydrogen?

KEY PROPERTIES

- Hydrogen is the lightest and most abundant element in the universe, consisting of one proton and one electron.
- It is a colourless, odourless, non-toxic gas at room temperature.
- Hydrogen can be used in two physical forms:
 - Gaseous hydrogen (GH₂): Most commonly used and stored under high pressure.
 - Liquid hydrogen (LH₂): Cooled to extremely low temperatures (-253°C) to become a liquid, allowing for higher energy density in a smaller volume.
- It is an energy carrier, not a primary energy source—meaning it stores and delivers energy but must be produced from other resources.



Why Hydrogen?

BENEFITS OF HYDROGEN

- Zero emissions at point of use: When used in fuel cells, the only by-product is water.
- Versatile applications: Can power vehicles, generate electricity, and provide industrial heat.
- High energy density: Especially in liquid form, hydrogen stores more energy per unit of weight than conventional fuels.
- Can be stored and transported for long durations, enabling energy security and balancing renewable power generation.
- Decarbonization potential: Replaces fossil fuels in hard-to-electrify sectors like heavy transport, aviation, and industry.



Hydrogen “Colours”

WHAT THEY MEAN

GREEN HYDROGEN

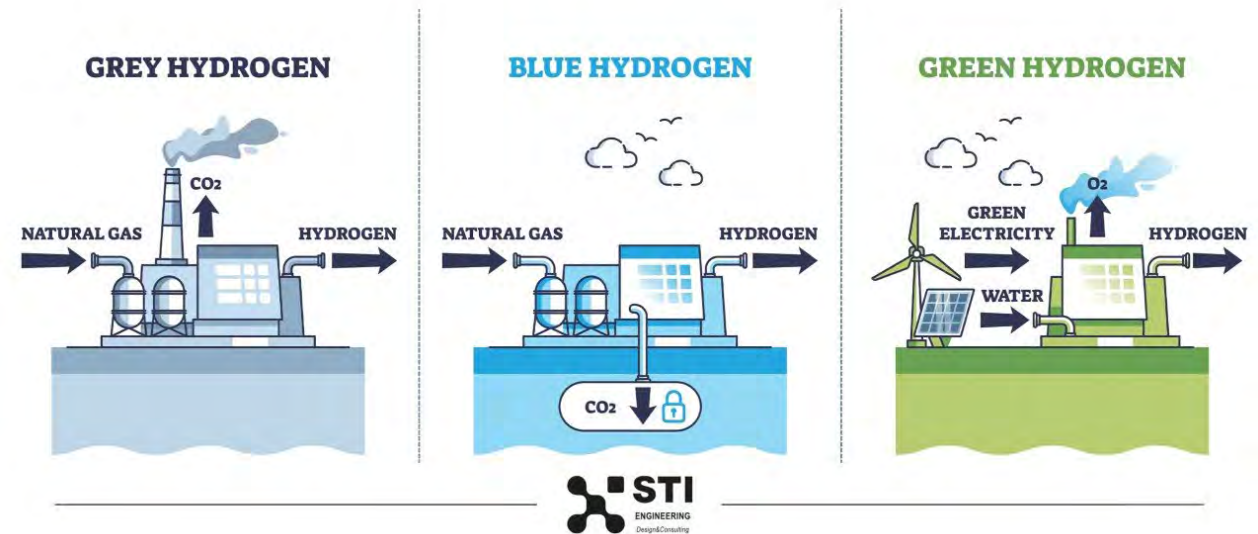
- Made from electrolysis using renewable electricity (solar, wind, hydro).
- Zero emissions – the cleanest kind!

BLUE HYDROGEN

- Made from natural gas, but carbon emissions are captured (CCS: carbon capture and storage).
- Cleaner than grey but still uses fossil fuels.








GREY HYDROGEN

- Also made from natural gas, but without capturing CO₂.
- Produces high emissions – the most common today, but not environmentally friendly.



Hydrogen as a Fuel

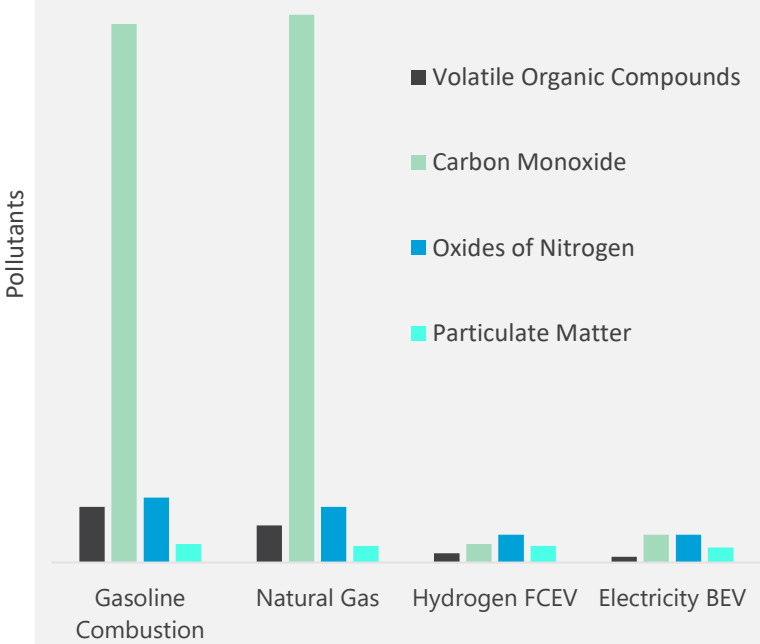
WHY USE IT?

		GASOLINE/DIESEL	HYDROGEN
	Irritating to the Skin and Eyes	✓	
	Poisonous to Ingest and Inhale	✓	
	Produces Particulate Pollution	✓	
	Produces NO _x and SO _x (smog)	✓	
	Produces CO and CO ₂ when burned	✓	
	Lingers after a spill, posing a fire danger	✓	
	Flammable	✓	✓

CLEAN – Does not produce any carbon at the tailpipe

EFFICIENT – Hydrogen fuel cells are more efficient than ICE engines

RENEWABLE – Can be produced from renewable sources

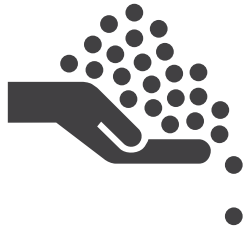


Gaseous Hydrogen

Gaseous Hydrogen

KEY PROPERTIES

ABUNDANT



75% of the mass in the universe

ENERGY CARRIER



Stores energy created elsewhere

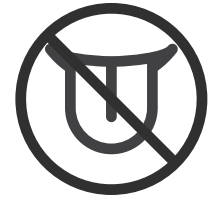
INVISIBLE



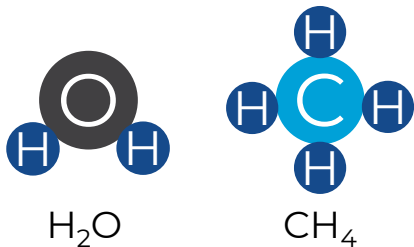
ODORLESS



TASTELESS



CHEMICAL BONDING

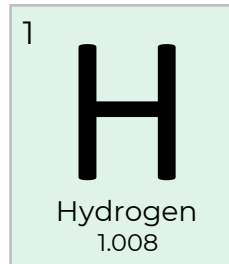


Rarely exists in a free state

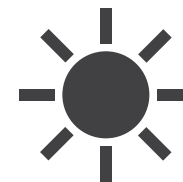
WEIGHT



Lightest element,
Atomic No. 1



HIGH UV









During combustion

HIGH BURN RATE



Hydrogen

A COMPARISON

		Hydrogen	Natural Gas	Gasoline
	Color	No	No	Yes
	Toxicity	None	Some	High
	Odor	Odorless	Mercaptan	Yes
	Buoyancy Relative to Air	14X Lighter	2X Lighter	3.75X Heavier
	Energy by Weight	2.8X > Gasoline	~1.2X > Gasoline	43 MJ/kg
	Energy by Volume	4X < Gasoline	1.5X < Gasoline	120 MJ/gallon

Source: California Fuel Cell Partnership

Liquid Hydrogen

Liquid Hydrogen

KEY PROPERTIES

CRYOGENIC



-253°C (-423°F) in liquid form

NON-CORROSIVE



Non-corrosive liquid (be aware of cryogenic burns)

Fog



Reduced visibility

OXYGEN



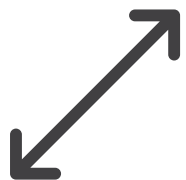
Oxygen-enriched air

ELEVATION



Cold gaseous hydrogen low to the ground until it warms

EXPANSION

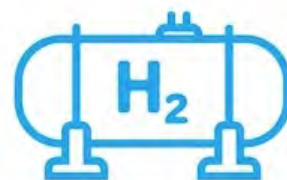


Large expansion ratio: 1 vol. liquid=848 vol. gas

DENSITY



14x less dense than water



ICE



Falling ice from vaporizers

COLD



Extremely cold, do not touch

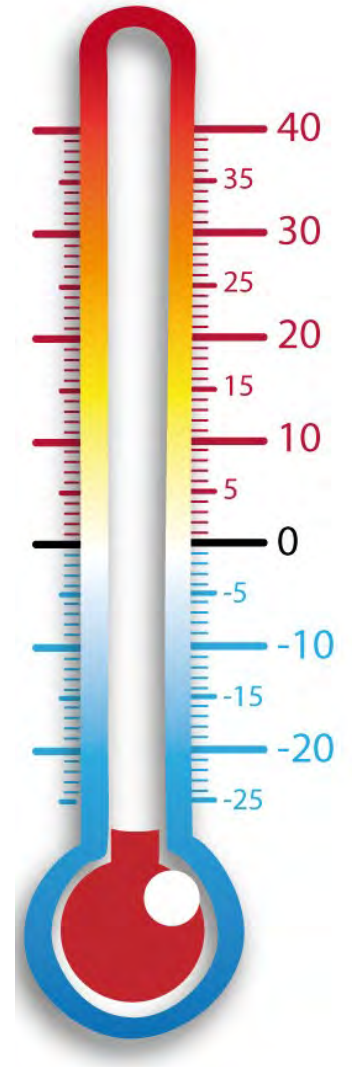
Liquid Hydrogen

RELATIVE TEMPERATURES

Industrial Gases are liquefied to cryogenic liquids to reduce transport costs.

Hydrogen liquifies at an extremely low temperature.

Hydrogen BP	-253°C	-423°F
Argon BP	-186°C	-303°F
Oxygen BP	-183°C	-297°F
Air Liquifies	-194°C	-317°F
Water Freezes	0°C	32°F
Average Body Temperature	37°C	98.6°F
Water Boils	100°C	212°F
Average Oven Cooking Temperature	177°C	350°F



Keep in mind that condensation will drip from the liquid hydrogen tank due to its temperature, these are not leaks!

SAFETY CHARACTERISTICS

Safety First!

ALWAYS

As with any other energy source, such as gasoline and diesel, hydrogen is also a combustible fuel, and we handle it with the utmost respect.



Hydrogen is Safe

- Hydrogen is not new - it's been in widespread industrial use for more than 100 years in Canada.
- Hydrogen's unique characteristics make it one of the safest energy carriers when compared to fuels, such as gasoline, diesel, or natural gas.

Hydrogen

THINGS TO KNOW

HYDROGEN STORED AT PRESSURE

One of the biggest risks when working with hydrogen systems is the sudden release of pressure:

- Creates a very loud noise
- Cause tubing to whip around

HYDROGEN VENTING

Venting of H₂ can be very loud depending on the vent size, pressure, and velocity of the exiting gas. Hydrogen is a colorless and odorless gas.

What can be seen during a venting event is water in the air condensing around the venting hydrogen.

ASPHYXIANT

Care must be taken in an enclosed space.

Hydrogen rises to the top and can quickly push air down, creating a low-oxygen environment.

IGNITES EASILY & IS FLAMMABLE

Hydrogen is extremely flammable, igniting at just 4% concentration in air.

Burns an invisible flame unless other than hydrogen is in the stream.

The only signs might be heat shimmer, sound, or distortion.

NFPA Hazard Placards

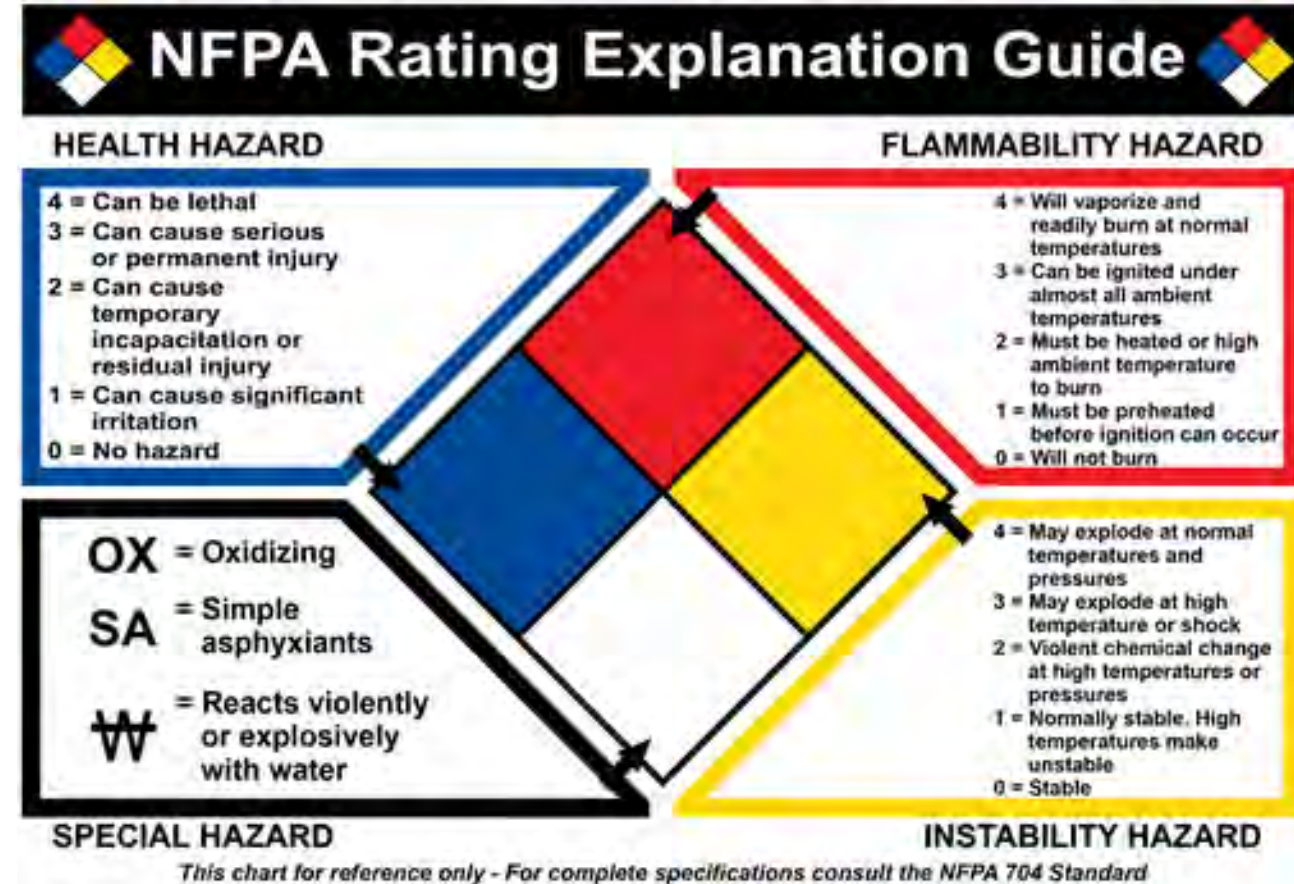
- **Red** = Flammability
- **Blue** = Health
- **Yellow** = Reactivity
- **White** = Special Precautions







Gaseous Hydrogen



Liquid Hydrogen



Comparison of Flammability

	Hydrogen		Natural Gas	Gasoline
	Liquid	Gas		
Flammability in air (LFL – UFL)				
	4.1% - 74%		5.3% - 15%	1.4% - 7.6%
Most easily ignited mixture in air	29%		9%	2%
Flame temperature (°C/°F)	2,210°C 4,010°F		1,961°C 3,562°F	1,977°C 3591°F



LFL = Lower Flammability Limit → Also called Lower Explosive Limit (LEL)
This is the lowest concentration (by %) of a gas or vapor that will burn in air in the presence of an ignition source

MITIGATION OF HYDROGEN HAZARDS

Mitigation of Hydrogen Hazards

FIRE FIGHTING

- Isolate the hydrogen before putting out the fire
- Use water to cool adjacent equipment
- Never spray water on/into the liquid hydrogen vent stack

FOR LIQUID HYDROGEN

- Low-temperature shutdown on the system
- Do not drive or walk through a fog

DETECTION AND ISOLATION

- Ventilation
- Emergency Shutdown
- Use a hydrogen detector and listen
- If the leak is audible a broom can be used to check for an invisible flame
- Siting requirements away from ignition sources/compounding hazards

REDUCE IGNITIONN SOURCES

- Electrical Classification
- Open flames and welding





THANK YOU!

We appreciate your time and commitment to learning about hydrogen safety. Your role as first responders is essential to the safe rollout of this clean energy solution.

Want to learn more?

- Continue with our training modules
- Email us at info@htec.ca to arrange a workshop, live demo, or tailored presentation for your department.

Together, we can build a safer, cleaner future.