



Powertech

The Power of Trust. The Future of Energy.

Hydrogen Safety Basics

Leanne Sharpe, P.Eng.
Engineering Team Lead, Hydrogen Infrastructure
Advanced Transportation
www.powertechlabs.com

September 2019

Introduction to Powertech Labs

Powertech's 11-acre facility located in Surrey, B.C. offers 15 different testing labs and is home to a broad range of approximately 200 scientists, engineers, and technical specialists.

T&D Technology and Testing

High Voltage Testing
Mechanical Testing
Cable Testing
Non-Destructive Testing
Condition Assessment
Field Testing Services

Advanced Transportation

High Pressure Testing
CNG & Hydrogen Testing
Hydrogen Infrastructure
DCFC Hardware Evaluation
Workplace & MURBS Charging
Infrastructure
EV-Grid Impact Studies

Substation Technology and Testing

High Power Testing
Insulating Oil Testing
Fuel Analysis
Oil Purification
Environmental Testing

Power System Studies

Grid Modelling
Grid Performance Optimization
Dynamic Security Assessment
Systems
Power System Reliability
Assessment

Grid Modernization

Distribution Automation
Intelligent City Accelerator
AeroMACS Certification
Smart Metering Infrastructure

Generation Technology and Testing

Materials Evaluation
Failure Analysis
Weld Repair Consulting
Coating & Corrosion
Generator Testing
Generator Modelling

Hydrogen Gas Comparison to other Fuels

	Hydrogen	Natural Gas	Propane	Gasoline
Odourant Added?	No	Yes, if compressed; no, if liquefied	Yes	No
Toxic?	No	No	No	Yes
Vapour Density (relative to air)	7%	55%	152%	400%
Autoignition Temperature	585°C	540°C	490°C	232°C
Ignition Energy (mJ)	0.02	0.29	0.26	0.24
Flammability Range (% in gas-to-air volume ratio)	4 to 75	5 to 15	2.1 to 10.1	1.4 to 7.6
Explosive Energy (gTNT/m ³)	2	7	29	44
Diffusion Coefficient (cm ² /s)	0.668	0.16	0.1	0.05

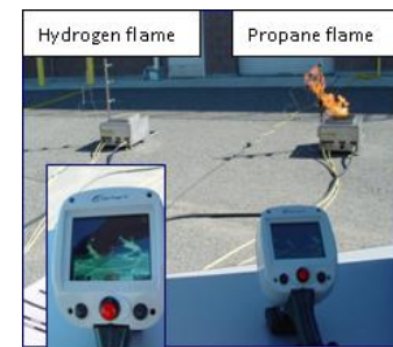
- In many ways, Hydrogen is safer than conventional fossil fuels:
- Hydrogen is 14 times lighter than air – therefore, it rises into atmosphere at a rate of 20 m/s (72 km/hr).
- The flames emit low radiant energy, which means that they're less likely to move to surrounding areas and spread fire.
- It is non-toxic.



0 Seconds

3 Seconds

1 Minute



A 100% hydrogen flame

Gasoline Tanker Fire



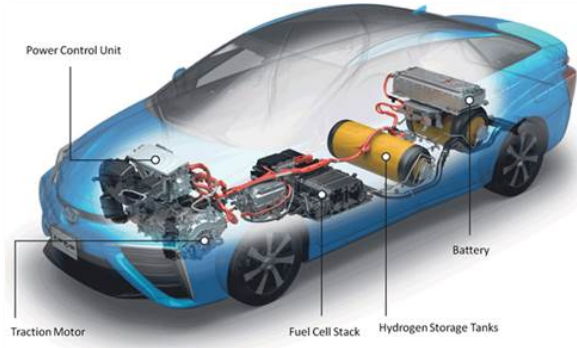
Hydrogen Gas Properties, Safety & Testing

Hydrogen Characteristic	Potential Hazard	Safety Measure
Colourless, odourless and tasteless	Undetectable to human senses	Detection sensors
Low viscosity and small atoms that can be absorbed into materials	Leaks and embrittlement of certain materials, potentially causing structural failure	Correct material selection, leak detection systems, ventilation
Low volumetric energy density	Stored at high pressures	Storage container and component design and testing, and pressure relief devices
Not breathable (like any other gas that displaces oxygen)	Can accumulate in confined spaces and act as an asphyxiant	Ventilation and leak detection systems
Wide flammability range of 4% to 75%	Leaks are a concern	Ventilation and leak detection systems
Low ignition energy	Ignition by even a small spark can be possible	Ventilation, grounding, and removal of possible ignition sources
Burns with a pale blue flame that is nearly invisible in daylight, produces no smoke, emits little heat	Potential for undetected flames	Flame detectors and leak detection systems

Hydrogen Fueling Station Safety

Safety Planning & Design Tools

- Hazard and Operability Analysis (HAZOP)
- Failure modes and effects analysis, what-if analysis, checklist analysis, fault tree analysis
- Probabilistic risk assessment
- Codes and standards specify requirements for equipment design and installation of hydrogen fueling stations to ensure that hydrogen is produced, stored, and dispensed safely.



Safety Considerations

- Operational Features of the Station
 - Use of pressure relief valves, hydrogen detectors, explosion-proof electrical systems, clearance distances, etc.
- Materials Selection used in Components
 - Sufficient strength for application, resistance to hydrogen embrittlement and permeation effects
- Functionality of Components
 - Equipment suitable for service conditions



How Do We Make Components Safe?

- Look at experiences in other industries with high pressure gas
- Review failures experienced to date involving high pressure hydrogen
- Establish "worst-case" service conditions for hydrogen fueling stations
- Develop standards for the testing components using simulated "worst-case" service conditions
- Testing of components
- Implement quality systems to control manufacture of components and assembly of stations



Safety/Destructive Studies

Wide variety of testing done on all hydrogen components and storage cylinders to ensure safety in vehicles and fueling stations.

Hydrogen Release



Crush/Impact



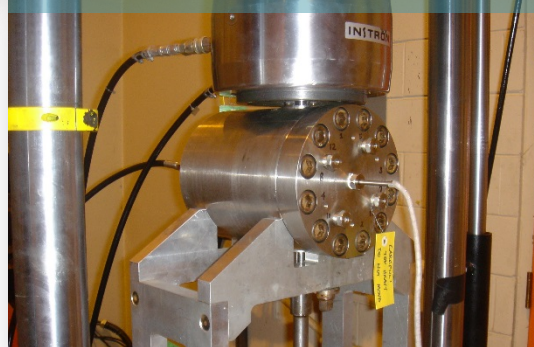
Damage Tolerance



Hydrogen Ignition



H2 Embrittlement



Vehicle Fire



Storage Tanks – Impact Resistance Test (gunfire penetration - 35 MPa hydrogen)

