Hydrogen Safety
UKHA Fact Sheet Number 2

UNITED KINGDOM HYDROGEN ASSOCIATION

ADDRESSING THE PROPERTIES OF HYDROGEN FOR COMMERCIAL ENERGY APPLICATIONS

For over 40 years, industry has used hydrogen in vast quantities as an industrial chemical and fuel for space exploration. During that time, industry has developed an infrastructure to produce, store, transport and utilise hydrogen safely. More recent uses of hydrogen as an energy carrier for a variety of applications in the transport, stationary, and portable power markets require the development of safety data and standards that utilise this broad industry expertise.

Hydrogen is no more or less dangerous than other flammable fuels, including petrol and methane. In fact, some of hydrogen's differences actually provide safety benefits compared to gasoline or other fuels. However, all flammable fuels must be handled responsibly. Like petrol and methane, hydrogen is flammable and can behave dangerously under specific conditions. Hydrogen can be handled safely when guidelines are observed and the user has an understanding of its behaviour.

The properties of hydrogen have required new systems for storage and distribution to be developed, as some current systems for methane and petrol are unsuitable due to the possibility of embrittling. In addition, since hydrogen gas has a low density, many applications store the hydrogen gas at pressures in excess of ratings for methane containers.

Physical Properties

Molecular Weight:	2.016
Boiling Point @ 1 atm:	-423.0°F (-252.8°C, 20°K)
Freezing Point @ 1 atm:	-434.5°F (-259.2°C, 14°K)
Critical Temperature:	-399.8°F (-239.9°C)
Critical Pressure:	188 psia (12.9 atm)
Density, Liquid @ B.P., 1 atm:	4.23 lb./cu.ft.
Density, Gas @ 68°F (20°C), 1 atm:	0.005229 lb./cu.ft.
Specific Gravity, Gas (Air = 1) @ 68°F (20°C), 1 atm:	0.0696
Specific Gravity, Liquid @ B.P., 1 atm:	0.0710
Specific Volume @ 68°F (20°C), 1 atm:	192 cu. ft./lb.
Latent Heat of Vaporization:	389 Btu/lb. mole
Flammable Limits @ 1 atm in air 4.00%:	-74.2% (by Volume)
Flammable Limits @ 1 atm in oxygen 4.65%:	-93.9% (by Volume)
Detonable Limits @ 1 atm in air 18.2%:	-58.9% (by Volume)
Detonable Limits @ 1 atm in oxygen 15%:	-90% (by Volume)
Autoignition Temperature @ 1 atm:	1060°F (571°C)
Expansion Ratio, Liquid to Gas, B.P. to 68°F (20°C):	1 to 848

SUITABLE INTERNATIONAL STANDARDS ARE UNDER DEVELOPMENT WITH UK INVOLVEMENT

Hydrogen technology standards are moving forward quickly. With the ever-expanding capacity of hydrogen production and the push towards a hydrogen economy, industry is working hard to ensure the safety of a future hydrogen network for the people who use it.

Research is currently being carried out to develop cheaper, more reliable and effective hydrogen sensors to detect leaks. This will not only help to prevent explosion hazards but will also avoid build up of hydrogen in enclosed environments (such as a production or storage facility).

There is also research into secure hydrogen storage facilities to provide safe storage of compressed or liquefied hydrogen8. Internationally recognised safety codes and standards for hydrogen storage, distribution, etc. are being developed.

The British Standards Institution (BSI) is the United Kingdom National Standards Body (NSB).
BSI has asked the UKHA to lead a new Subcommittee of PVE/3-8, with the full, delegated responsibility to deal with matters on hydrogen technologies.

For additional information about hydrogen technologies, please see the following UKHA Fact Sheets:

How Hydrogen Can Help – UKHA Fact Sheet Number 1

Hydrogen Distribution & Delivery – UKHA Fact Sheet Number 3

Hydrogen Storage – UKHA Fact Sheet Number 4

Or visit www.ukha.org for additional information

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General Handling Guidance

Hydrogen typically is delivered as either a compressed gas, or in liquefied form. Compressed hydrogen gas is typically packaged in cylinders at high pressure, although it can also be packaged in a stable, solid hydride storage container. It poses an immediate fire and explosive hazard when concentrations exceed 4%. It is much lighter than air and burns with an invisible flame.

Hydrogen gas is odourless and non-toxic but may produce suffocation by diluting the concentration of oxygen in air below levels necessary to support life. Caution: The amount of hydrogen gas necessary to produce an oxygen-deficient atmosphere is well within the flammable range, making fire and explosion the primary hazards associated with hydrogen and air atmospheres.

Hydrogen Facts

- Hydrogen is non-carcinogenic
- Hydrogen is non-toxic.
- Hydrogen produces no hazardous combustion products. Hydrogen is non-polluting.
- Hydrogen has an energy content equivalent to 0.34 litres of petrol per cubic metre.
- Hydrogen burns with very little heat radiated from the flame. Hydrogen does not auto-ignite.
- Hydrogen is not radioactive.
- Hydrogen does not decompose.
- Hydrogen is much lighter than air and dissipates quickly upwards in open air.

Hydrogen can be used in a fuel cell or an internal combustion engine or turbine. Fuel cells are electrochemical and use a non-combustive process.

The wide flammability range, 4% to 74% in air, and the small amount of energy required for ignition necessitate special handling to prevent the inadvertent mixing of hydrogen with air. Care should be taken to eliminate sources of ignition, such as sparks from electrical equipment, static electricity sparks, open flames or any extremely hot objects. Hydrogen and air mixtures within the flammable range can explode and may burn with a pale blue, almost invisible flame.

Handling and Storage- Compressed Hydrogen

Cylinder storage locations should be well- protected, well-ventilated, dry, and separated from combustible materials. Cylinders should never knowingly be allowed to reach a temperature exceeding 52 degrees C (125 degrees F). Cylinders of hydrogen should be separated from oxygen cylinders or other oxidizers by appropriate distances or by a barrier of non-combustible material at least 2 metres high having a fire resistance rating of at least 1 hour. Cylinders should be stored upright with valve protection cap in place and firmly secured to prevent falling or being knocked over. Protect cylinders from physical damage; do not drag, roll, slide or drop. Use a suitable hand truck for cylinder movement. Post "No Smoking or Open Flames" signs in the storage areas. There should be no sources of ignition. All electrical equipment should be explosion proof in the storage and use areas. Storage areas must meet national electric codes for class 1 hazardous areas.

HANDLING: Do not "open" hydrogen cylinder valve before connecting it, since self-ignition may occur. Hydrogen is the lightest gas known and may collect in the top of buildings with out proper ventilation. It may leak out of a system which is gas-tight for air or other gases. Leak check system with leak detection solution, never with flame. If user experiences difficulty operating cylinder valve, discontinue use and contact supplier. Use only approved connections. DO NOT USE ADAPTERS. Never insert an object (e.g., wrench, screwdriver, pry bar, etc.) into valve cap openings. Doing so may damage valve, causing a leak to occur. Use an adjustable strap wrench to remove over-tight or rusted caps. Never strike an arc on a compressed gas cylinder or make a cylinder a part of an electrical circuit. SPECIAL PRECAUTIONS: Use piping and equipment adequately designed to withstand pressures to be encountered. Use a check valve or other protective apparatus in any line or piping from the cylinder to prevent reverse flow.

Handling and Storage- Liquid Hydrogen

The hazards associated with handling liquid hydrogen are fire, explosion, asphyxiation, and exposure to extremely low temperatures. Consult the Material Safety Data Sheet (MSDS) for safety information on the gases and equipment you will be using. The potential for forming and igniting flammable mixtures containing hydrogen may be higher than for other flammable gases because:

- Hydrogen migrates quickly through small openings.
- The minimum ignition energy for flammable mixtures containing hydrogen is extremely low. Burns may result from unknowingly walking into a hydrogen fire. The fire and explosion hazards can be controlled by appropriate design and operating procedures. Preventing the formation of combustible fuel-oxidant mixtures and removing or otherwise inerting potential sources of ignition (electric spark, static electricity, open flames, etc.) in areas where the hydrogen will be used is essential. Careful evacuation and purge operations should be used to prevent the formation of flammable or explosive mixtures. Adequate ventilation will help reduce the possible formation of flammable mixtures in the event of a hydrogen leak or spill and will also eliminate the potential hazard of asphyxiation. Protective clothing should be worn to prevent exposure to extremely cold liquid and cold hydrogen vapours.
- Cold burns may occur from short contact with frosted lines, liquid air that may be dripping from cold lines or vent stacks, vaporizer fins, and vapour leaks. Air will condense at liquid hydrogen temperatures and can become an oxygen-enriched liquid due to the vaporization of nitrogen. Oxygen-enriched air increases the combustion rate of flammable and combustible materials.

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