

# Programme

- 9.30 Introduction to MetroHyVe project
- 9.45 Overview of the day
- 10.00 Gas sampling devices (overview)
- 10.30 Gas sampling vessels (overview)
- 11.00 Break
- 11.30 Particles sampling (overview)
- **11:45 Health and safety**
- 12.05 Lunch
- 13.00 Head over to the hydrogen refuelling station for a visit

# METROLOGY *for* HYDROGEN VEHICLES

## Health and safety

Oliver Büker, Karine Arrhenius - RISE

Workshop on Hydrogen sampling training course  
12<sup>th</sup> of March 2020, Delft, The Netherlands

# Introduction to hydrogen safety

Everyone who will be working with or around hydrogen should be adequately trained on hydrogen safety procedures and should understand:

- Hydrogen properties and behavior
- Safety requirements for working with or around high-pressure hydrogen gas (if applicable)
- Safety requirements for working with or around cryogenic liquid hydrogen (if applicable)
- Hydrogen equipment inspection, operation, and maintenance
- First aid procedures
- Emergency notification and evacuation/response policies and procedures

This workshop only gives general information about safety

# Overview



## Safety culture



## Safety planning

- Conducting work safely and responsibly to protect 1) the health, safety, and welfare of the organization's staff and 2) its equipment and property
- Protecting the health, safety, and welfare of the general public
- Protecting the environment

- Identify hazards,
- Evaluate risks by considering the likelihood and severity/consequence of an incident associated with the hazards
- Minimize the risks associated with a project.

To achieve these goals, various hazard analysis and risk assessment techniques are used, in conjunction with safety reviews.

# Overview



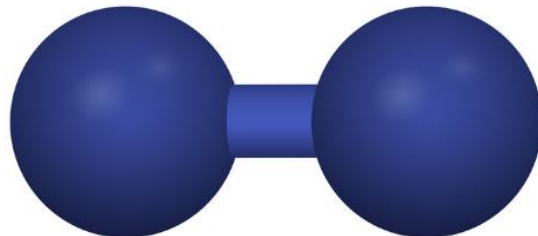
- Chemical properties of hydrogen
- Environmental effects of hydrogen
- Health effects of hydrogen
- Physical dangers
- Hydrogen ignition and flame
- Hydrogen safety checklist
- Useful references

# Some chemical properties of hydrogen

Hydrogen is odorless, colorless, and tasteless making it undetectable by human senses

Hydrogen gas is fourteen times **lighter than air** and rises at a speed of almost 20 m/s, 6 times faster than natural gas which means **that when released, it rises and disperses quickly** in well-ventilated areas and outdoors. If hydrogen is released in a closed room, it will accumulate at the highest point.

Hydrogen is the most flammable of all the known substances



*Effect on plants or animals:* Any effect on animals would be related to oxygen deficient environments. No adverse effect is anticipated to occur to plant life, except for frost produced in the presence of rapidly expanding gases.

*Effect on aquatic life:* No evidence is currently available on the effect of hydrogen on aquatic life.

# Hydrogen ignition

Hydrogen gas **requires very little energy to ignite**. Furthermore, a mixture of hydrogen gas and air can be ignited along a very wide area (volume fraction of 4 % to 75 %). To prevent static charges accumulating in the constructions, materials that conduct electricity well are used and potential equalisation shall be ensured.

Note: Friction of garments can even suffice to generate this small level of energy.

The self-ignition temperature is 585°C.

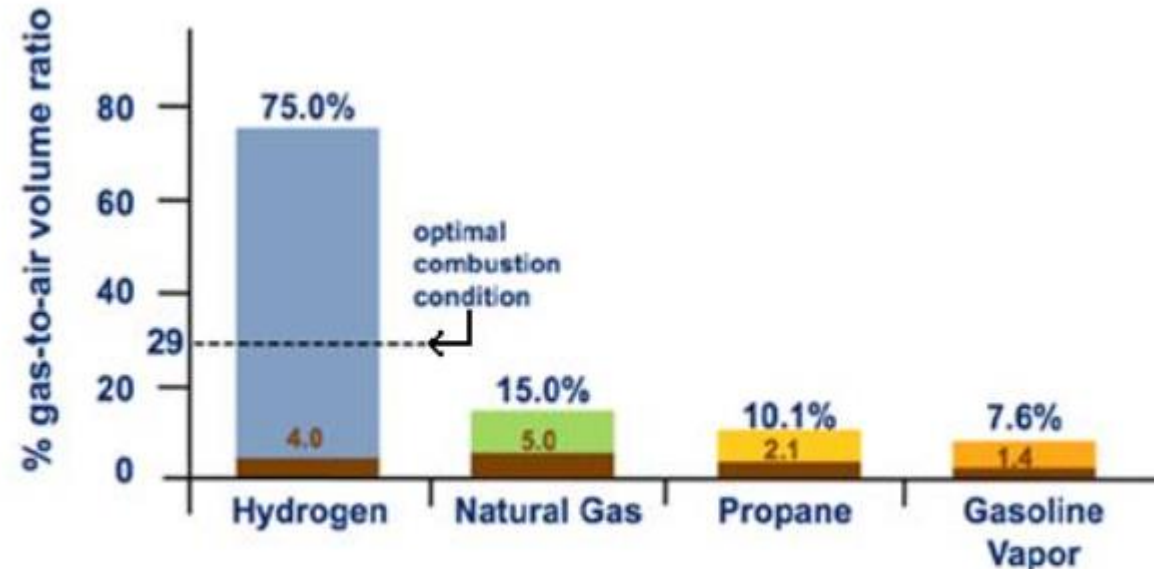
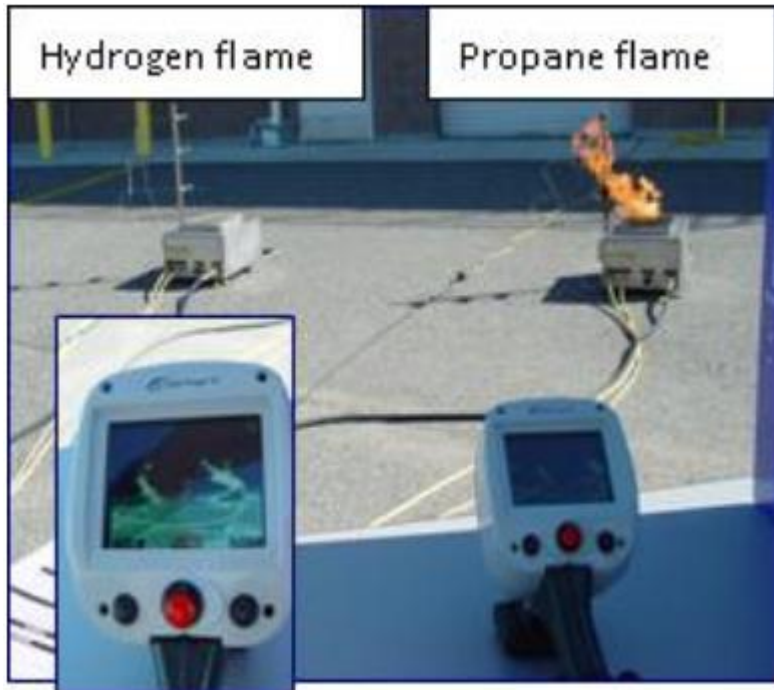


Figure 3. Flammability Range



# Hydrogen flame

Since hydrogen has a colourless, hardly visible flame and has hardly any heat radiation a **hydrogen fire cannot be easily detected by people**. A flame can be detected using special thermal imaging cameras and/or UV measurement.



# Physical dangers

In case of fire:

- Shut off supply; if not possible and no risk to surroundings, let the fire burn itself out; in other cases extinguish with water spray, powder, carbon dioxide.
- Keep cylinder cool by spraying with water.
- Combat fire from a sheltered position.

## *Effects of exposure to hydrogen:*

- Routes of exposure: On loss of containment, a harmful concentration of hydrogen in the air may be reached very quickly. The substance can be absorbed into the body by inhalation. High concentrations of this gas can cause an oxygen-deficient environment.
- Individuals breathing such an atmosphere may experience symptoms which include headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting and depression of all the senses. The skin of a victim may have a blue color. In case of inhalation: Fresh air, rest. Artificial respiration may be needed. Refer for medical attention
- Hydrogen is not expected to cause mutagenicity, embryotoxicity, teratogenicity or reproductive toxicity. Pre-existing respiratory conditions may be aggravated by overexposure to hydrogen.

- Hydrogen is non-corrosive, but it can embrittle some metals (i.e., cause significant deterioration of the metal's mechanical properties).
- Due to the **small size of its molecules**, hydrogen can **diffuse** in or even through materials. Since this increases the probability of leaks, only a few materials are suitable for use in combination with hydrogen.

# Hydrogen safety checklist



- 1. Recognize hazards and define mitigation measures (plan).
- 2. Ensure system integrity (keep the hydrogen in the system).
- 3. Provide proper ventilation to prevent accumulation (manage discharges).
- 4. Ensure that leaks are detected and isolated (detect and mitigate).
- 5. Train personnel and ensure that hazards and mitigations are understood and that established work instructions are followed (manage operations).

More details: [https://h2tools.org/sites/default/files/HydrogenSafetyChecklist\\_130.pdf](https://h2tools.org/sites/default/files/HydrogenSafetyChecklist_130.pdf)

- ISO19880-1: **Gaseous hydrogen — Fuelling stations — Part 1: General requirements**
- Hydrogen Incident Reporting and Lessons Learned Database: <https://h2tools.org/lessons>
- Hydrogen Safety Best Practices: <https://h2tools.org/bestpractices>
- NFPA 2, “Hydrogen Technologies Code”: <http://www.nfpa.org>
- Hydrogen Tools Portal: <http://h2tools.org/>



# THANK YOU



[metrohyve.eu](http://metrohyve.eu)

**Oliver Büker**

**Oliver.buker@ri.se**

**(+46) 010 516 5889**