Work Package 5

SAFETY

Objectives/Status/Outlook

OBJECTIVES

- To assess the safety of hydrogen when used as a fuel in vehicles and of associated infrastructure.

- To perform a comparative study of of hydrogen versus current vehicle fuels such as CNG and LPG.

- To support the safety issues in work package WP2 ‘refuelling station’, WP3 ‘refuelling interface’ and WP4 ‘vehicle’.

OVERVIEW

- **Sub-task 5.1**: Review of existing safety data on hydrogen and comparative fuels.

- **Sub-task 5.2**: Risk analysis of re-fuelling infrastructure.

- **Sub-task 5.3**: Safety study of CGH2 vehicles.

- **Sub-task 5.4:** Experimental test programme on hydrogen/methane/propane combustion.

- **Sub-task 5.5**: Comparative study of risk to health, safety and environment associated to hydrogen and other fuels.

Sub-task 5.1: Review of Hydrogen Safety Data.

Compilation of Existing Safety Data on Hydrogen and Comparative Fuels

Shell made a compilation of existing data on the safety of hydrogen and comparative fuels. The report reviewed the influence of the various physical properties of the fuels which may have an impact on safety, such as for instance: propensity to leak, flammability, ignition characteristic, sensitivity to detonation …

Factors making hydrogen safer

- Propensity to dissipate quickly.
- Relatively high LFL
- Low energy density

Factors making hydrogen less safe

- Wide flammable range.
- Low ignition energy
- Small quenching gap
- Propensity to detonate

Sub-task 5.1: Review of Hydrogen Safety Data.

Compilation of Existing Safety Data on Hydrogen and Comparative Fuels

- **Conclusion:**

concerning the explosion hazard, hydrogen can be safer than conventional fuels in some situations and more hazardous in others. The relative safety of hydrogen compared to other fuels must take into consideration the particular circumstances of its accidental release.

For the introduction of hydrogen as a retail fuel, quantitative risk assessment over the whole supply chain as well as the vehicle is needed.

Status - Work Completed

- ✓ Established Rapid Risk Ranking (RRR) method for H_2 filling stations
- ✓ Established Risk Acceptance Criteria for H_2 filling stations
- ✓ RRR analyses of 6 H_2 filling station concepts, including H_2 production
- ✓ Hazop analysis of H_2 filling station based on hydrogen production by water electrolysis
- ✓ NCSRD CFD H_2 gas dispersion calculations based on assumed hydrogen filling station layout and design geometry
- ✓ CFD calculations of H_2 dispersion and explosion inside electrolysis container

Sub-task 5.2: Risk analysis of re-fuelling infrastructure

Refuelling station concept analysed with RRR methodology	***Participants***
GH_2, production by water electrolysis	Hydrogen Systems, Shell, Air Liquide, DNV
GH_2, production by Methanol Steam Reforming	BP, Volvo, Norsk Hydro, Haldor Topsoe, Methanex, DNV
GH_2, production by Ammonia splitting	Norsk Hydro, DNV
GH_2, production by Natural Gas Steam Methane Reforming	Norsk Hydro, DNV
CGH_2, supplied from pipeline or truck	Air Liquide, Air Products, Volvo, BP, Hydrogen Systems, DNV, Norsk Hydro
Liquefied H_2, supplied from truck	Air Liquide, Air Products, Volvo, BP, Hydrogen Systems, DNV, Norsk Hydro

Some general findings (based on RRR)

- **Hydrogen gas releases is a main hazard:**
  - High pressures (large release rates)
  - Confined areas and explosion risk
- **Hazards associated with supply/storage of feed stock and H_2.**
- **Safety Measures should include, but not be limited to:**
  - Strict requirements to grounding systems.
  - Safety valves – ventilation to safe location.
  - Protecting dispenser against collisions.
  - Implementation of measures to reduce the risk of releases/ignition in confined areas (containers).
  - Gas leak, smoke, fire detection coupled to emergency systems.

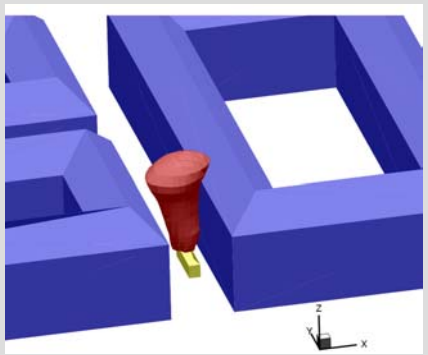
WP5.2 Work to be completed

- ✓ Quantitative risk assessment as input to
  - Safety distances
  - Classification of explosive zones
  - Acceptable risk outside refuelling station
- Technical information for a generic refuelling station will be based on information from WP2

- Results from WP5.2 Safety Studies will be input to Standardisation work in WP2 Refuelling Station.

Sub-task 5.3: Safety Study of CGH2 Vehicles.

➢ Develop an understanding of the dispersion and combustion of hydrogen in **realistic accident scenarios**.The following scenarios have been selected for **CFD calculations** :



NCRSD dispersion calculation

- ↗ Tunnels
- ↗1983 Stockholm Accident
- ↗ Bus accident in an inner city environment
- ↗ CNG
- ↗ Maintenance garage

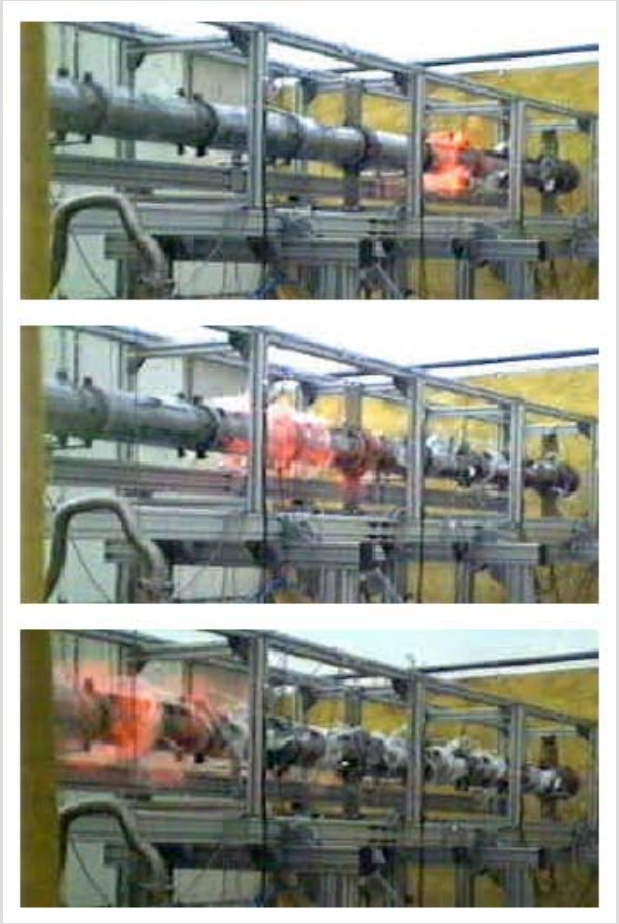
➢ Modelling of accident scenarios to form the basis of a consequence analysis to be used in a **wider safety study** of commercial vehicles (urban buses).

➢ Assist developing **safe components and systems** for use with hydrogen.

➢ Provide input to the continuing development of the **draft ECE regulation** for the use of CGH_2 in vehicles.

➢ Provide an **informed basis** for discussion with the authorities and public regarding the introduction of hydrogen as a commercial vehicle fuel.

Sub-task 5.4: Experimental Test Programme



- FZK has been performing **experiments** of gas combustion. Objectives of the tests include:
  - Study of **critical conditions** for strong Flame Acceleration and DDT in vented tubes and semi-confined geometry;
  - **Comparison** of explosion properties of hydrogen and typical hydrocarbon fuels in semi-confined geometry ;
  - Generation of the data necessary for **validation** of computer codes for simulation of gaseous explosions in semi-confined geometry.
- In the experiments fuel type, concentrations and geometrical configurations are varied in a way which covers **relevant scenarios**.

Sub-task 5.5: Comparative study of Risk to HSE

- DNV and EC-JRC will conduct an **overall comparative study of risk to Health, Safety and Environment** (HSE) associated to hydrogen and other fuels. The investigation will include the results from sub-task 5.1, 5.2, 5.3 and 5.4.

- Work to be undertaken in the **third year** of the project.