HyApproval

WP6 – Vehicle requirements

Safety During Refuelling

Deliverable 6.4

- PUBLIC -

Version: 0.1

31 August 2007

Scope

This document focuses on the safety requirements for the Liquid and Compressed Hydrogen Refuelling Process at Hydrogen Refuelling stations.

The purpose of this document is not to describe the vehicle homologation process or the design criteria for a Hydrogen Refuelling Station, but it gives an overview about the safety related measures during hydrogen refuelling.

The vehicle

Safety during refuelling depends on four effects:

1. The man
2. The hydrogen vehicle at the dispenser domain
3. The Hydrogen Refuelling Station
4. The refuelling process

1 The Man

The driver who initiates a refuelling of a hydrogen vehicle can not be a safety measure for the refuelling process.

For the driver of a hydrogen vehicle, the OEMs will train the drivers. The refuelling process should be described in the vehicle manual.

The main interface between vehicle and fuelling station is the driver. A driver must clearly understand and adhere to OEM instructions for properly and safely fuelling the vehicle. In addition, a driver shall follow all instructions and safe operating procedures posted by the station operator.

OEMs are uniquely positioned to educate, respond, and offer guidance to drivers during the vehicle initial orientation. An OEM shall deliver clear fuelling instructions in such a manner the OEM is comfortable with driver's ability to safely operate and refuel the vehicle, including guidance on general safety measures taken by station operators.

Each OEM is also positioned to identify distinct fuelling procedures related to its own vehicle. These procedures shall be reviewed during driver training and may include:

- A vehicle fuelling mode;
- Fuelling with communication between vehicle and station;
- Liquid or Compressed Hydrogen Storage System in the vehicle
- Pressure of hydrogen storage, e.g. 70MPa versus 350MPa;
- Vehicle shut down procedure systems, e.g. vehicle fuel filler door open;
- How to react in the event of an emergency.

1.1 Basic Training for driver

Driver shall follow the OEM instructions to prepare the vehicle for filling, including:

- Properly positioning the vehicle for fuelling;
- Following the proper instructions in the vehicle manual, (and any additional training approved by the OEM);
- Using the proper nozzle and/or dispenser

Divers shall be aware of the safety devices and procedures at the HRS:

- Emergency shut down (E-STOP), locations, how to activate;
- Hydrogen or fire detection system and/or fire suppression systems;
- In the event of an alarm, a leak (hissing sound), or fire, push the E-STOP (if possible) and leave the area.

1.2 Basic information provided by the station operator

Fuelling stations are operated by a variety of organizations, from local governments to traditional retail gasoline stations. Station operators shall ensure the following information is clearly delineated in a conspicuous manner:

- Clearly identified stations and dispensers (signs);
- Access procedures (private, public, or other);
- Fuelling procedure (clear steps via diagram and/or dispenser interface);
- Emergency stops (sign / posting);
- No smoking / open fire / electronic devices near dispenser (sign / posting);
- Do not leave fuel pump unattended when fuelling the vehicle (sign / posting);
- Do not let children operate the dispenser.

2 General Vehicle Safety

All hydrogen vehicles are build to meet the design criteria of the SAE 2578. The vehicle hydrogen storage systems are designed according SAE2579. Both standards are references SAE-, IEC-standards, EU directives, CMVSS, UL publications.

The following design considerations for the vehicle hydrogen storage system are accurately specified in the SAE-2579.

Consideration
DESIGN CONSIDERATIONS
• General Safety Features
Hazardous Material Exposure
Automatic Fail-Safe Fuel Shutoff
Management of Flammable Conditions
Over-pressure Protection
Thermal (Over-Temperature) Protection
Fault Monitoring
Crashworthiness
• Service Life Conditions
Pressure
Ambient Temperature
Fuel Quality
Shock and Vibration
Durability
• Material Selection
Hydrogen Compatibility
Liquid Fuel Compatibility
Thermal Conditions
Corrosion and other External Effects
DESIGN QUALIFICATION
• Compliance with Recognized Codes
• Performance Requirements
PRODUCTION PROCESS QUALIFICATION AND VALIDATION
• Quality Control Systems
• Process Verification
• Routine Production Tests (each unit produced)
• Periodic Production Tests (Batch/Lot Tests)
VEHICLE INTEGRATION
• SAE J2578 Specifications
• Labels
• Installation and Mounting
• Fuelling and De-Fuelling
• Discharge Systems
• Owner Guide or Manual
• Emergency Response
• Maintenance
• Service Life Limitations
REGULATORY APPROVAL

2.1 Scope

It is important to protect persons from hazardous conditions, where the fundamental hierarchy of vehicle system safety design is:

a. To protect vehicle occupants and the public from injuries that could result from the failures of components within the vehicle systems that support operation and/or as a result of damage caused by external events (e.g., collisions).
b. To protect vehicle occupants, general public, and service personnel from hazards associated with operation or servicing of the fuel cell vehicle (e.g., hazardous voltage, extreme temperatures, high pressure, and flammable or toxic fluids).
c. To minimize vehicle system damage caused by subsystem or component failures.

2.2 Design for Safety

The vehicle and associated subsystems should be designed with the objective that a single-point hardware or software failure should not result in an unreasonable safety risk to any person or uncontrolled vehicle behaviour.

2.3 Isolation and Separation of Hazards

Isolation and separation of hazards are approaches used to prevent cascading of failures and preclude unwanted or unexpected interactions. Ignition sources should be isolated from hazardous fluid systems.

2.4 Fail-Safe Design

The vehicle design should consider fail-safe design of electrical and hazardous fluid system controls. Automatic electrical disconnects should open and fuel shutoffs should close when deactivated. By so doing, any interruption of this control signal will cause isolation of electrical or fuel sources.

2.5 Bonding and Grounding

If hazardous voltages are contained within a conductive exterior case or enclosure that may be exposed to human contact as installed in the vehicle, this case should be provided with a conductive connection to the vehicle chassis.

2.6 Vehicle Bonding

Conductive components that are a part of the fill process (e.g., receptacle for nozzle, fill door) should have an electrical connection to the vehicle conductive structure.

2.6.1 Vehicle Interior Bonding

Interior component materials should be selected that do not promote static discharges.

2.6.2 Electrical Components Bonding

Components, which are located in hazardous areas or receive hazardous voltages from sources outside their conductive enclosures, should have conductive cases grounded either directly or indirectly through

the wiring harness.

2.7 Grounding to Fill Station During Refuelling

A means needs to be provided to have the vehicle ground plane at the same potential as the fuelling station prior to fill nozzle connection. A conductive path should exist from the vehicle chassis to common earth ground. The total resistance through the tires should not exceed 125 Megohms and the fuel receptacle should be bonded to the chassis. See SAE J1645 for recommended practices for minimizing electrostatic charges and their effects.

2.8 Fuelling

The fuelling location on the vehicle should be designed to prevent the accumulation of flammable gases and the ingress of foreign material. See SAE J2579 for guidance in the design of fuelling systems and SAE J2600 for nozzle and receptacle requirements for compressed hydrogen.

- If appropriate, the vehicle system should contain automatic systems to ensure that the vehicle traction system is de-energized and the vehicle is ready for fuelling.

- Vehicle should contain measures to prevent unintended movement. (e.g. park brake and gear leveller in P position)

- Vehicle shall meet the grounding requirements mentioned in Section 2.6 and 2.6

- Hydrogen Vehicles shall designed according SAE2578 and Vehicle Hydrogen Storage Systems shall designed according SAE2579

3 General Station Safety

The station design shall consider all design criteria to build an Inherent safe hydrogen Refuelling Station.

The available codes, standards and regulations shall be considered.

Measures for risk analysis e.g. HAZOP shall be done for the HRS

Fuelling stations are operated by a variety of organizations, from local governments to traditional retail gasoline stations. Station operators shall ensure the following information is clearly delineated in a conspicuous manner:

- Clearly identified stations and dispensers (signs);
- Access procedures (private, public, or other);
- Fuelling procedure (clear steps via diagram and/or dispenser interface);

- Emergency stops (sign / posting);
- No smoking / open fire / electronic devices near dispenser (sign / posting);
- Do not leave fuel pump unattended when fuelling the vehicle (sign / posting);
- Do not let children operate the dispenser.

3.1 Grounding

The refuelling station shall provide measures to enable the discharge of any charges from the vehicle to the ground.

Usually this will be secured by a conductive pas in the dispenser domain. The Value of the resistance shall be according the available regulations e.g. VDTUEV 510

If the conductivity of the pad is not sufficient, additional measures shall be installed. (e.g. ground wire)

3.2 Check for severe leakage

In case of a severe leakage, the filling station shall autonomously interrupt the fuelling process. The severe leakage shall be detected by the fuelling station itself.

- e.g. Hose break detection
- e.g. Hydrogen sensors
- e.g. Flow detection

3.3 Assure proper connection to the receptacle

A proper connection to the receptacle shall be checked by the fuelling station.

- e.g. Pressure pulse
- e.g. Leak test

3.3.1 Hardware Coding for CGH2

The dispensers of the available Pressure levels at the Hydrogen Refuelling Station have to be equipped with the appropriated Nozzle according to SAE J2600

3.4 Provide Breakaway Coupling

In case of a crash during refuelling or unintended drive away with attached nozzle, excessive leakage of the filling path shall be prevented by a breakaway coupling.

4 Process safety

The station shall follow the filling process as described in the deliverable 6.3 Refuelling Process.

The vehicle could not prevent to get refuelled. Therefore the HRS is full responsible to keep the vehicle hydrogen storage system in the operating limits and the station shall prevent over heat, over pressurized and overfill the HSS.

The vehicle might transmit data of its hydrogen storage system. The data should be taken by the HRS control system to optimise the refuelling process. In case of such a communication fill the HRS is still responsible to keep the vehicle storage system within the operation limits. Nevertheless if the vehicle data exceed the temperature and pressure limits, the HRS shall interrupt the refuelling process immediately

If the vehicle is not transmit data of its hydrogen storage system the station algorithm shall calculate the refuelling limits in a way to keep the vehicle storage system in the operation limits under all circumstances.

4.1 2. Keep HSS Temperature and Pressure within operating limits

To prevent over pressurization the station shall control the supply pressure to the vehicle hydrogen storage system. The station shall interrupt the refuelling process if the MAWP is reached.

In addition a pressure relieve valve is necessary as a hardware device to keep the vehicle hydrogen storage system in the design limits.

The station algorithm shall stop the refuelling process if the operating limits of the Hydrogen Storage System are achieved.

4.1.1 Compressed Hydrogen Storage System

- Stored Hydrogen Gas Temperature < +85°C
- Precooling Temperature > -40°C
- Density of stored Hydrogen < 40 g/l
- assure overfill- and overtemp protection for all ambient and vehicle conditions
- CaFCP/IrDa: use T and p signal to support calculation of fill level and Temperature supervision.
- CaFCP/IrDa: The HRS shall recognize fill commands submitted by the vehicle and react accordingly. E.g. the HRS shall stop if an abort signal is transmitted.

4.1.2 Liquid Hydrogen Storage System

- Refuelling of tanks with a MAWP between 2 and 10 bar
- Bi-directional refuelling (refuelling line and backgasline) shall be implemented

- Nozzles shall have a means to prevent the ingress of solid matter from upstream sources. For example, the requirement is met if the nozzle has a filter upstream of adequate size to protect its functionality.

- The Nozzle shall be protected against solid and liquid contamination when in parking position

- The nozzle shall be designed for flow rate through the filling pipe of up to 120g/s of liquid hydrogen.