EIGA

TECHNICAL BULLETIN

Prepared by WG-11

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Secondary Identification of H2 Vehicle at Dispenser

Introduction

Hydrogen vehicles are a growing alternative for mobility in various regions in the world and namely Europe. Refuelling infrastructure has been deployed in some countries and the EU Directive on Alternative Fuels is paving the way to establishing a network of refuelling stations to allow its citizens to own and use Fuel Cell Vehicles or FCVs throughout the entire European community. While those vehicles are scarcely deployed to date, interoperability standards govern already their design to ensure that connection to dispensers, quality of fuel and protocol for fuelling are common and suitable for all EC-79 approved vehicles . However, as various compressed gases (compressed natural gas or CNG, hydrogen or H_2) and nominal pressures are established for fuelling, the consequences of misuse are to be assessed across the whole alternative fuels market. In particular, it is identified that fuelling of a vehicle with lower service pressure than the selected dispenser poses safety concerns that are to be carefully addressed. It has also been observed recently that Hydrogen Refuelling Stations or HRS may be used to fill unknown vessels equipped with receptacles allowing them to connect to the dispenser's nozzle. This document discusses the degree of risk and mitigation that have been identified.

Rise of Hydrogen vehicles

In the 20+ years development of the hydrogen Fuel Cell vehicle technology, the storage tank pressure has increased from initial 25MPa to up to 70MPa with the aim to improve driving range. Those vehicles now provide satisfactory range for the targeted markets, and fuelling time is in line with equivalent gasoline based vehicles.

In the specific case of passenger cars, the range requirement has directed design towards storage pressure of 35 and 70MPa to be compared with 25 to 35MPa for natural gas. This has been standardised through the industry by joint industry effort and in particular by the Society of Automotive Engineers (SAE) with the development of refuelling protocol SAE J2601 and associated standards for vehicle design and interfaces.

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Risk analysis of existing systems

1. Vehicle pressure system design

In order to accommodate varying ambient temperatures as well as the heating effect that occurs during gas compression in tank vessels, hydrogen tanks are allowed to be filled to 125% of service pressure with a target settled pressure at 15°C. Thus, a 35 MPa hydrogen tank can be filled to about 44 MPa at 85°C.

The vehicles storage systems for compressed gas are designed in accordance with SAE J2579 for hydrogen and those define a minimum burst ratio of 2,25 times the service pressure.

The following table describes the maximum filling pressure and minimum associated burst pressure for the various fuelling pressures identified.

	H25	**H35**	**H70**
Nominal fuelling pressure at 15°C (MPa)	25	35	70
Maximum allowed fuelling pressure (MPa)	31	44	88
Minimum burst pressure (MPa)	56	79	158

Typically, the only pressure protection for the vehicle storage system is provided by the fuel dispenser. According to standards, protection such as relief devices should be set at the Maximum Working Pressure of the lowest rated device in the system and in any case shall be set no higher than 140% of the tank service pressure, or about 48 MPa for a 35 MPa dispenser in order to meet the fuelling protocols requirements. The vehicle storage tank is not equipped with any pressure relief devices that would activate to protect it from overpressure.

2. Potential consequences of misuse

Ffuelling a vehicle with the incorrect gas would create potential mechanical damage to the vehicle or propulsion system. This should be prevented but may not create a direct catastrophic event.

However, overpressure scenarios are more critical. The consequence of using a 70 MPa hydrogen dispenser to fill a 25 or 35 MPa hydrogen vehicle, any CNG vehicle, and virtually any industrial gas cylinder is likely to create an immediate safety hazard through leakage and/or the potential for catastrophic rupture.

Failure of a storage vessel has severe consequences. Modelling of the effects of a tank burst indicates a risk for multiple fatalities in the immediate vicinity of the vehicle . The identified zone for potential injury in case of burst at approximately 70 MPa would be as large as 50m radius.

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3. Existing Protection

In order to prevent the various mis-connection scenarios identified, a system of mechanically coded nozzles on the fuel station and mating receptacles on the vehicle has been established. ISO17268:2020 standard specifies the nozzle/receptacle geometries for hydrogen vehicles. These mating pairs are made unique for each Hydrogen Service Level such that a higher-pressure nozzle will not fit onto a lower pressure receptacle, nor can hydrogen or CNG nozzles mate to the wrong vehicle receptacle.

This mechanical system protection is such that it is theoretically not possible to lock an undesired nozzle onto a vehicle.

4. Misconnection examples

A number of scenarios have been identified that could potentially lead to misconnection at refuelling stations despite the protection currently in place:

- Incorrect receptacle installed on a vehicle: It is considered unlikely that a major vehicle manufacturer would deliver a vehicle with the wrong mechanically coded receptacle. However, these parts currently look similar and often use the same internal connections. With a growing number of new manufacturers and vehicles deployed, the potential for fitting an incorrect receptacle exist either during manufacturing or maintenance and repair.
- Incorrect nozzle installed on station: Similar to the above, it is conceivable that a mistake could be made during installation or maintenance at a station that would lead to an incorrect pressure nozzle being installed on the station.
- Adapters and custom-built systems: Proof of intended attempts of misconnection to hydrogen fuelling stations exist already in the early days of Hydrogen vehicles. Customers have been seen filling pressure vessels at refuelling stations where adapters and/or incorrect receptacles for lower pressure rated vehicle inadequate for 70 MPa have been used.

Misconnection can be a severe problem. This requires mitigation

Mitigation

A number of potential solutions exist to provide additional layers of protection against the misconnection risks. Some countries (e.g. Japan) are making a regulation for the HRS operator to check the validity of the tank before refuelling.

A communication device between vehicle and refuelling station offers a number of advantages for that matter.

Vehicle to station communication is currently in use on H70 and some H35 vehicles on the market. As of today, this communication consists of an Infra-red signal from the vehicle indicating the pressure rating of the onboard tank (H35 or H70), which provides a secondary means of confirmation that the vehicle being filled can accept 70 MPa hydrogen. This provides an additional level of protection against inadvertent installation of wrong componentry and makes it more difficult to purposely provide the wrong fuel pressure. In addition, the signal is

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currently used to provide information such as tank volume, gas pressure and internal gas temperature which help improve the state of charge fuelling as well as safety.
Other communication technologies are being introduced that would provide improved reliability and extend the benefits that could be obtained from using communication.

Recommendation

With the forecast of an increasing number of vehicles on the road in the future, the risk of unintended mistakes of intended misuse of vehicles or fuelling stations is significant and should be accounted for in risk evaluations. In particular, future vehicle fleets are likely to consist of a wide range of vehicles including motorcycles, cars, buses, and trucks. This increases the challenges of properly fuelling the vehicle and preventing misapplication by only using a limited number of nozzle/receptacle geometries.

Communication between vehicle and station has been demonstrated over the years in this application and is readily available on existing vehicles based on IR technology. It can provide a satisfactory secondary identification of the vehicle to be fuelled to prevent most mishandling scenarios.
While the design of such a system on station and vehicle sides need to be developed to meet the intent of a safety system, the EIGA, based on the experience of its members operating hundreds of HRS and refuelling hydrogen vehicles millions of times, recommends both:

- a mandatory implementation of communication as required by ISO 19880-1 for fuelling of hydrogen vehicles, and
- limiting the refuelling pressure to H35 pressure level in the absence of communication.

References

[1] REGULATION (EC) No 79/2009 on type-approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC (14 January 2009)

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