European Train the Trainer Programme for Responders

Lecture 7

Unignited hydrogen releases outdoors and their mitigation

LEVEL I

Firefighter

The information contained in this lecture is targeted at the level of Firefighter and above.

This topic is also available at level II, III and IV

This lecture is part of a training material package with materials at levels I – IV : Firefighter, crew commander, incident commander and specialist officer. Please see the lecture introduction regarding competence and learning expectations

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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Summary

Unwanted hydrogen releases are followed by the mixing of escaped gas with air, thus establishing the initial conditions for fire and explosion hazards. The unignited releases involve the escape of compressed gaseous hydrogen stored at high pressures at FCH systems and infrastructure.

Keywords

Unignited release, detection

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1. Target audience

The information contained in this lecture is targeted at LEVEL 1: Firefighter. Lectures are also available at levels II, III and IV: crew commander, incident commander and specialist officer.

The role description, competence level and learning expectations assumed at crew commander level are described below.

1.1 Roll description: Firefighter

A firefighter is responsible and expected to be capable of carrying out operations safely in personnel protective equipment including breathing apparatus using equipment provided, like vehicles, ladders, hose, extinguishers, communication and rescue tools, under any climatic conditions in areas and to emergency situations which can be reasonably anticipated as requiring a response.

1.2 Competence level: Firefighter

Trained in the safe and correct use of PPE, BA and other equipment which it is expected they will operate first responders must be supported by appropriate knowledge and practice. Behaviours that will keep them and other colleagues safe should be described by Standard Operating Procedures (SOP). Practiced ability to dynamically assess risk to self and others safety is required.

1.3 Prior learning: Firefighter

EQF 2 Basic factual knowledge of a field of work or study. Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools. Work or study under supervision with some autonomy.

2. Compressed hydrogen leaks

As it is already known from previous lectures FC vehicles are equipped with on-board hydrogen storage tanks pressurised up to 70 MPa, and a refuelling infrastructure operates at pressures up to 100 MPa [1]. Due to the small size of its molecule, hydrogen is prone to leakage. Predominantly hydrogen releases/leaks originate from valves and connections [2], which may occur both indoors and outdoors. The releases can be unignited (i.e. non-reacting) or ignited (i.e. reacting). Although a full-bore rupture of a pipe or vessel is a rare event, it should be considered as a credible worst-case scenario. Special efforts should be made to prevent the unwanted hydrogen releases. A release of hydrogen either through a PRD or from a pipe rupture will result in a high-pressure jet.

Table 1 summarises the types of leaks and equipment or components generating hydrogen leaks [3].

Table 1. Leak sources and scenarios developed by EIGA (2007) [3]

Equipment/component	Type of leak
Pipework	Pinholes, pipe split
Flange's	Gasket failure, thermal movement, material creep
Weld connection	Weld crack
Solder connection	Solder crack, solder melt
Union connection	Thermal movement, leak
Screw connection	Leak, sealant failure, creep, material split
Hose connection	Seal leak, material split, human error
Valves	Stem leak, seal leak, bonnet/housing split opened by impact
Hoses	Perforation split
Instruments	Element rupture
Regulators	Diaphragm rupture, seal leak, downstream rupture (overpressure)
Solenoid valves	Seal leak
Pumps	Perforation, seal leak
Cylinder	Perforation, rupture, permeation leak

3. Blow-down of a compressed hydrogen storage tank

A CFD study carried out by Li et al. [4] demonstrated that:

- for unignited hydrogen releases from storage tanks pressurised to 35 MPa and 70 MPa, the longest hazard distances occur within 10 s after the opening of the TPRD and the duration of the hazards associated with the release of hydrogen is less than 2 min;
- the deterministic hazard distances for unignited hydrogen releases from a TPRD, orientated vertically downwards under a FC car, are significantly shorter than those of free jets;
- for both the members of the general public and Responders not equipped with the thermal protective clothing maximum hazard distance from unignited release ranges from 8 to 12 m depending on storage pressure;
- to ensure that the concentration of hydrogen is always less than LFL (4 vol. %) at the location of the air intake of buildings, the hazard distance should be at least 11 m for 35 MPa releases and 13 m for 70 MPa releases.

4. Detection of hydrogen leaks

It is also important to know that in hydrogen safety technologies sensors do not provide a complete detection strategy due to the buoyancy and diffusivity of hydrogen. For example, a hydrogen sensor will be of little use in a large enclosure or outdoors. The placement of sensors should be carefully considered and tools such as CFD may be used to simulate leak scenarios to provide insight into sensor positioning. Both fixed location and personal/hand-held monitors are necessary for the protection of personnel and facilities.

The suggested positioning of hydrogen sensors is detailed below:

- locations where hydrogen leaks or spills are possible;
- at hydrogen connections that are routinely separated (for example, hydrogen refuelling ports);
- locations where hydrogen could accumulate;
- in building air intake ducts, if hydrogen could be carried into the building;
- in building exhaust ducts if hydrogen could be released inside the building.

There are also requirements to fit hydrogen sensors on FC vehicles to warn about potential leaks. Hydrogen detectors locations for Fuel Cell Electric Vehicle (FCEV) are marked as blue dots on Figure 1 and include [5]:

- exhaust pipe (process control) ;
- passenger cabin (safety) ;

- engine (safety) ;
- fuel Cell stack (safety).

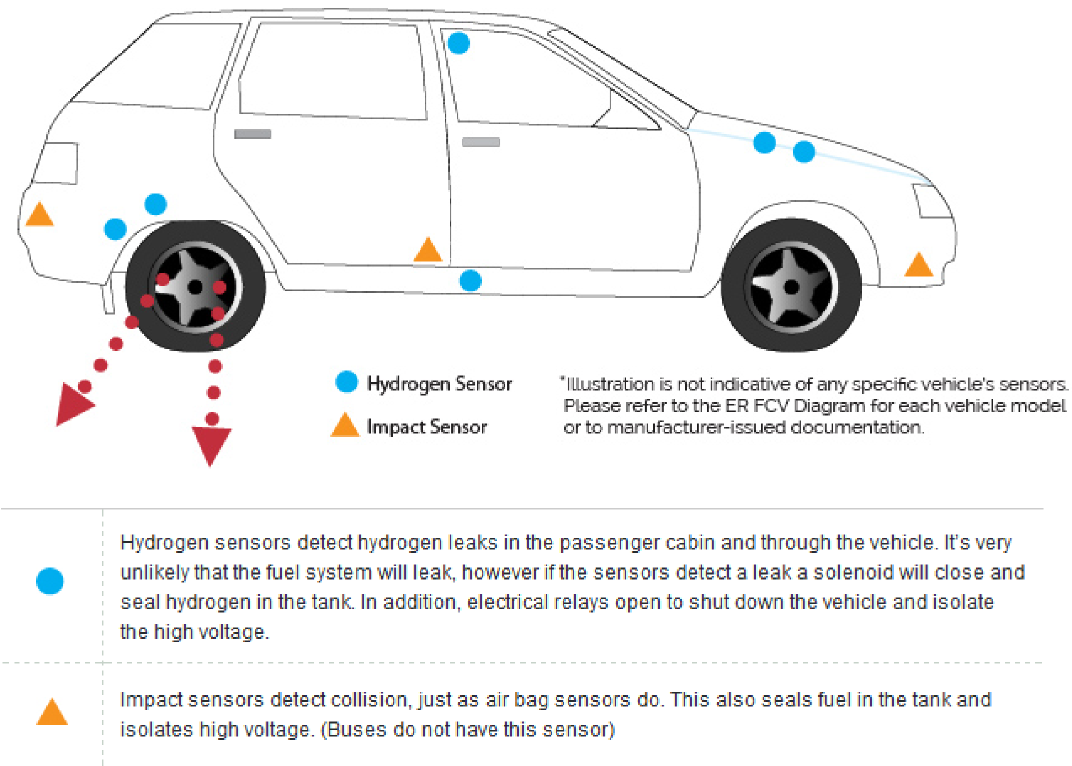

Figure 11 Possible location of hydrogen sensors in a FCEV [5].

Acknowledgement

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