HYTUNNEL - Internal Project on Tunnel Safety

Work package /project number	19			**Start date or starting event:**	month 14		
Activity type	Internal Project **(PHASE 1 only)**						
Participant ID	BMW	BRE	NCSRD	GexCon	JRC	UNIPI	UPM
Person-months per participant	2	2.5	1	1.9	0.5	0.3	2
Participant ID	Volvo	WUT	INASMET	FZK	FZJ	TNO	UC
Person-months per participant	1.25	1	1	1.5	0.5	0.5	0.5

Abstract

The Phenomena Identification and Ranking Table (PIRT) exercise has highlighted that hydrogen powered vehicles in the confined space of a tunnel could pose a serious hazard of fire and explosion to the tunnel and its users. The PIRT exercise has also identified a number of scenarios associated with the use of such vehicles in a tunnel. It is therefore crucial that to ensure the safe introduction of hydrogen-powered vehicles into the tunnel traffic, these scenarios are properly understood and their hazard and risk assessment carried out in relation to the conventional fuel powered vehicles. The distribution and mixing characteristics of hydrogen, and the resulting potential development of fire and explosion, under normal and emergency modes of operation of tunnel ventilation, needs to be understood. The appropriate risk assessment strategies and adaptation of safety concepts of existing tunnels will then have to be devised. For future tunnel construction, design requirements need to be determined, aiming at a synchronous advance of vehicle and infrastructure technology. Where possible, the study is intended to address various mitigating design measures, hydrogen flow rates, combustion speeds, pressure loads, and ignition times and locations.

A systematic approach to achieving the goal of the safe introduction of hydrogen powered vehicles in tunnel starts with a state of the art survey of tunnel safety technology. Current regulations and standards, and currently available fire and explosion mitigation techniques, need to be investigated. Worst-case accident scenarios involving hydrogen-powered vehicles or fuel supply trucks will then be identified. This will be an extension to the PIRT exercise already completed, but focussing now on specific tunnel hazards.

Previous experimental and numerical modelling work will be reviewed, and a recommended programme of further activities, experimental and modelling, produced. Numerical modelling (CFD etc) will be undertaken in support of experimental design and/or as part of the SBEP activity (WP3).

In Phase 2 of HYTUNNEL, to be undertaken in the period covering months 31 to 48, tunnel experiments will be conducted accompanied by ‘blind’ and ‘open’ numerical simulations to establish the validity of different modelling approaches. Experiments would build upon previous work, e.g. project such as EIHP, while the modelling activity would be integrated into the SBEP and CFD Club activities. Furthermore, guidelines addressing hydrogen related vehicle and tunnel safety will be developed, and will be forwarded for consideration by bodies such as UNECE WP29 and the European Commission.

Objectives

Technical objectives

- To review current regulations and standards (covering the broad European view) and fire and explosion mitigation techniques in current and planned tunnels; and to assess them with standards and guidelines produced under other EC funded projects (HYAPPROVAL, HYCOM, HYGUIDE etc).

- To review accident scenarios for hydrogen-powered vehicles and hydrogen fuel supply trucks inside tunnels.
- To understand the distribution and mixing characteristics of hydrogen inside tunnels, and the potential development of fire and explosion hazards under normal and emergency modes of tunnel ventilation (considering longitudinal, transverse and semi-transverse ventilation). Consideration will be given to the influence of existing or future mitigation measures. Particular attention will be given to any release or tunnel characteristics that can lead to high speed deflagrations or DDT.
- To review previous performed experimental and numerical modelling work of relevance to hydrogen releases and subsequent fire/explosion risks inside tunnels.
- To undertake numerical (CFD, network etc) simulations and verification experiments to study the relative risk posed by CG2/LH2 powered vehicles compared to conventional fuelled vehicles, and to establish the validity and correct use of the numerical models. This objective will be addressed primarily in the period covering months 31 to 48 (Phase 2 of HYTUNNEL).
- To develop guidelines for tunnel and vehicle safety systems to counter the hazards associated with the release of hydrogen.
- To develop a road map for the introduction of the guidelines to the appropriate forums for introduction to appropriate legal requirements, etc.

Scenarios

The PIRT exercise has identified some critical scenarios associated with the safe use of hydrogen-powered vehicles in tunnels. This work needs now to be refined, and there is a need to distinguish between GH2 & LH2, as the behaviour of the released hydrogen in the early stages of the release will be very different, i.e., the buoyant gas from a GH2 release will contrast with the much denser cold gas in the early stages of a LH2 release. The quantity of hydrogen involved in commercial vehicle accidents may be significantly larger than for passenger cars, and different release points may affect the behaviour of the released hydrogen especially in the confined environment of a tunnel. Liquid hydrogen spill from rupture tank could cause ice to develop on the road, causing increased risk of collision of the incident vehicle with other vehicles. The wide flammability limits of hydrogen could pose a serious fire and explosion hazard, which could lead to the potential risk of fire spread from one vehicle to another. Some potential scenarios are identified below:

- A low pressure/small quantity release (resulting from system damage or component failure caused by a traffic accident, component failure, vandalism etc., or by routine fuel-cell purging)
- A high pressure/large quantity release (resulting from system damage or component failure caused by traffic accident, component failure, bullet, vandalism etc)
- A vehicle (CG2, LH2) crash / overturn / failure leading to damage to the fuel tank.
- A catastrophic failure of the storage system in a tunnel.
- A container failure, which could have a low probability due to various design features and safeguards, but may have high hazard consequence.
- A release via a pressure relief or safety device (this may be unintentional, i.e. component failure, or intentional, i.e. in the event of a fire to avoid failure of the pressure or cryogenic vessels).
- A fire in a tunnel (caused by the burning of hydrocarbon fuel or other non-hydrogen commodity) which then provides thermal loading on the hydrogen vehicle(s).

Description of work

PHASE 1
Sub-task 19.1: Review regulations, standards and practice in selected countries
Sub-task 19.2: Review and agree on specific accident scenarios and the scope of work
Sub-task 19.3: Review related modelling and experimental work to date, e.g. EIHP, FZK and US CNG work.
Sub-task 19.4: Develop a road map for further activities
Sub-task 19.5: Undertake numerical (CFD) simulations in support of experiment design and also 'blind' predictions as part of a SBEP problem (if selected by WP3).

PHASE 2 (for period covering months 31 to 48)
Sub-task 19.6: Blind numerical simulations (continued) against existing experimental data and against data obtained in new experiments.
Sub-task 19.7: New experiments to study hydrogen tunnel hazards and provide data for numerical model validation.
Sub-task 19.8: Open numerical simulations to provide insight into anomalies/inconsistencies between predictions and experimental data from the new experiments.
Sub-task 19.9: Develop guidelines for the safe introduction of hydrogen powered vehicles in tunnels
Sub-task 19.10: Develop a road map for the introduction of the guidelines.

Deliverables

D49. HyTunnel Activity Report (month 22) including the review of regulations, standards and current practice.
D62. HyTunnel Activity Report (month 29) including the review of previous experimental and modelling activities relevant to hydrogen hazards in tunnels.