Car parks ventilation in the case of vehicle hydrogen release

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ABSTRACT
New fuels used for the vehicles, especially hydrogen gas, are very efficient and offers even three times higher combustion energy compared to gasoline. But on the other hand they introduce new hazards. The biggest danger related with them could be an accidental gas release from a car's installation, especially occurred in the underground car parks. The paper presents possible incident scenarios and the hazard mitigation methods, especially concentrated on different ventilation systems.

INTRODUCTION
The standard basic considerations for the safety of hydrogen systems [1] gives 11 general recommendations to minimize the severity of the consequences of a potential hydrogen release in a confined spaces. Some of them could be relevant to the enclosed car parks, where hydrogen fueled cars are expected. These are mostly:
• prevention of hydrogen-oxidizer mixtures from accumulating in confined spaces (under the eaves of roofs, in equipment shacks or cabinets, or within equipment covers or cowlings);
• using of alarms and warning devices (including hydrogen and fire detectors);
• natural or mechanical ventilation systems.
The most difficult of the above for correct implementation are the ventilation systems. In accordance with the standard [1] considerations for ventilation should appropriately address the scenario of release from the vehicle tank. It is expected that the ventilation system should remove hydrogen from the confined space or at least keep its concentration below the appropriate lower flammability limit. As it is visible on the base of the synthesis, the conventional requirements for hydrogen ventilation systems are not detailed and allow different technical solutions, which can give their different efficiency.

METHOD AND RESULTS
During hydrogen emission in a car park several scenarios are possible. Fig. 1 presents the event tree used for derivation of possible incident scenarios. As the initiating event, the continuous release of hydrogen from a tank is taken into account, with ten different outcomes considered. It is clear that an explosion is the worst-case scenario and can be expected in two situations, shown in the black lines on the event tree. An important and influential parameter is the ignition source (for example, hot elements in the garage). This can occur when a ventilation system does not work, and this can happen when there is a lack of detection and ventilation systems. More accurate analyses of the presented scenarios would be undertaken through CFD simulations. Through the use of simulations, it became possible to see the influence of ventilation on hydrogen dispersion in a car park. As a first step of calculations a validation of the FDS software, used for the modelling is presented. It is realized by comparison of the experimental [3] and simulation results. Figs. 2 and 3 confirm that the increase of hydrogen concentration in the CFD simulation occurs very similarly to the experimental result. After the positive FDS validation results, the program would used for verification of different ventilation solutions (mechanical and natural with a different efficiency, based on the preliminary hand calculations) in a real scale car park space.

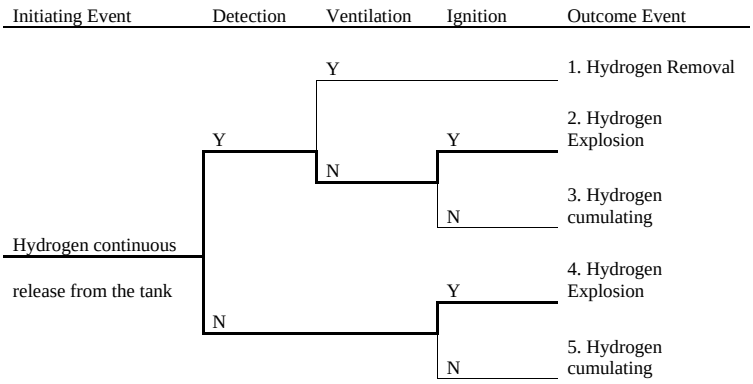

Figure 1. Event tree used for the derivation of possible incident scenarios.

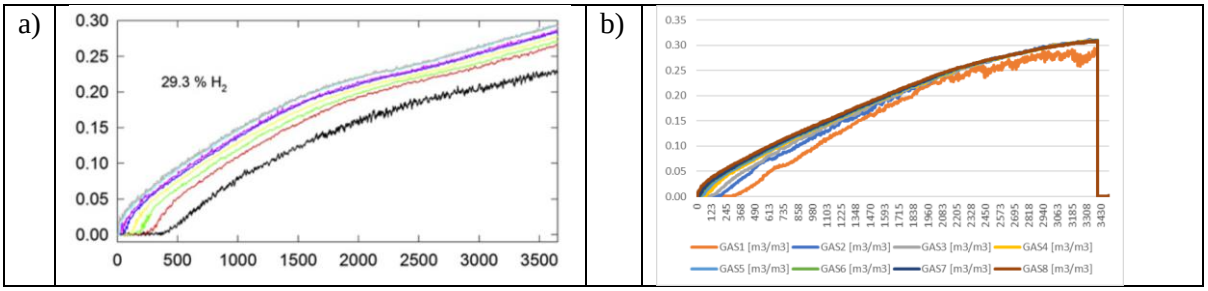

Figure 2. Hydrogen concentration increase a) experiment, b) CFD.

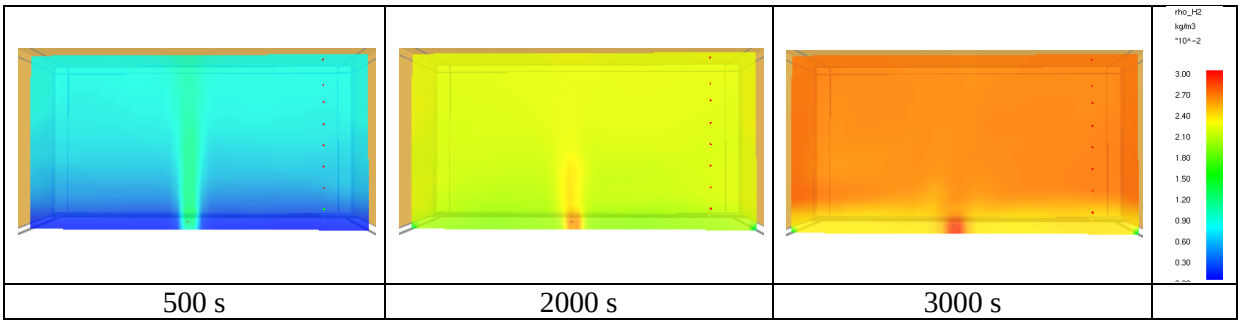

Figure 3. Hydrogen concentration increase in time.

CONCLUSIONS

The CFD analyses confirmed that, in non-ventilated garage, a high explosive hazard could be expected, and each ventilation system can give a different level of efficiency in hydrogen removal. However, all of them kept the hydrogen concentration below 20% of lower explosive limit (LEL). The most effective solution appeared to be the natural ventilation system with an exhaust opening in the ceiling of the garage. The full paper will present series of simulation results for different ventilation system solutions in a real scale car park, in the case of hydrogen tank lekakage.

REFERENCES

1. British Standard PD ISO/TR 15916:2015 Basic considerations for the safety of hydrogen systems.
2. D. Brzezińska, Ventilation System Influence on Hydrogen Explosion Hazards in Industrial Lead-Acid Battery Rooms, Energies 11 (2018); DOI: 10.3390/en11082086.
3. W. Pitts, J. Yang, M. Blais, A. Joyce, Dispersion and burning behavior of hydrogen released in a full-scale residential garage in the presence and absence of conventional automobiles, International Journal of Hydrogen Energy, 37 (2012) 17457-17469