fact sheet

Support Facilities for Hydrogen-fueled Vehicles: Conceptual Design and Cost Analysis Study

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Driving for the future

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Summary
California Fuel Cell Partnership members are beginning to place limited numbers of fuel cell vehicles and hydrogen fueling stations into communities for the purpose of advancing their use in real-world conditions. The members are working together with the CaFCP to facilitate these placements, and to demonstrate the ability of fuel cell vehicles to meet consumer requirements. Among the steps to successful commercialization is the availability of supporting infrastructure, including the safe housing and servicing of hydrogen fuel cell vehicles (HFCVs).

To that end, the CaFCP commissioned a comprehensive study to examine practical facility designs for housing and servicing HFCVs, from vehicle maintenance facilities to enclosed parking structures and residential garages. The CaFCP sought to better understand how current design and construction practices relate to the accommodation of HFCVs parked in enclosed buildings, and what potential modifications and incremental costs may be necessary. In particular, the study considered how facilities that are designed to meet current code requirements for compressed natural gas vehicles might need to be modified to accommodate hydrogen-fueled vehicles.

Background
The study began in April 2002 and concluded in May 2004. Parsons Brinckerhoff, a global planning, design and construction management firm, conducted the study with support from a team of experts in alternative fuel vehicles and hydrogen properties. Industry and government organizations provided valuable expertise on FCVs and hydrogen. To ensure the study's applicability, the assumptions and results were reviewed with local fire officials.

The study provides the results of several hydrogen leak scenarios for hydrogen-fueled vehicles housed within four facility types:
1) Commercial multi-story above-ground parking
2) Commercial multi-story below-ground parking
3) Commercial maintenance/repair facilities
4) Residential, two-vehicle garage.

For each case study, a baseline building design was developed incorporating functional requirements and current, applicable building codes. Dr. Michael Swain, of the University of Miami, utilized a modeling method – known as Computational Fluid Dynamics (CFD) -- to visualize and analyze various hydrogen leak scenarios for a vehicle in a facility.

Assumptions

The approach and assumptions applied to the four case studies were based on thoroughly investigated physical properties of hydrogen, including its diffusion properties and flammability range; vehicles designed to Society of Automotive Engineers (SAE) recommended practices, which include provisions for safety systems onboard the vehicle designed to detect and limit leaking hydrogen in certain conditions; climate conditions simulating the California environment; and consumer-level users.

Modeling scenarios assumed a 5-passenger sedan with a gaseous hydrogen tank at 10,000 psi (~700 bar), holding 6 kg of hydrogen. Given today's technology, this amount of fuel is sufficient to obtain driving ranges comparable to a conventional gasoline fueled vehicle. The hydrogen fuel storage system contained a number of safety features such as pressure relief devices and emergency shut-off valves. Additionally, the scenarios assumed a vehicle with four hydrogen sensors on board, one located within each wheel well.

Conclusions

A review of existing and potential codes and standards did not result in major additional hydrogen-related recommendations for the facilities. For example, open parking structures, due to high air circulation rates, were shown as unlikely to allow the accumulation of combustible hydrogen mixtures under the assumed leak scenarios. Underground garages already require high air circulation rates to protect against the accumulation of carbon monoxide.

CFD modeling results revealed that in all four case studies a flammable concentration of leaking hydrogen did not extend beyond two feet immediately surrounding the vehicle. In parking and maintenance facilities, typical airflow (from natural or mechanical ventilation) resulted in dilution of leaking hydrogen to lower than the lowest flammable concentration levels. In cases with low ventilation, model results showed leaking hydrogen spreading quickly to the wheel wells where it would be detected by hydrogen sensors, and leak control could be automatically enacted to activate shut-off valves at the fuel tank.

While the study cautions that its results should be taken in the context of pre-commercialization of fuel cell vehicles and still-developing codes, standards, and regulatory schemes, the results nonetheless suggest that facilities compliant with today's codes may accommodate HFCVs without further modification even in the unlikely event of a relatively large

hydrogen leak. The study further identifies the important role that preventive measures integrated into the vehicles can play in reducing the hazards associated with a hydrogen leak.

The study also examined additional facility safety measures, such as hydrogen detectors placed in the facility that could be installed at a premium cost. However, verification of any potential benefits these safety measures might offer would require additional modeling.

To read the complete report, please visit the California Fuel Cell Partnership's website: www.cafcp.org. For more information about hydrogen safety and fuel cell vehicles, the following organizations and websites may be of interest:

- National Hydrogen Association – www.hydrogenus.com
- Parsons Brinckerhoff – www.pbworld.com
- "Fuel Leak Simulation", Dr. Michael Swain (University of Miami) - http://www.eere.energy.gov /hydrogenandfuelcells/pdfs/30535be.pdf
- National Renewable Energy Laboratory-supported site – www.fuelcellstandards.com
- International Code Council – www.iccsafe.org
- National Fire Protection Association – www.nfpa.org