Proposed Vehicle-level Bonfire Test for Hydrogen-fueled Vehicles

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Outline

- NHTSA H_2 R&D Plan
- High Pressure Cylinder tests
  - FMVSS 304 for CNG
  - Hydrogen burst test
- Proposed Vehicle System-Level Test
- Other Topics
  - Fuel System Integrity (FMVSS 301)
  - Pressure Relief Device Standard
  - Hydrogen Leaks Inside Buildings
- Conclusions

NHTSA 4-Year H2 Vehicle R&D Plan

- Available at www.nhtsa.dot.gov
  - Click on Docket Management System
  - Do simple search on 18039
  - Download document 3
  - Comments from MVFRI are document 5
  - Comments were desired by Oct 12, but you can still submit if you wish

NHTSA 4-Year H2 Vehicle R&D Plan

- R&D Tasks include
  - Component level testing
  - Onboard refueling system performance testing
  - Full vehicle performance testing
  - Corporate Average Fuel Economy (CAFE)
  - International Harmonization of codes and standards

NHTSA 4-Year H2 Vehicle R&D Plan

- Major Comments
  - Determine leak limits by experiment – not by selecting same energy release rate as gasoline
  - Improve FMVSS 304 bonfire test
  - PRDs also need a standard
  - Gather accident data on NG & H_2 vehicles
  - Tanks may be weaker in crashes at less than full pressure

High Pressure Cylinder Tests
(FMVSS 304)

- Bonfire test is routinely done for CNG
- A similar test has been drafted for H2
- Bare tank and PRD are exposed to bonfire for 20 minutes. Must either:
  - Remain intact, or
  - Vent safely
- Problems
  - Fire not well specified – just temperatures under tank
  - PRD must be shielded from direct flame impingement

304 Test on CNG tank

FMVSS 304 - Conclusions

- Tank Burst is very energetic
  - Mechanical energy is released in milliseconds
  - Unacceptable to have tank burst
  - PRD *must* work
- 304 is mainly a PRD test – not a tank test
  - No modern composite tank will last for 20 minutes

Hydrogen Burst Test

- Goals:

(1) to study the temperature and fire resistance of the tank and the temperature and pressure its contents prior to burst

(2) to determine the characteristics of the energy release from a fire induced burst

- Performed 304-like test w/o PRD

Instrumentation

- Tank internal temperature and pressure
- Exterior temperatures
- Blast pressures at 4 locations
- Visual and IR video

Burst Test

Burst Test Conclusions

- Temperature and pressure inside tank increased a negligible amount
  - Temperature up 20 C
  - Pressure up 200 psi
- Largest fragment (14 Kg) landed 270 feet away
- 43 psi overpressure at 6.3 feet
- 6 psi overpressure at 21 feet

Burst Test Conclusions

It is unacceptable for a H2 tank to burst!!

The PRD valve must work!

Conclusions (continued)

- Successful operation of PRD is a system-level issue
  - Number and location of tanks
  - Plumbing
  - Number and location of PRDs
  - Redundant PRDs?
  - Sizing of vent lines
  - Shielding and insulation of tanks
- A bare tank with a single PRD does not simulate a real vehicle

System-Level Bonfire Test

- Europeans require bonfire test on plastic fuel tanks – ECE R-34 Annex 5
- Test is not required in the US, but most tanks sold in US are qualified with this test

ECE R-34 Test

- Whole vehicle or buck used
- Tank is filled 50% with gasoline
- Exposed to gasoline pool fire
  - One minute at full heat flux
  - One minute with ceramic screen which cuts heat flux
- The tank “passes” if it survives for 2 minutes of exposure

ECE R-34 Test on Vehicle

Observations

- Tank “passed” the test at 2 minutes
- Tank failed 7 seconds later
- Two minutes may be long enough for an uninjured person to escape
  - It is clearly too short if the occupant needs to be extricated

Proposed System Level Test for H2

- Composite hydrogen tanks are plastic
- Why not apply something similar to European test?
- It tests the whole system
- It is independent of the hydrogen storage technology
  - Compressed gas
  - Liquid Hydrogen
  - Hydrides

Modifications

- Replace gasoline pool fire with a propane planer flame – diffused through sand
  - Easier to control
  - Less air pollution concern
- Exposure duration ?
  - Suggest 20 minutes like FMVSS 304
  - Must either vent safely or stay intact

Future Work

- Issue to study
  - Passenger compartment may become untenable well before 20 minutes
- Debug the test procedure
- Recommend to NHTSA

Allowable Leak Rate for Hydrogen
(FMVSS 301 modified for H_2)

- 301 allows 1 ounce per minute of gasoline
- Set at lowest level practical to measure
  - *Not* determined by flame spread tests
- Some propose H_2 leak rate to give same energy release rate as gasoline
- Could measure smaller leaks with H_2, but
- Larger leaks may be acceptable
- Better to base on untenability experiments

H_2 PRD Draft Standard

- Available from CSA-America julie.cairns@csa-america.org
- Major Comments
  - Activation time may need to be faster
  - Document the rationale for all numbers
  - Vendors should have Quality Plans also
  - Mark distinctly from NG PRDs

Parsons-Brinkerhoff Facility Study

- Available at www.cafcp.org
- Assumptions
  - 4 types of parking facilities
  - H_2 leak at 20 CFM
  - Wheel well sensors will shut off supply
  - No ignition sources within 2 feet of vehicle
- Results
  - No special ventilation required
  - “None of the recommendations in this report are ready for implementation”

Facility Study (continued)

- Major Comments
  - Need to consider PRD release scenarios and leaks upstream of the pressure regulator
  - There are ignition sources in and around the vehicle
  - Need independent validation and documentation of computer simulations

Conclusions

- A vehicle-level bonfire test has been proposed
- Base post-crash allowable leak rate on flame spread tests – not gasoline equivalent energy
- Improvements to PRD standard are suggested
- More research is needed on H_2 leaks in buildings