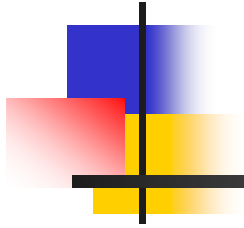


CRASH-INDUCED FIRE SAFETY ISSUES WITH HYDROGEN-FUELED VEHICLES



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OUTLINE

- WHAT IS MVFRI ?
- CURRENT FIRE PROBLEM
- REFERENCE VEHICLE
- POTENTIAL FIRE SAFETY ISSUES
- CANDIDATE RESEARCH TASKS
- CONCLUSIONS – NEXT STEPS



MOTOR VEHICLE FIRE RESEARCH INSTITUTE

- Non-profit organization
- Funded by GM from settlement
- Approximately \$4M over 3 years
- Crash-induced fire research
- Automobiles and light trucks



CURRENT FIRE PROBLEM

- Fire in 2.9% of fatal crashes
- Fire rates have decreased 70% since 1980
- 328 fatalities where fire is “Most Harmful Event” (out of 42,000)



CURRENT FIRE PROBLEM (cont'd)

- 51% of fires from frontal crash
- 6% of fires from rear crash
- Fires only occur in 20-25% of leaks
- 85% have electrical ignition source
- Occupant escape times
 - Rear pool fire – ca 2-3 minutes
 - Frontal/underhood fire – ca 10 min.



REFERENCE VEHICLE

- Compressed Hydrogen/Fuel Cell/Battery Hybrid
- Also briefly discuss:
 - Liquid Hydrogen
 - Hydride storage
 - Reformer



POTENTIAL FIRE SAFETY ISSUES

- Safety Standards for H₂ vehicles
- Fire progression pathways
- Electrical fire sources
- Hydrogen release issues
- Countermeasures



SAFETY STANDARDS

- FMVSSes from NHTSA/DOT
- 301, 302, 303, 304, 305
- Manufacturers frequently test to higher standards and additional standards
- Hydrogen standards from non-governmental organizations



FIRE PROGRESSION PATHWAYS

- H2 leak/ignition source/ignite plastic and other materials/passenger compartment
- Frontal crash/electrical fire/underhood fluids and plastics/vehicle engulfed/H2 fuel tank rupture/passenger compartment
- Pool fire from another vehicle/H2 tank exposure/rupture/passenger compartment
- Many others



ELECTRICAL FIRE SOURCES

- Current fires 85% electrical
- Frontal crashes
- Carbon tracking, arcs, and shorts
- Flammable underhood fluids and plastics
- Progression pathways
- FC/H2 vehicles are essentially EVs (ca 300 volts)
- Assume there are plenty of ignition sources

UL Carbon Tracking test



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HYDROGEN RELEASE ISSUES

- Crash forces and exposure to fire
 - Tank
 - Regulators
 - Fuel Lines
 - Hydride device
 - Reformer
 - Fuel Cell
- Regulator failures
- Venting from various sources
- Mechanical energy from tank rupture

Quantum Tank Cutaway



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SwRI CNG pool fire test



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CANDIDATE RESEARCH TASKS

- Vehicle buck ignition and flammability tests
- Sled test for bare tank and regulator
- Pool fire test
- Self-Ignition experiments
- Low-cost hydrogen sensors
- Debris shields



VEHICLE BUCK IGNITION AND FLAMMABILITY TESTS

- Accurate plumbing configuration
- Controlled H₂ releases
- Various ignition sources and placements
 - Hot wires
 - Electrical arcs and sparks
- Flame propagation to materials



SLED TEST FOR BARE TANK

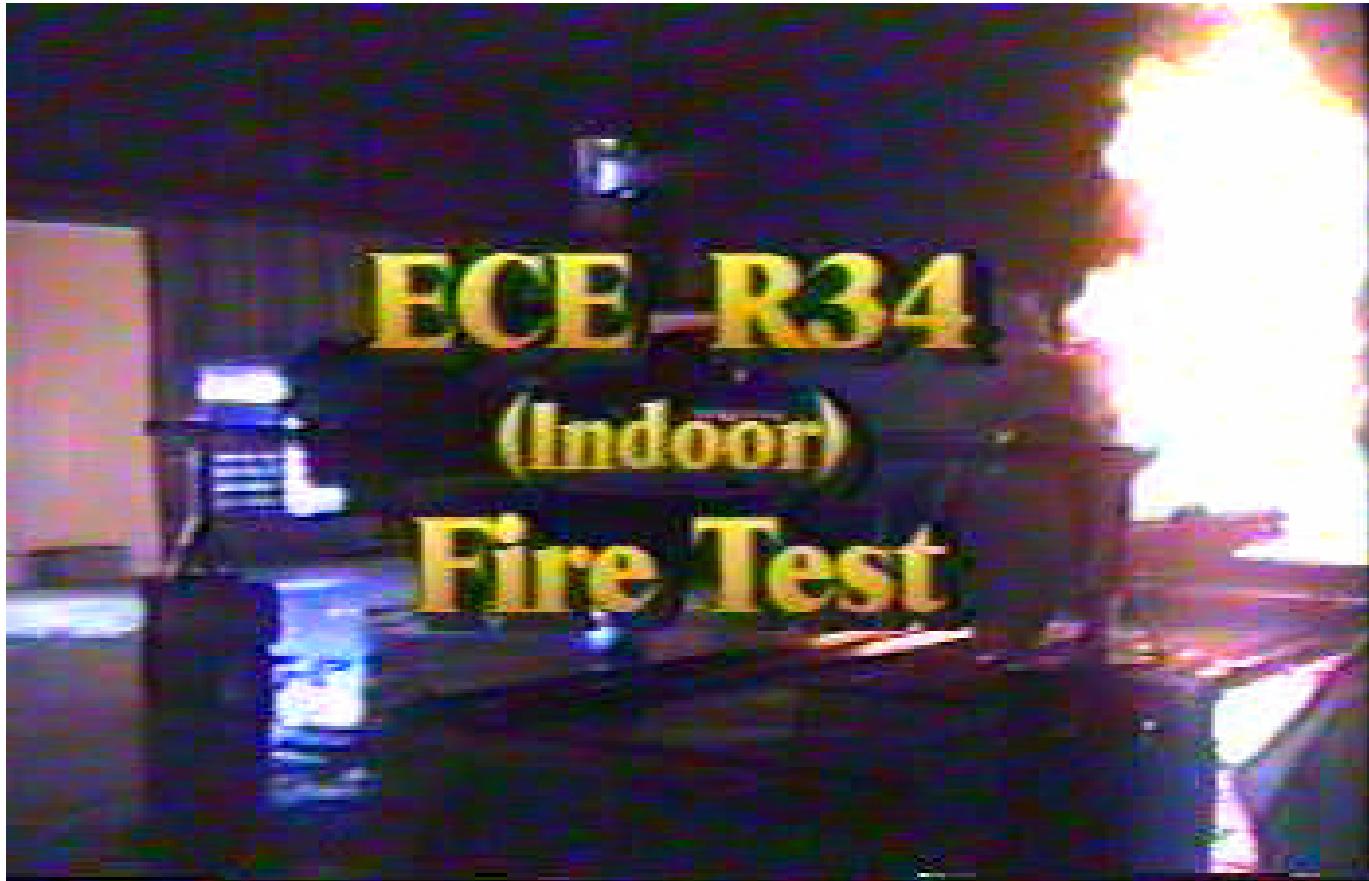
- Tank stationary
- Include regulator and all plumbing exposed to high pressure
- Moving barrier (3000 pounds at 50 mph?)
- More repeatable
- Less expensive



POOL FIRE TEST

- Use vehicle buck
- Get flame flow right
- Consider the ECE R-34 type of test
 - Exposure duration?
- Verify correct operation of pressure relief device

SwRI ECE pool fire test



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SELF-IGNITION EXPERIMENTS

- Flow conditions for self-ignition
 - Vent design
 - Intermediate and low pressure line leaks
 - Flow rate
 - Particulate load
- Should design for self-ignition



LOW-COST HYDROGEN SENSORS

- Sensing may be desired to control active ventilation and to warn driver
- Current sensors are too expensive
- Prefer response to hydrogen only



DEBRIS SHIELDS

- Protect tank and plumbing from impacts from road debris
- May affect tank heating from pool fire
- Could adversely affect PRD operation



CONCLUSIONS – NEXT STEPS

- Hydrogen cars could be more or less safe than conventional
- There are special safety issues
- Please review suggested research tasks
 - Add things I have missed
 - Tell me if the work has already been done
 - Tell me if the work is not needed



CONCLUSIONS – NEXT STEPS (cont'd)

- Send feedback to: rodys@earthlink.net
- We will interact with DOE, NHTSA, and USCAR
- MVFRI has not yet decided to fund anything in this field
- Visit www.mvfri.org
 - See the currently funded tasks
 - Links to the GM-funded fire research