

A Research Program to Study Impact Related Fire Safety

Kennerly Digges & Rhoads Stephenson

Motor Vehicle Fire Research Institute
(www.mvfri.org)

Presentation Outline

- Who is MVFRI?
- Selected Research Projects
 - Analysis of field accident data – priorities for fire safety research and improvements
 - Analysis of GM, NHTSA, and MVFRI vehicle burn tests
 - Research in Fire Safety of H₂ Fueled Vehicles
 - 42-volt battery abuse tests
- Conclusions

MVFRI - Charter

- The Motor Vehicle Fire Research Institute (MVFRI) is an independent, nonprofit, organization specializing in automobile fire safety research.
- MVFRI performs objective research to develop and implement successful technology to reduce the incidence of injuries and death resulting from post-collision fuel fed fires in existing and future designs of passenger vehicles.

Background of Research

- From 1995-2000 GM funded \$10 million in fire research in a GM/DOT Settlement of an investigation of an alleged defect in C/K pickup trucks.
- Beginning in 2001 GM began funding \$4.1 million in fire related research as result of a judicial settlement of the alleged defect.
- This research is being administered by MVFRI with K. Digges at trustee.

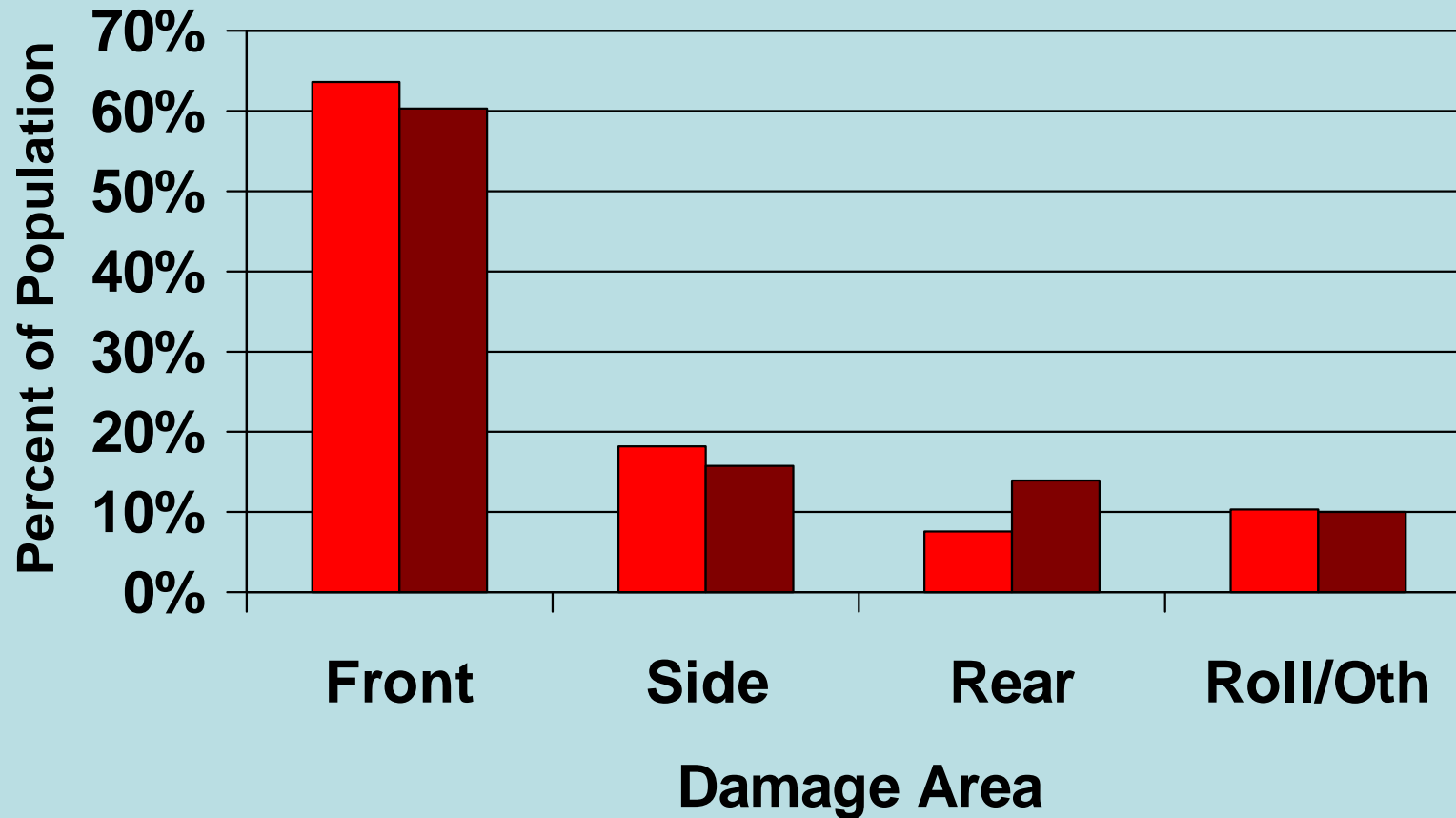
Analysis of Field Accident Data

Fires and Fires with Entrapment (FARS 94-03)

Annual Average:

- Fatal crashes with fire involvement – 1,596
- Fatal crashes with fire as most harmful event (MHE)– 432
- Fatal crashes with fire as MHE and entrapment - 100

Fires and Fires with Entrapment as Most Harmful Event (FARS 94-03)



Crash to Rescue Times from FARS Cases with Reported Time

Land Use	Percentiles in Minutes	
	50%	75%
Urban	8	12
Rural	15	24

Percentiles are time in minutes from crash to rescue

Results of Vehicle Burn Tests

Time from Ignition to Untenability

- 11 vehicles crashed and burned under GM/DOT fire research project
- Results summarized under Contract with FM Global – Average time to untenability:
 - Rear impact pool fires; fuel leakage from tank
 - 0.5 to 3 min
 - Front impact underhood fires; fluids and plastics
 - 10 to 24 min

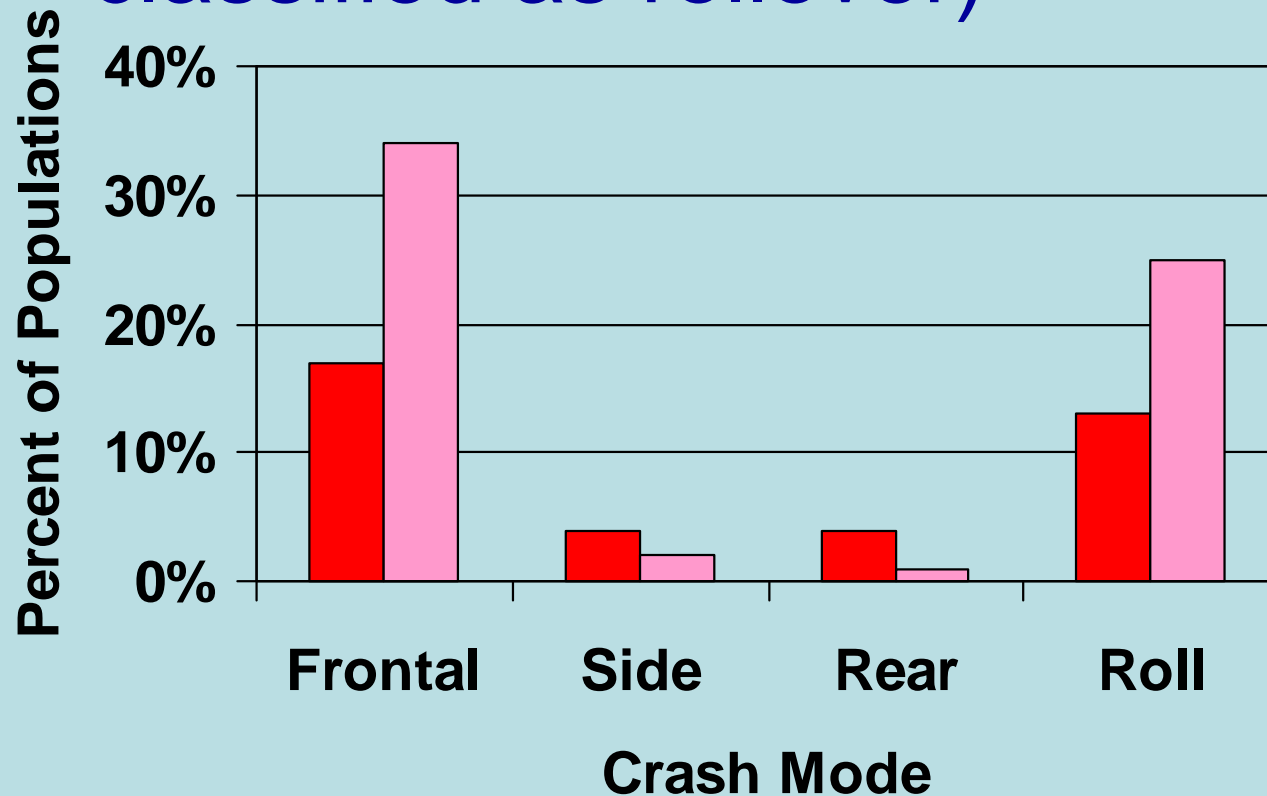
Results of Vehicle Burn Tests (con't)

- See SAE paper 2005-01-1555
- Final report available this summer
- Compared mini, small, intermediate, and full scale tests
- Summarizes flammability data
- Analyzes fire growth, toxic gases, and tenability

Conclusions

- Frontals – fire penetrates through windshield and HVAC ducts
- Rear pool fires – fire penetrates through split seams, door gaps, drain holes, and by conduction through floor pan
- Once penetration of the passenger compartment occurred, untenability occurred very rapidly – ca 1-3 minutes
- Burns and heat stroke usually occur before toxic gases cause incapacitation

NASS Fires by Crash Mode (Multiple crashes with rollover classified as rollover)



Observations Fire Tests and Accident Data

- Entrapment occurs in about 25% of FARS cases with fire as most harmful event
- Crash and burn tests indicate time from ignition to untenability is less than 3 min for pool fires
- For under hood fires, untenability time is longer – 10-24 minutes
- 50% of FARS rescue times are longer than 8 minutes for urban and 15 minutes for rural crashes
- Rollover is a large source of major and minor fires

Fire Safety Research for Hydrogen Fueled Vehicles

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

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

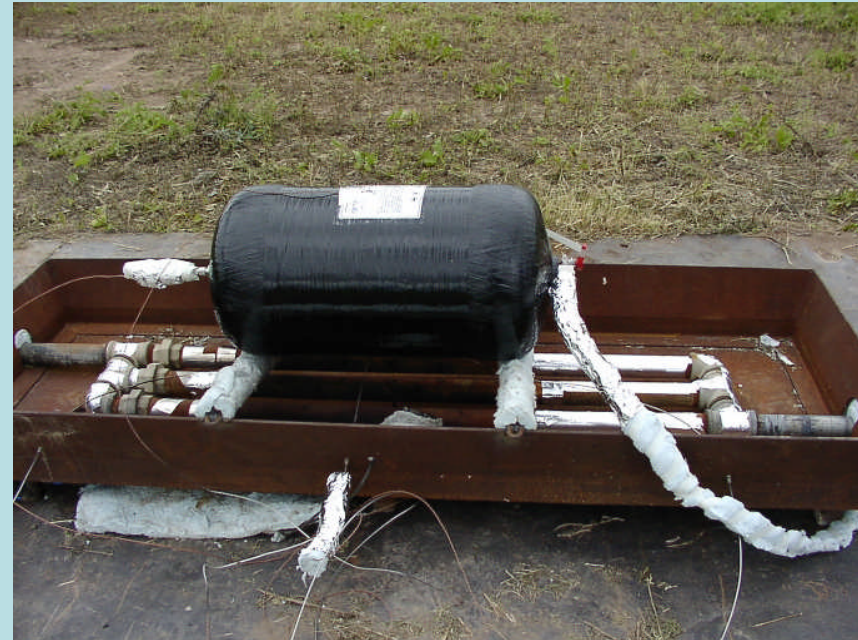
Hydrogen Burst Test

- 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

Hydrogen Fuel Tank Test Setup

Instrumentation

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



Tank positioned in bonfire test rig

Burst Test



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Tank Failure Times

- The composite material on the surface of the tank ignited 45 seconds into the test
- The tank ruptured 6 minutes and 27 seconds into the 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



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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

42-volt Battery Abuse tests

- Performed by SwRI
- Tested 36-volt and 12-volt lead-acid batteries
- 4 Abuse tests from SAE J2464
 - Penetration
 - Crush
 - Radiant Heat
 - Short Circuit

42-volt Battery Abuse tests (con't)

- Results
 - No significant difference between 12 and 36-V
 - Self-heating did occur
 - Temperatures not sufficient to cause severe burns or ignite fluids and plastics.

Conclusions

- Focus fire protection advances on frontals and rollovers
- Entrapment is an issue in fire survival
 - Consider a door opening requirement
- Perform vehicle-level bonfire test for hydrogen-fueled vehicles – the PRD must work!!
- No special fire hazard from abuse of 42-V batteries

The End

Please visit our website at -

mvfri.org