

The MVFRI Research Program

Presentation by K. Digges

January 2006

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Presentation Outline

- Who is MVFRI?
- Selected Research Projects
 - Analysis of Field Data
 - Possible Causes and Consequences of Automotive Fires
 - Survey of SOA in Fire Safety Technology
 - Tests of a Fire Suppression System
- Major Findings

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.

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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. Neither of the settlement parties specify the research to be done.

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Selected Research Projects

- Analysis of Field Data
- Possible Causes and Consequences of Automotive Fires
- Survey of SOA in Fire Safety Technology
- Tests of a Fire Suppression System



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Analysis of Field Data

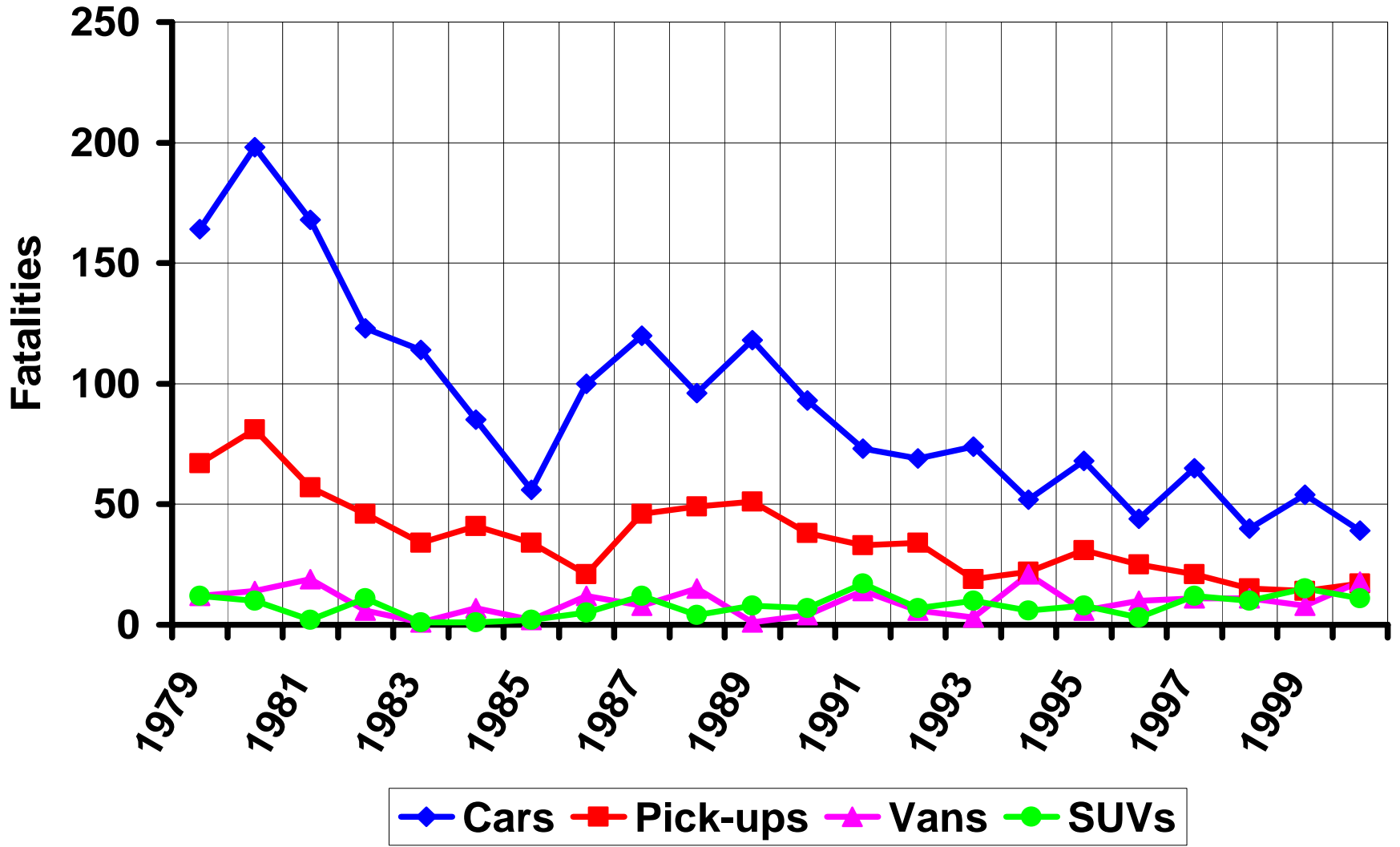
- FARS 1979-2000
- Vehicle age 0-4 years
- Occupants of vehicles where fire/explosion was most harmful event

Output:

- Fatality counts and
- Fatality rates per million vehicle registered years

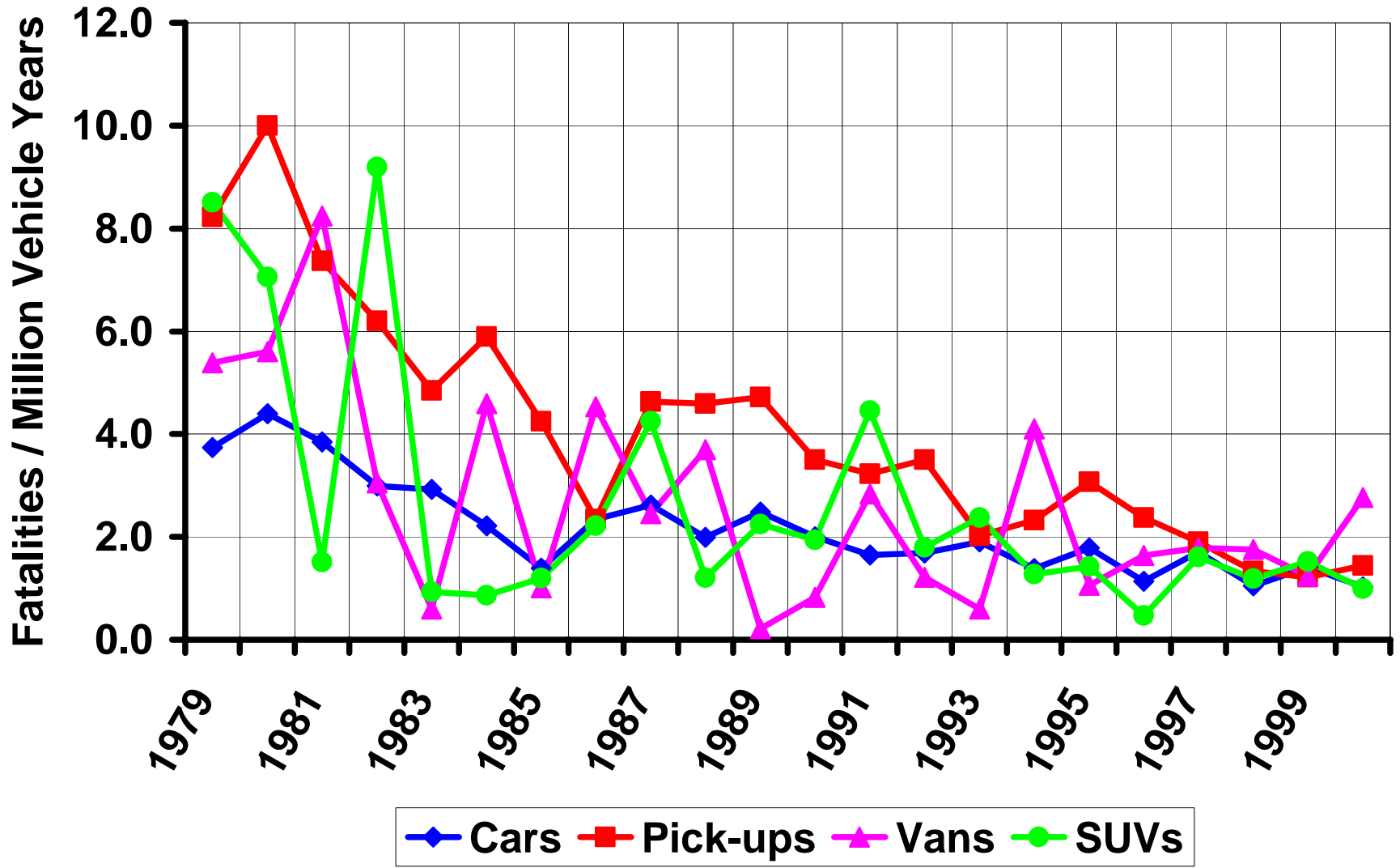
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Fatality Counts - Fire/Explosion as Most Harmful Event



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Fatality Rates - Fire/Explosion as Most Harmful Event



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Observations – Fire Fatalities

- Number of *fatalities* from fire/explosion decreased by 65% since 1979
- Overall *fatality rate* from fire/explosion decreased by 72 % since 1979
- For *pickups* the *fatality rate declined* from >8.0 to <2.0 per million vehicle years
- Average fatality rate, (all vehicle classes) for last 5 years < 2.0 per million vehicle years
- Rates by vehicle class are similar

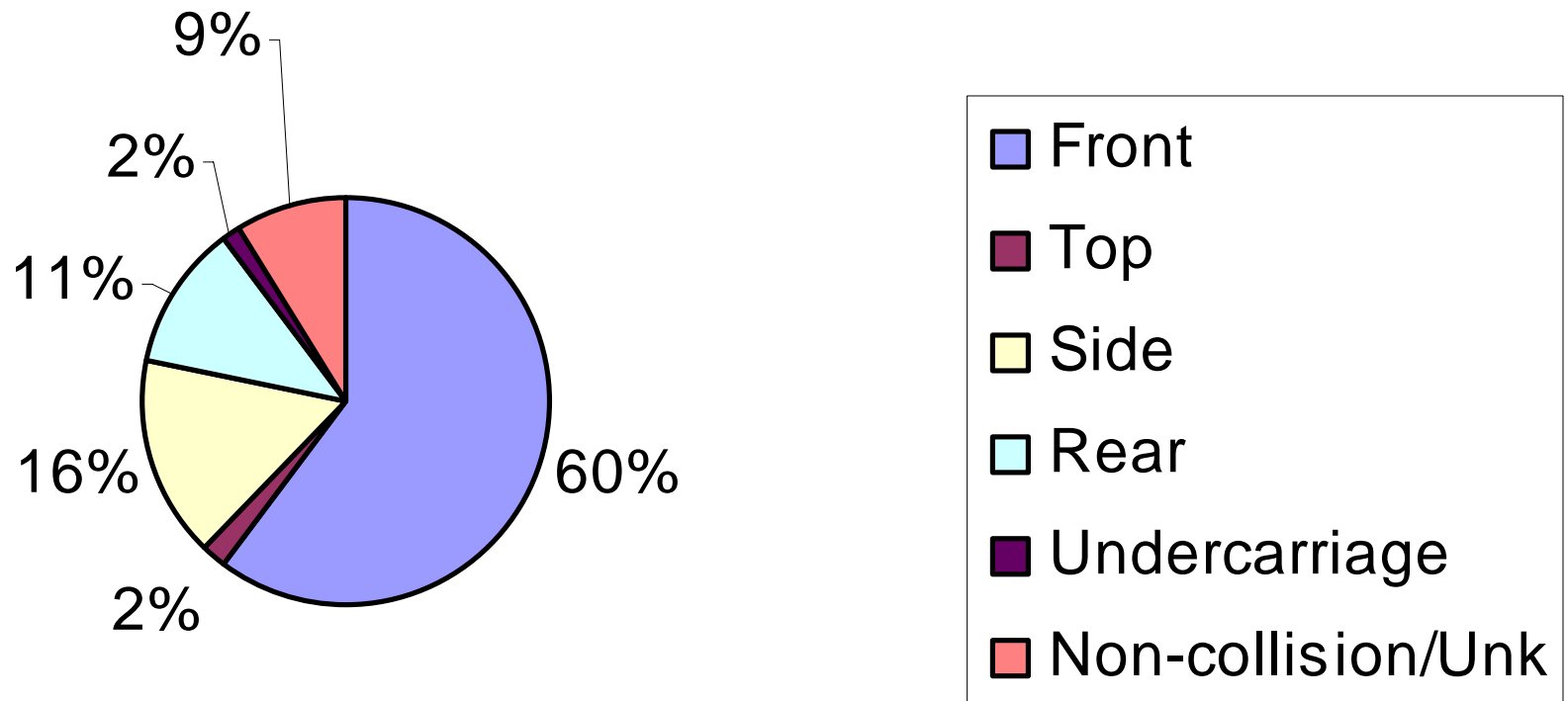
Observations

- 2.6 to 2.9% of fatal crashes are fire related. (1991 to 2000 FARS data)
- Fire fatality rate has remained fairly constant for the past 10 years!!!

Analysis of Most Harmful Event in FARS

Most harmful event applies to the vehicle.,
not the people in the vehicle. Therefore,
one can not assume that the most harmful
event for a vehicle was the cause of any
death or injury for any specific individual
within the vehicle.

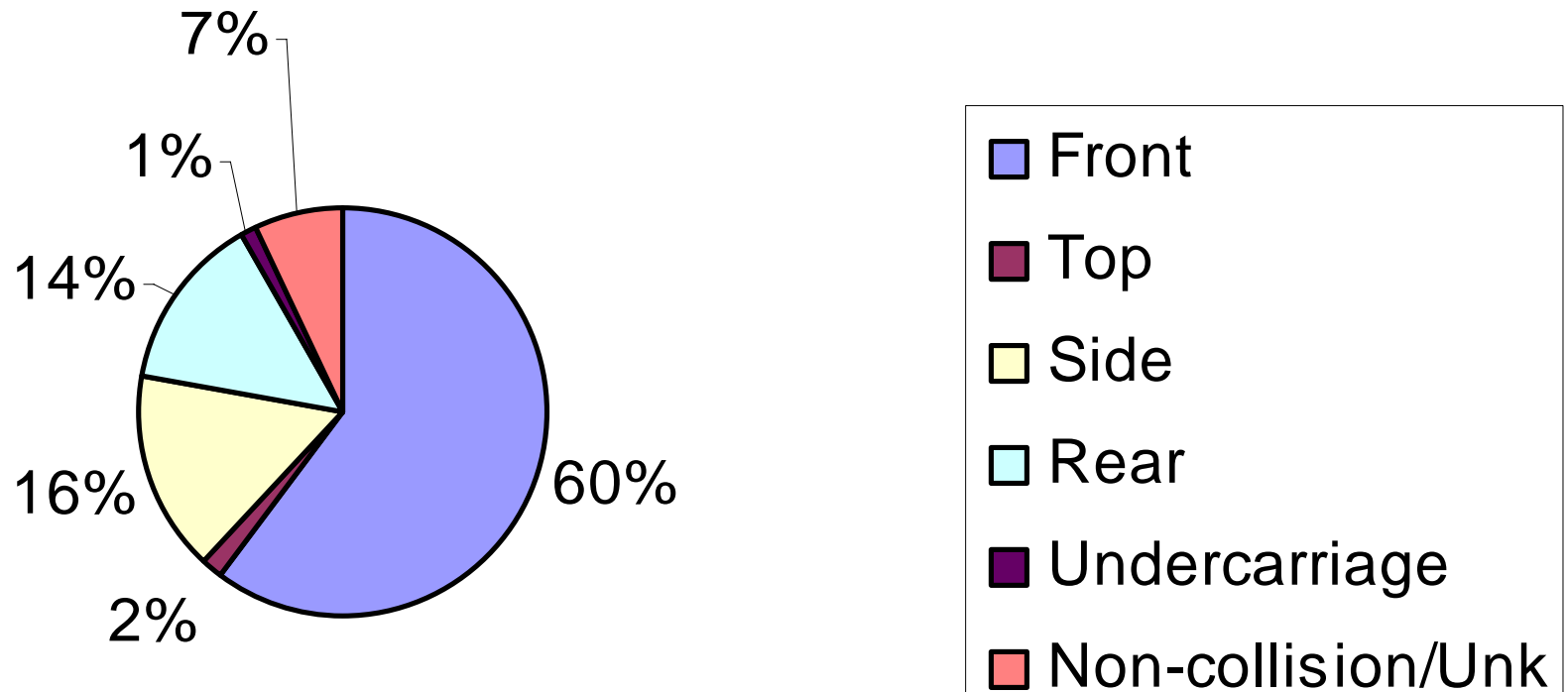
Damage Location for Fatal Fire Cases where Fire is Most Harmful Event



FARS 1994-2003 – 4,322 Cases

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Damage Location for Fatal Fire Cases Requiring Extraction where Fire is the Most Harmful Event

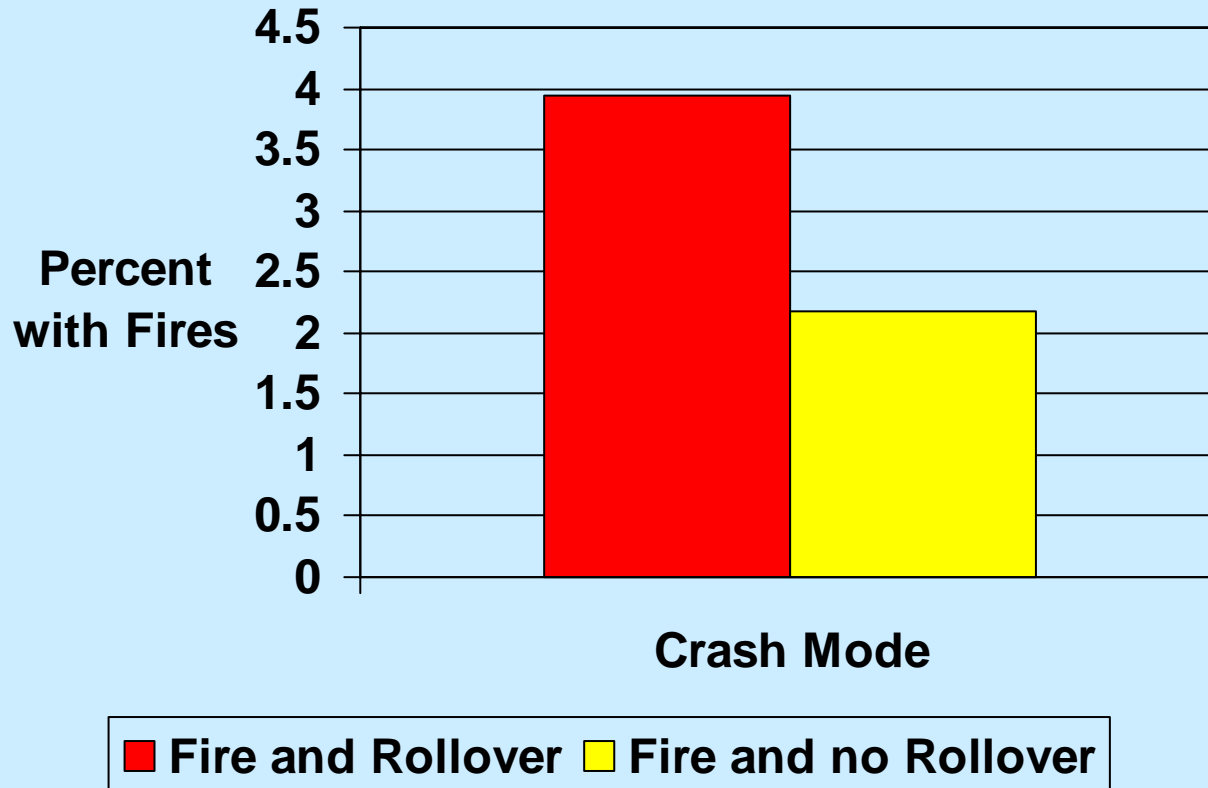


FARS 1994-2003 – 1004 Cases

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Rollover vs. No Rollover Fires

FARS 2000-2002



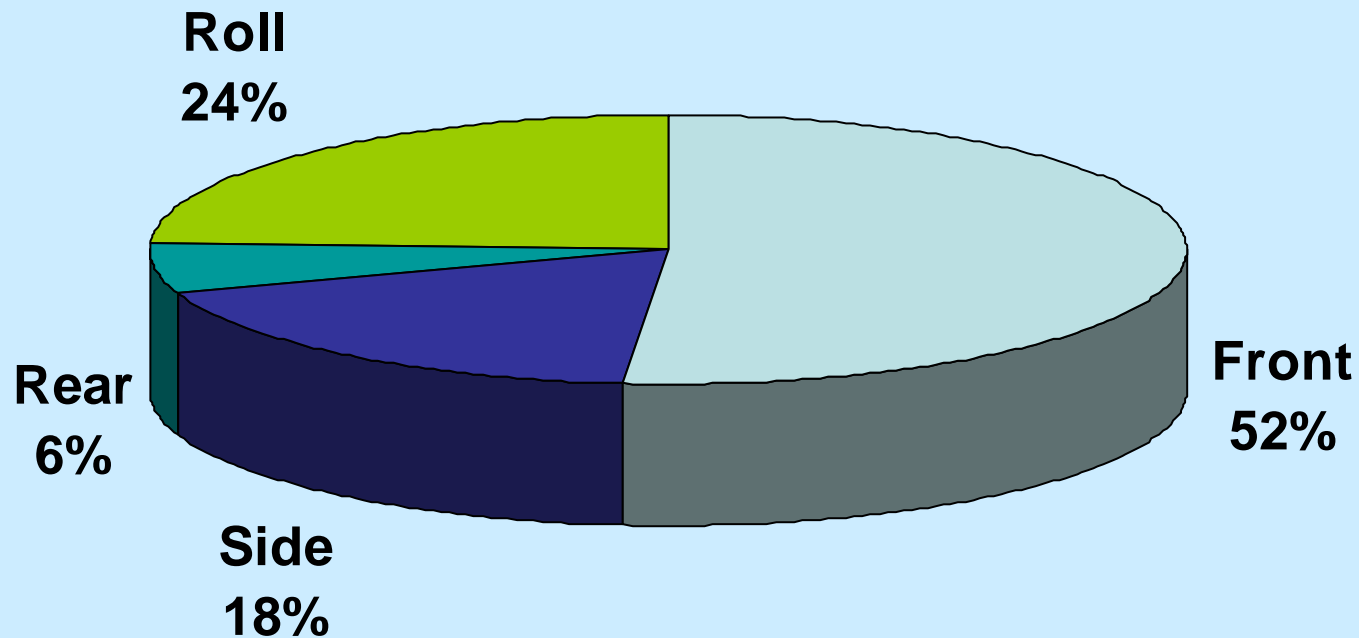
NASS/CDS 1994-2002 Data

513 crashes in which there was an occurrence of fire – expanded to 66,243 (weighted) vehicle fire occurrences.



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NASS Fires by Impact Direction

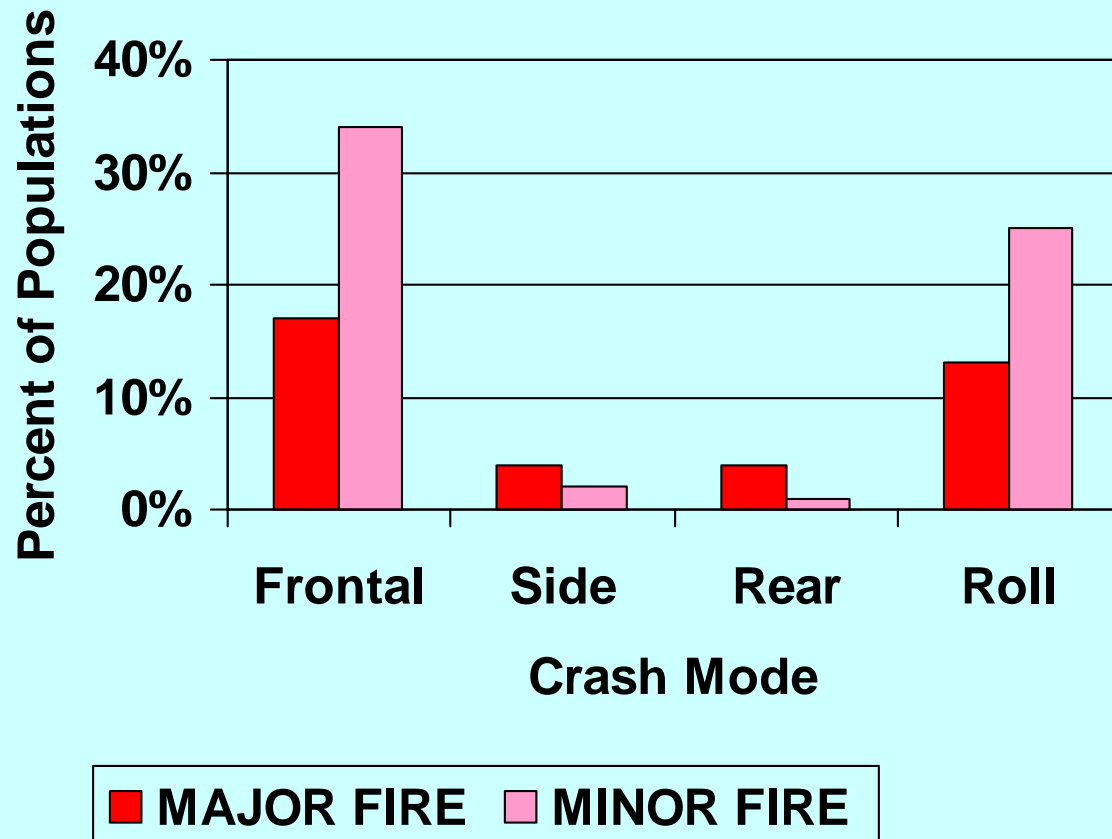


Frontal impact is most frequent mode
Rollover is Number 2

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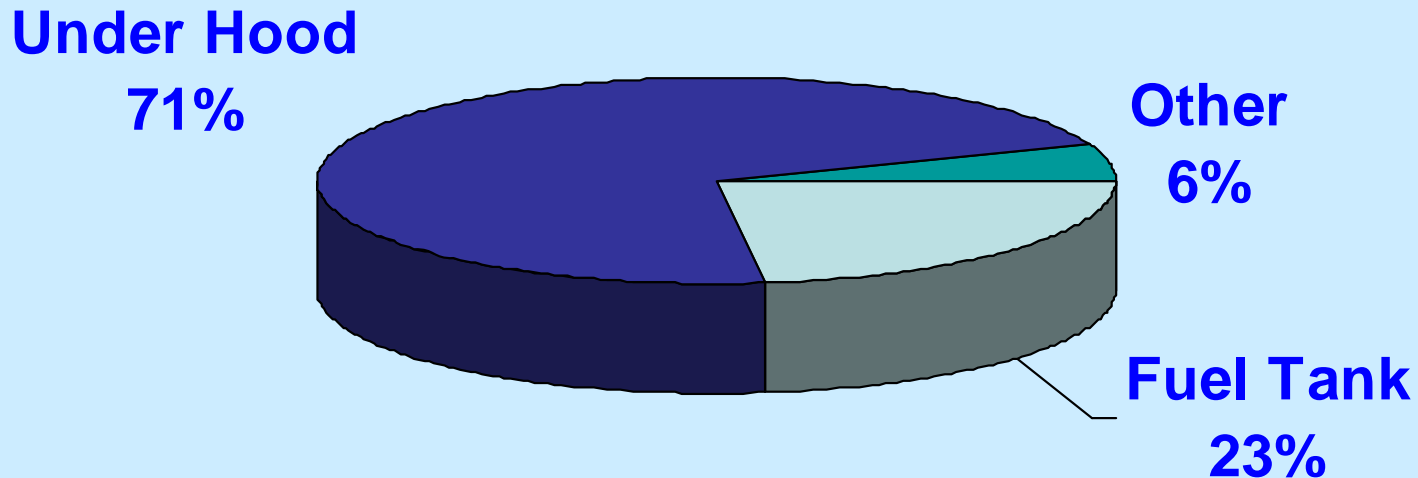
Major & Minor Fires by Crash Mode

(Multiple crashes with rollover classified as rollover)



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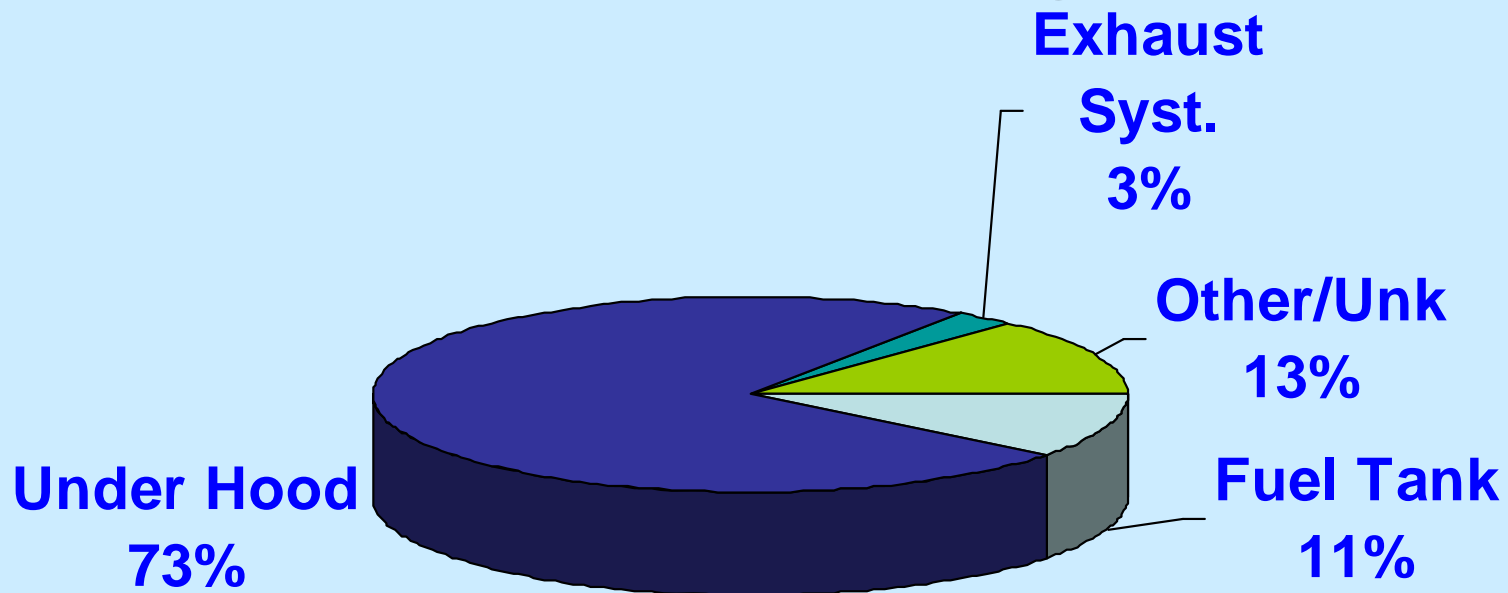
NASS Major Fires by Fire Origin



- **Engine compartment fires are most frequent**

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NASS Major Rollover Fires by Fire Origin



- Engine compartment fires are most frequent

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Observations from the Data

- Most fatal fires are in frontal crashes and rollovers.
- About 25% of fatal fires also involve occupant entrapment.
- Most major fires start under-the-hood.



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Possible Causes and Consequences of Automotive Fires

- DoT/GM fire research and crash & burn tests
- Rescue response times
- NFIRS ignition source data
- Underhood temperature study
- Underhood fluid ignition properties
- Data analysis of pickup fires (state data)
- Underhood insulation ignition properties

Results of Vehicle Burn Tests from DoT/GM \$10M Research Summarized by MVFRI SAE Paper 2005-01-1555

- Compared mini, small, intermediate, and full scale tests
- Summarized flammability data
- Analyzed fire growth, toxic gases, and tenability in full scale burn tests

Results of Vehicle Burn Tests

Time from Ignition to Untenability

- 11 vehicles crashed and burned under GM/DOT fire research project
- 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**

Fire Penetration of the Occupant Compartment in Crash-and-Burn Tests

- Frontals (Underhood) fires –windshield and HVAC ducts
- Rear pool fires –split seams, door gaps, drain holes, and by conduction through floor pan
- Untenability after occupant compartment penetration
 - 1 to 3 min

Crash to Rescue Times from FARS Cases with Reported Time

	<i>Rescue Time Percentiles</i>	
<i>Land Use</i>	50%	75%
Urban	8 min	12 min
Rural	15 min	24 min

Percentiles are time in minutes from crash to rescue arrival

Ignition Source Findings from NFPA

Ignition Sources from M. Aherns – using NFIRS and NFPA data (See SAE-2005-01-1420)

Source	Nr Fires	Nr Deaths
Arcing	23%	4%
Heat	38%	24%
Spark/flame	6%	11%
Friction/spark	3%	12%

In present day vehicles the fuel load from combustible components is in the order of 200 lb - higher energy than that of the gasoline

Underhood Temperature Study

- **Four Vehicles Tested**
- Max Exhaust Manifold Temperature Range
From 241 C° to 550 C°

Tests of Vehicles After Up-hill Run

Max Recorded Underhood Temperatures

Vehicle	Manifold	Cat. Converter
	Deg C	Deg C
Focus	295	387
Caravan	374	328
Neon	550	332
Silverado	366	390

Under-hood Fluid Tests

Fluid	T_{flash}	T_{hot}
Motor Oil (Petroleum)	134	310
Motor Oil (Synthetic)	160	324
Gear Lubrication Fluid	154	325
Power Steering Fluid	188	312
Automatic Transmission	163	304
Brake Fluid	123	287
Antifreeze	116	506

Observations – Underhood Fluids

- Maximum exhaust manifold temperatures measured on four vehicles ranged from **241 C° to 550 C°**
- T_{flash} and T_{hot} measured for under-hood fluids were:
 - T_{flash} **110 to 188 C°**
 - T_{hot} **310 to 506 C°**
- Hot surfaces could be an underhood ignition source

Results of State Data Analysis

- V-8 and V-6 pickups of the same model tend to have higher fire rates than I-4 and I-6 pickups.



Fire Tests of 20 Underhood Insulation Materials

- 20% offered a high fire resistance.
- 35% offered little resistance to combustion.



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Survey of SOA in Fire Safety Technology

- New vehicle database at mvfri.org
- Data on fuel system features
- 82 vehicles; MY 2003
- In sales volume representative of:
 - 95% of pickups
 - 94% of minivans
 - 98% of full size vans
 - 72% of SUVs
 - 76% of passenger cars

Survey of Practices in New Vehicles

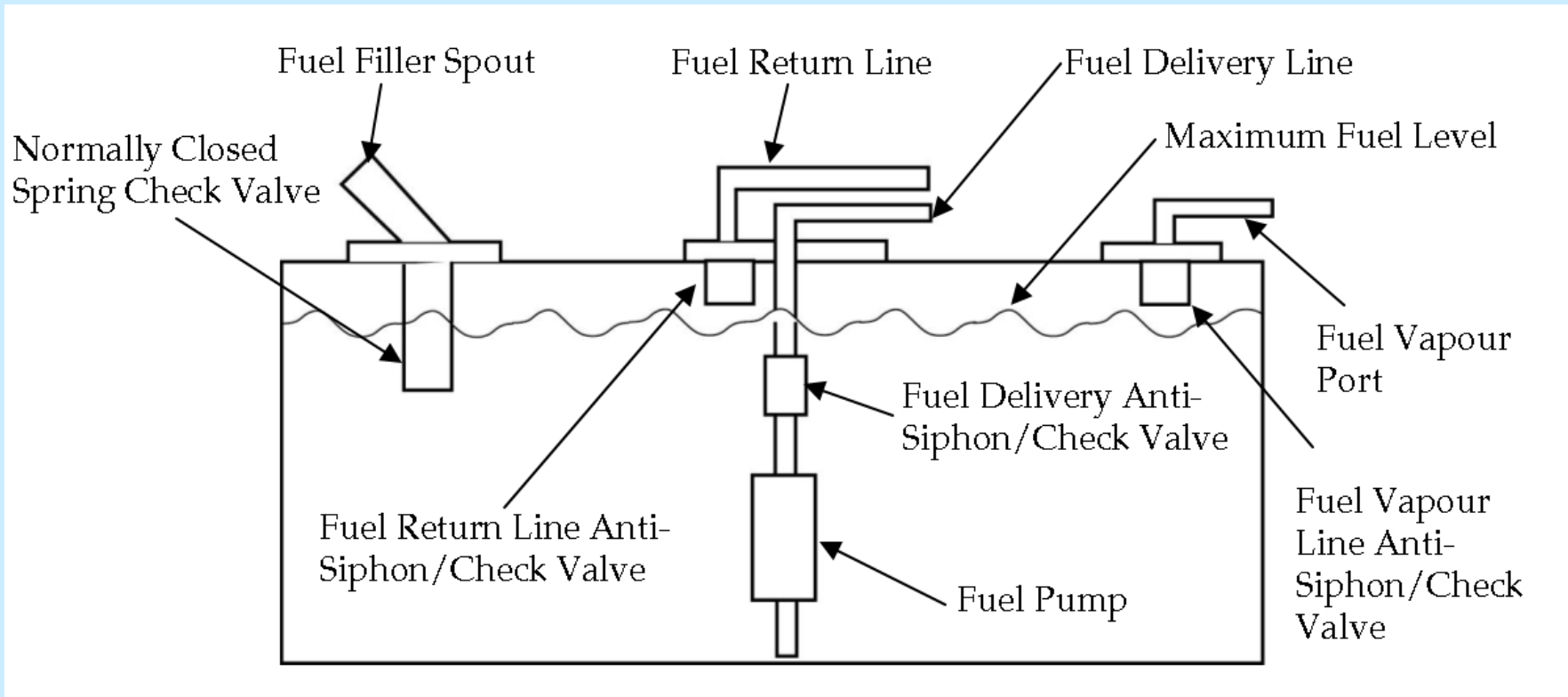
Most common features:

- Check valves in filler tube
- Rollover valves in fuel lines
- Full or partial shielding of the fuel tank
- Plastic fuel tank
- Tank location under body, in front of rear axel
- Insulated cap over positive battery terminal
- Fuel pump shut-off after crash
- Battery disconnect after crash
- No return fuel system

Evaluation of Existing Fuel Containment Technology in Present Day Vehicles

- 20 fuel systems evaluated by simulating a rollover with leak measurements at 45° roll increments
- None leaked with all lines in-tact
- 6 leaked at all orientations when lines were severed
- *4 did not leak in any orientation when each of the lines was severed and the system was rolled*

State-of-the-art Fuel Safety Technology



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Underhood Fire Suppression

- UMd report on Nitrogen based foam system completed
- Successfully demonstrated the ability to control an 80 Kw underhood fire
- Tested on 4 wheels and on roof (rollover)
- Dr. Anthony Hamins of NIST assisted in defining tests and assessing performance

Tests of UMd Fire Suppression System

Fire



Gasoline Pool Fire

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Suppressed 80 Kw Fire in Engine Compartment



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Major Findings

- Most fires and fatal fires are in frontal crashes and originate under-the-hood
- Entrapment occurs in 25% of the fatal fires
- Rollovers carry an increased risk of the vehicle fires (FARS & state data)
- Tests of undehood temperatures indicate that exhaust manifold temperatures on some vehicles can reach temperatures high enough to ignite underhood fluids

Major Findings

- State-of-the-art technology is available to prevent fuel leakage from severed lines
- In some vehicles, the underhood insulation blankets resist fires – others contribute fuel
- Under-hood fire suppression performed well in tests

Half Full - Conclusions

- Number of fatalities from fire/explosion decreased by 65% since 1979
- Overall fire/explosion fatality rate from fire/explosion decreased by 72 % since 1979
- Average fatality rate, (all vehicle classes) for last 5 years less than 2.0 per million vehicle years
- Fire fatality rates by vehicle class are similar

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Half Empty Conclusions

- No reduction in fire/explosion fatality rate for the past 10 years!!!
- Technologies exist on some current vehicles to reduce fuel load and to prevent fuel leakage, but they are not in wide use
- Rollovers have the highest fire risk and represent 11% to 28% of the crash induced fires – no rollover crash test exists

Half Empty Conclusions

- Most major fires start under the hood – there is no fire safety standard to address these fires
- The current interior flammability standard has not addressed changes in the fire threat and in fire testing technology

Thank you for this opportunity

Please visit our website
mvfri.org



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