Fire Occurrence in Frontal Crashes Based on NASS/CDS

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Motor Vehicle Fire Research Institute

MVFRI
Earlier Test Data

- GM Crash Test - SAE paper 2005-01-1788
  - Leakage from damaged power-steering system was fire origin in two crash tests

- GM Crash and Burn tests – GM/Dot Settlement
  - Crash tests - Fire initiated by electrical fault
  - Burn tests – For fire origin in engine compartment, tenability time for occupants ~ 10 to 28 minutes
Data Sources

The Fatality Analysis Reporting System (FARS) years 1979 to 2005

The National Automotive Sampling System - Crashworthiness Data System (NASS/CDS) 1997-2005
Definitions

FARS Fires – Any vehicle in the FARS file where there was both a fatality and a fire.

FARS MHV (Most Harmful Event) Fires – The FARS cases where fire was the most harmful event that occurred to the vehicle. The MHV does not necessarily apply to the people in the vehicle. Therefore, one can not assume that the most harmful event for a vehicle was the cause of the death or injury for any specific individual within the vehicle.

NASS Major Fire – Any NASS case where fire enters the occupant compartment

NASS Major Fire with a Fatality – Any NASS case in which there is a major fire and a fatality. The fatality could have been due to crash forces or to the fire or to both.
Presentation Outline – Fires in Frontal Crashes

- Overview of Fires in FARS
  - Frontal crashes relative to other crash modes

- NASS/CDS Data on Frontal Crashes with Major Fires and Fires with Fatalities

- Examination of Eight Cases in NASS where Fire may have contributed to the Fatality

- Conclusions
Annual US Motor Vehicle Fatalities (FARS)

![Graph showing annual US motor vehicle fatalities from 1978 to 2004](image-url)
US Motor Vehicle Fatality Rate

![Graph showing the US Motor Vehicle Fatality Rate from 1979 to 2005. The rate decreases over time, from approximately 3.5 fatalities per 100 million miles in 1979 to around 1.5 in 2005.](image-url)
Annual Fire Rates in FARS

![Graph showing annual fire rates in FARS from 1980 to 2005. The graph plots FARS Fires and FARS MHE Fires over time.]
US Passenger Vehicle Fatalities (FARS - 5 Year Moving Average)

Frontal crash fatals are decreasing

Ave. Annual Fatalities

FARS Year (5 year Average)
Most Harmful Event Fires by Crash Mode (FARS - 5 Year Moving Average)

Frontal MHE fires fatals are increasing
Distribution of Fatalities with Fire MHV by Crash Direction
FARS 2001-2005

- Front: 47%
- Rear: 9%
- Other: 5%
- Side: 11%
- Roll: 9%
- Side-Roll: 5%
- Pure Roll: 14%
- Front-Roll: 28%
- Rollovers: 5%

Frontal crash precedes ~ 50% of rollovers
Fire Rate (Fires per Crash Involved Vehicle in FARS) vs. Age of Vehicle

FARS 2000-2002

Age of Vehicle, Years

Fire Rate

- Increased fire rate
- Reduced fire rate
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NASS/CDS Data on Frontal Crashes with Major Fires and Fires with Fatalities

The National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) 1997-2005 –

• Vehicles less that 10 years old
• 87 vehicles with frontal impact and major fires
• When weighted expands to 10,337 vehicles
• Standard error ~ 23% for this size NASS population
Distribution of Major Fires and Fires with Fatalities; Vehicles <10 Years Old
- Fire Origin

NASS 1997-2005

Origin of the Fire

- Engine Comp.
- Fuel Tank
- Interior
- Other
- Unk.

All Major Fires
Fires with Fatals

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2008-01-0256
Distribution of Major Fires and Fires with Fatalities; Vehicles <10 Years Old
- Fuel Leakage Location

NASS 1997-2005

<table>
<thead>
<tr>
<th>Fuel Leakage Location</th>
<th>All Major Fires</th>
<th>Fires with Fatals</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Leakage</td>
<td>57%</td>
<td>51%</td>
</tr>
<tr>
<td>Tank</td>
<td>4%</td>
<td>24%</td>
</tr>
<tr>
<td>Fuel Delivery</td>
<td>2%</td>
<td>7%</td>
</tr>
<tr>
<td>Filler Neck</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>9%</td>
<td>2%</td>
</tr>
<tr>
<td>Unk</td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

NASS 1997-2005
Distribution of Major Fires and Fires with Fatalities; Vehicles <10 Years Old -Object Contacted

Object Contacted (Highest Damage)

NASS 1997-2005

- Large Fixed Object: 84%
- Vehicle: 27%
- Ditch/Culvert: 13%
- Other Object: 0.5%

All Major Fires
Fires with Fatals

2008-01-0256
CDC - Extent of Deformation

Extent of Damage - Frontal Crash Direction
Range 1 to 9
1 to 5 - Equally Divided to Firewall
6 – Front to Rear of Windshield
7 & 8 – Equally Spaced; Rear of Windshield to B-Pillar
9 – Beyond B-Pillar

Definition Of CDC Damage Extent
Distribution of Major Fires and Fires with Fatalities; Vehicles <10 Years Old
-Extent of Damage

NASS 1997-2005

CDC Extent of Damage

- All Major Fires
- Fires with Fatals
Distribution of Major Fires and Fires with Fatalities; Vehicles <10 Years Old - Damage Type

NASS 1997-2005

- All Major Fires
- Fires with Fatals

Wide: 58% All Major Fires, 88% Fires with Fatals
Corner: 12% All Major Fires, 2% Fires with Fatals
Narrow: 16% All Major Fires, 1% Fires with Fatals
Unknown: 14% All Major Fires, 9% Fires with Fatals
Distribution of Major Fires and Fires with Fatalities; Vehicles <10 Years Old - Extent of Entrapment

NASS 1997-2005

Extent of Entrapment

<table>
<thead>
<tr>
<th>Distribution %</th>
<th>Entrapped</th>
<th>Not Entrapped</th>
<th>Unknown</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>17%</td>
<td>83%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>59%</td>
<td>37%</td>
<td>4%</td>
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2008-01-0256
Pre-crash Factors – All Major Fires

73% were single vehicle crashes

63% involved run-off-the-road

25% involved braking and steering pre-crash maneuvers
Other Statistics - Fatalities

66% were in multi-impact crashes
30% involved a large fixed object as the second object impacted
25% involved secondary damage from ditches or culverts
General Observations from NASS – Frontal Crashes with Major Fires

- Under-hood is predominate fire origin
- Fuel leakage generally not present
- Fuel leakage more prevalent in fires with fatalities; tank most frequently the origin; undercarriage damage often suspected
- Prevalent crash mode – large fixed objects
- Prevalent damage – wide
- Most fatalities associated with CDC Extent 5+
- Entrapment frequent among fatalities
Presentation Outline – Fires in Frontal Crashes

- Overview of Fires in FARS
  - Frontal crashes relative to other crash modes

- NASS/CDS Data on Frontal Crashes with Major Fires and Fires with Fatalities

- Examination of Eight Cases in NASS where Fire may have contributed to the Fatality

- Conclusions
Examination of Eight Cases in NASS where Fire may have contributed to the Fatality

Of 86 major fires, 27 vehicles had occupants with fatal injuries.

8 vehicles had occupants with burns coded as the most severe injury.

- Eight cases are insufficient to extrapolate results to the entire population of crashes.
- They provide useful insights into fire causation.
Summary of 8 NASS Cases with Fatalities and Burns as the Most Serious Injury

<table>
<thead>
<tr>
<th>Case</th>
<th>Origin of Fire</th>
<th>Leakage Location</th>
<th>CDC Damage Extent</th>
<th>CDC Damage Width</th>
<th>Entrapped?</th>
<th>Object Contacted</th>
<th>2nd Object Contacted</th>
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<tbody>
<tr>
<td>1</td>
<td>Eng. Comp</td>
<td>See Note</td>
<td>4</td>
<td>Wide</td>
<td>Door Jam</td>
<td>Large Tree</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Eng. Comp</td>
<td>None</td>
<td>4</td>
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</tr>
<tr>
<td>3</td>
<td>Eng. Comp</td>
<td>None</td>
<td>7</td>
<td>Corner</td>
<td>Entrapped</td>
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<tr>
<td>4</td>
<td>Eng. Comp</td>
<td>Tank</td>
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<td>Ditch/Culvert</td>
<td>Large Tree</td>
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<td>5</td>
<td>Fuel Tank</td>
<td>Tank</td>
<td>3</td>
<td>Wide</td>
<td>Door Jam</td>
<td>Barrier</td>
<td>Top of Barrier</td>
</tr>
<tr>
<td>6</td>
<td>Eng. Comp</td>
<td>None</td>
<td>2</td>
<td>Wide</td>
<td>None</td>
<td>Vehicle Side</td>
<td>Sideslap</td>
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Note: Leakage Location - Line/Pump/Filter

Cases 1 thru 4: Lane departure with severe frontal damage from impact with tree
Case 4: Culvert may have damaged fuel tank
Case 5: Hardware on top of barrier may have damaged fuel tank
Case 6: Frontal under-ride with a tractor/trailer
Cases 7 and 8: Fire probably originated in other vehicle
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- Cases 1 thru 4: Lane departure with severe frontal damage from impact with tree
- Case 4: Culvert may have damaged fuel tank
- Case 5: Top of barrier may have damaged fuel tank
- Case 6: Frontal under-ride with a tractor/trailer
- Cases 7 and 8: Fire probably originated in other vehicle
Underhood Vehicle Fire – Run-off-road – Tree Impacted

Driver – AIS 3 Pelvic
RF Pass – AIS 6 Burn
Engine Comp Fire
No Fuel Leakage

Damage Profile CDC- 4
Jammed Door

Case 2004 43 343
Underhood Vehicle Fire – Run-off-road – Tree Impacted

Driver – AIS 3 Chest
RF Pass – AIS 6 Burn
Engine Comp Fire
No Fuel Leakage

Road departure mounted curb

Case 2005 12 160

Vehicle Damage

Damage Profile CDC – 7
Entrapped
Fuel Tank Fire Origin

Case 1998-6-139

- Vehicle Fire
- Light Pole on top of barrier
- Tank Damage
- Frontal Impact
- Roadside Barrier

Driver – AIS 6 Burn
RF Pass – AIS 3
RR Pass – AIS 1
LR Pass – AIS 1
Engine Comp Fire
Fuel Tank Leakage

Vehicle Damage

Damage Profile CDC -3
Jammed Door
Observations – 8 Fatal Cases in NASS

- Most prevalent crash - lane departure and severe impact with fixed object
- Fire origin in other vehicle (from rear or side impacts) may contribute to frontal impact fire fatalities
- Undercarriage impacts prior to frontal impact may contribute to fuel leakage
- Entrapment was prevalent in these cases
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- Observations & Conclusions
Conclusions

- Frontal crashes are ~50% of NASS major fires and FARS crashes with fire as MHE
- The numbers, while small, have been increasing (FARS)
- The engine compartment is the most frequent fire origin (NASS)
- Run-off-the-road impacts with fixed objects most frequent mode
- Multi-impacts with possible undercarriage damage also frequent
- Entrapment frequent in fatal cases
Possible Countermeasures

Electronic Stability Control and Lane Departure Control

Countermeasures to enhance egress in severe frontal crashes

Fuel tank protection from undercarriage impacts

Technology to prevent electrical faults and fluid leakage from frontal damage

Underhood fire suppression systems
Questions??