A CASE STUDY OF 214 FATAL CRASHES INVOLVING FIRE

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ABSTRACT

A detailed case study of 214 fatal fire related crashes was conducted to determine whether the death was caused by the fire or blunt trauma. The cases were also examined to determine the specific crash conditions which caused the fire. This analysis was necessary because none of the existing fatal crash databases contained sufficient details to determine the impact configuration or the cause of death. Two hundred and ninety three (293) fatalities occurred in these crashes. Sixty-five (65) of these fatalities resulted from fire, with 30 of these fatalities from 16 rear impacts. The speed of impact was determined in eight of the 16 cases which caused these 30 burn fatalities. In these eight cases, the average rear impact speed was 54 mph with speeds ranging from 50 - 60 mph, at 71% overlap (71 % of the rear vehicle width engaged), and collinear at 6:00 O'clock. By projecting these cases to the national sample, the number of rear impact fire related fatalities may be estimated between 94 and 191.

INTRODUCTION

A case study of 214 fatal fire related crashes was conducted. FARS (Fatal Analysis Reporting System) data were queried for 1990, 1991, 1992 and 1993 to obtain a listing of cases in which fire was coded. Cases were obtained by soliciting seven states for crash records in which case history information was available. The crash records may have included all or part of the following: (1) photographs which documented the crash site and the vehicle damage, (2) "police accident reports" (PARs) which described the crash according to the opinion and findings of the investigating officer, (3) witness statements sometimes indicating the intensity, location, and timing of the fire, (4) medical records which stated whether an autopsy was performed and what the findings of the autopsy were related to the cause of death, typically differentiating between conflagration and blunt trauma. The states solicited were Illinois, Florida, Colorado, Arizona, Ohio, Delaware, and West Virginia. Approximately 303 cases were received from which 89 were eliminated for one or more of the following: (1) The case Information was insufficient to determine impact mode, (2) the cause of occupant's death could not be determined, (3) there was a multiple vehicle collision with no fatality in the vehicle which burned, (4) the fatally injured was a motorcycle rider (two cases). While this sample is not claimed to represent a statistically valid sample, it does represent a large randomly selected sample of fatal crashes in which a fire was involved.

FARS data for 1990-1993 were used to compare the trend of fatalities in these seven states to the national FARS data for the four years used in this study. In 1990-1993 FARS there are 4,090 vehicles involved in a crash with a fire, known principal impact point, and at least one occupant fatality. Likewise, for the seven states there are 698 vehicles coded for the four year study. Table 1 shows the number and distribution of these vehicles by principal impact point.

METHODOLOGY

The study consisted of reviewing the available hard copy case files and determining from the available data the likely crash scenario which caused the fire. Note that this is different from FARS coding which does not attempt to identify the event that caused the fire. The only similar parameter available from FARS is the principal impact point (see Table 1) which may or may not be the cause of the fire. To determine the impact speed and crash configuration, the police accident report and the scene photos were used. If data were sufficient, the specific impact condition which caused the fire was compared to available crash test data to estimate the crash severity and crash conditions likely to cause similar damage.

Additionally, the cause of death was determined by judgemental decisions based on the crash severity, likely occupant kinematics, crash type, and autopsy or coroner's report. Priority was given to death certificates by a medical examiner, unless there were confounding findings in the case analysis. Witness statements were also used in a few cases to determine the immediate post crash state of the burn victim.

Table 1.
Number and Percent of Vehicles with at Least One Occupant Fatality and a Fire

Crash Configuration	National Sample FARS	Seven State FARS
Front	2797 (68.4%)	483 (69.2%)
Rear	286 (7.0%)	43 (6.2%)
Side	844 (20.6%)	145 (20.8)
Top	87 (2.1%)	21 (3.0%)
Other	6 (0.9%)	76 (1.9%)

To project the number of fatalities expected from fire on an annual basis, the 1995 FARS automated files were queried. Assuming these cases were representative, an annual projection was made and statistical variance calculated.

FINDINGS

From the 214 fire related crash cases, 45 cases (21%) resulted in one or more fatalities due to the fire (burn related trauma). There were 293 total fatalities in 251 vehicles which burned, consisting of impact related trauma to 228 occupants (78%) and burn related trauma to 65 occupants (22%).

The distribution of all 214 cases by crash mode is shown in Figure 1. To compare the selected seven state cases to all fatalities as reported in FARS, see Table 1. This comparison indicates that the seven states are almost identical to the overall national FARS data. However, as might be expected due to inconsistencies as previously discussed, the data in Figure 1 and Table 1 are not entirely consistent. This may be explainable by differences in FARS coding and the detailed case study which only focused on the impact which caused the fire. Additionally, Figure 1 is sorted by crash case whereas the FARS data are sorted by vehicle. Therefore a vehicle reported in FARS as involved

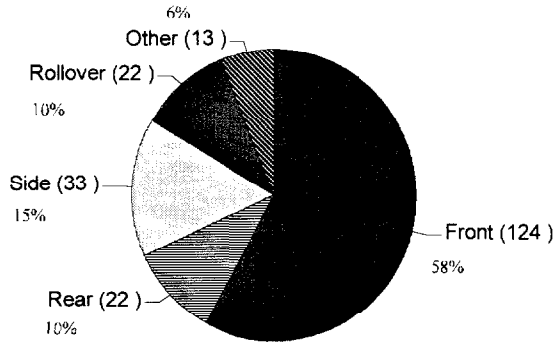

Figure 1. Distribution of all occupant fatal crashes in which a vehicle caught fire (total cases 214).

in a fire crash with principal frontal damage, may have run in to the back of a vehicle which caught fire from fuel leakage and caused both vehicles to burn. Therefore FARS analysis would have double counted this case under front and rear impacts, whereas the case study would have only counted the source of the fire (rear struck).

The distribution of all fire related fatal crashes (Figure 1) does not establish the most probable impact to cause a burn fatality, but does show the majority of fires occur in frontal impacts. The subset consisting of 45 cases in which the fire was judged to have caused the fatality is shown in Figure 2 as a distribution of fatalities. For the 45 cases and 65 fatalities in which the occupant was judged to have died because of the fire (burn trauma), a distribution was calculated for percent of fire trauma fatalities by impact type. This distribution shows that 46% of the fatalities occur from rear impacts, 23% from front impacts,

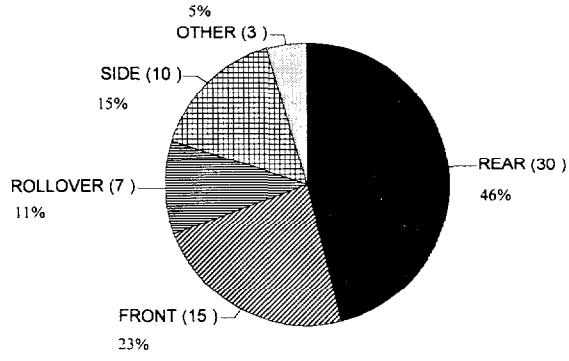

Figure 2. Distribution of occupant fatalities due to fires in vehicle crashes (total fire fatalities 65).

15% from side impacts and 11% from rollover crashes. In addition, four percent of the fatalities were classified as "other". The appendix summarizes the crash cases in which the fire caused the fatality. If the percentage of fatally burned victims and the distribution of crash type determined by these cases is assumed to represent the entire population of fatal fires, a prediction of annual fire related fatalities by impact mode may be estimated. FARS data from 1995 shows there were 1392 car and light truck fire related fatalities (approximately 5 times the study sample). By assuming the cases in this study are representative of 1995 fatalities, we may estimate that 22% (65 burn victims out of 293 fatalities in the study) of these fatalities would have resulted in burn trauma for a total of 309 fatalities/year. Of these, the number of projected fatalities based on Figure 2 are 143 rear impact fatalities, 71 front impact fatalities, 33 rollover fatalities, 48 side impact fatalities and 14 others. The 95% upper and lower confidence limits (1) for the projected fatalities are calculated as shown in Table 2.

Table 2.
Projected Upper and Lower Confidence Limits of 1995 Fatalities Based on the Sample of FARS Cases Analyzed for Impact Condition and Fatality Cause

Crash Configuration	Lower Limit of Fatalities	Projected '95 Fire Fatalities	Upper limit of Fatalities
Front	36	71	106
Rear	94	143	191
Side	19	48	76
Rollover	9	33	58
Other	0	14	30

Past studies have attempted to distinguish burn trauma from impact trauma injuries associated with fire. Since FARS currently has no means of distinguishing cause of death in crash-related fires, some researchers have attempted to use the variable called "Most Harmful Event or MHE". A search was done on FARS data to check the correlation of the coding of this variable as "fire/explosion" for the cases in this study for which we determined death resulted from burn trauma. It was found that MHE was coded for the vehicle as fire/explosion in only 29% of the cases. This finding points out the need for a better indicator to determine the cause of harm to the occupant in a fire-related crash.

The case narratives are included in the appendix for the 45 cases discussed above for which fire was judged as the cause of the fatalities. Of all crash configurations, only rear impacts have consistent crash and fire scenarios. In all 16 rear impact cases the vehicle is struck in the rear causing loss of fuel from the tank area which ignites during impact and results in a rapidly spreading fire and resulting fatalities.

At the end of each crash description for the rear impacts, the crash test simulation based on the available information which best replicates this scenario is summarized. For this summary the impact speed is normalized to a 3000 pound moving deformable barrier (MDB) , striking the rear of the stationary subject car. Listed in this summary are: the speed of impact, the percentage of overlap, and the angle from collinear (0 degrees representing collinear). This level of detail was available for eight of the 16 rear impact cases. The average of these eight is a 54 mph MDB impact at 71% overlap. Seven of the eight cases were collinear. Therefore it appears that a 70% overlap 3000 lb. rear moving deformable barrier at 50-55 mph may provide a reasonable crash simulation of real world rear impact fatal burn cases (2).

REFERENCES

1. Freund, John E., Mathematical Statistics, Englewood Cliffs, N.J. Prentice Hall, Inc, 1962, Chapter 10, pp. 232-233.

2. Ragland, Carl, "Research Tests to Develop Improved FMVSS 301 Rear Impact Test Procedure", The Sixteenth International Technical Conference on the Enhanced Safety of Vehicles, Windsor, June 1998.

APPENDIX

Rear-End Crashes

CASE NO. 220 V1, a 1979 Pontiac 2 dr Sunbird while traveling westbound at high rate of speed (approx. 80 mph) in the middle lane of a 6 lane divided highway, impacted the right rear end of V2, a 1984 2 dr Mustang, which had just pulled into the middle lane out of a driveway 180 feet before the impact. V2 exploded upon impact in the vicinity of the rear mounted tank. Attempt to extricate the driver were unsuccessful as the car was quickly consumed by fire. At impact The Mustang speed was estimated at 30 mph and the Pontiac speed at 80 mph (no pre impact braking). The damage severity and pattern were compared to a NHTSA

research crash test using a moving deformable barrier into the right rear of a 1993 Ford Mustang at 52 mph at 80% overlap. The results were almost identical. The crash test resulted in a ruptured fuel tank and excessive spillage of stoddard solvent (Used in place of gasoline). Fuel tank rupture must be assumed as the cause of fire. The gas tank was also reported in the PAR to be damaged, spilling gasoline and causing fire. It also was reported to have been pushed up and into passenger compartment. The autopsy concluded the cause of death as "Thermal burns". (52 mph, 80%, 0 degree)

CASE NO. 9 This was principally a two vehicle front to rear impact with minor involvement with third vehicle. V1, an 1988 Chevy Beretta, 2 dr was traveling in a 45 mph speed zone and failed to stop for V2, a 1979 Chevrolet (Nova?) 2 dr sedan which was stopped for traffic congestion due to construction. V2 was pushed forward into the rear of V3, resulting in minor bumper damage to V3. D1 was coded as 'possible injury' and D2 a 25 year old male was fatally injured. Autopsy findings stated that the cause of death was "Conflagration injuries". Autopsy also found "blunt posterior thoracic trauma with hyper extension injury through T-2 vertebra and fracture of left 6-9 ribs in the subscapular line". I would estimate the speed of impact to be approximately 50 mph with a 50% overlap on left side and collinear. There was some underride of bumper due to braking. (50 mph, 50%, 0 degree)

CASE NO. 129 A 1981 Plymouth Champ sideswiped two vehicles and was directed into the path of a tractor/trailer which impacted the rear end of the Champ. According to the PAR, the sole occupant, a 27 year old male driver was trapped inside the vehicle and died from fire burns. (Since no photos were available specific crash conditions were unknown)

CASE NO. 142 A 1987 Jeep Cherokee was stopped at a light and struck in the rear by a 1972 Mercedes 230. The Cherokee was pushed in the intersection into the side of a third vehicle. The Cherokee burned and the Coroner's report listed fire burns as cause of fatal injuries for the 33 year old male driver. Also 8.6% CO was noted in the blood. (Since no photos were available specific crash conditions were unknown)

CASE NO. 165 A 1982 Ford Mustang, 2 door, was stalled in traffic and struck in the rear by a 1986 Chrysler Lebaron. There were three occupants in the Mustang. Two occupants were able to exit the vehicle before it became engulfed in flames. The driver did not escape the fire and died. No Coroner's report was provided, but it must be assumed that the incident was survivable based on the safe exit of the other two occupants. From sketches this appears to be a right offset/oblique impact to the rear of the Mustang. (Since no photos were available specific crash conditions were unknown)

CASE NO. 144 A 1984 Mercury Marquis was stopped in traffic when struck in the rear by a 1985 International 175 straight truck. The Marquis was pushed into another vehicle which in turn was pushed into yet another. Neither of the secondary collisions resulted in fatalities or serious injuries and the damage severity was relatively low. There were four occupants in the Marquis, two in front and two in the rear. Their ages ranged from 59 to 82 years old. According to the coroner report three positively died from the fire as evidenced from CO found in lungs (ranging from 10-53%) and one left rear seated 82 year old female was so severely burned that the lab was unable to perform TOX test. The autopsy found fracture of third and fourth ribs causing laceration of aorta and contusion of the heart. It may be reasonably assumed that fire would have caused the death of a younger and stronger individual. Therefore this will also be consider for this analysis as a burn related fatality. This was a major fire in which the entire vehicle was consumed, by fuel tank to fuel filler separation. Ignition was likely a result of bumper dragging pavement. Photocopy photos were available but of little use because of poor quality. The crash was approximately 60 - 70 % overlap at 6:00 on the right side of the Marquis. The speed of the truck was reported to be 60 mph but had to have slowed considerably by time of impact, probably to approximately 30-40 mph at impact due to evasive maneuver to right and pre-impact braking. Subject car was spotted just 15 feet prior to impact according to truck driver's statement but this would not have allowed sufficient time for documented evasive maneuvers. (Est. 55 mph MDB, 65 % overlap, 0 degrees)

CASE NO. 175 A 1977 White tractor/trailer was making a lane change and impacted the left rear corner of a 1992 Honda Accord. There was a major fire from fuel tank rupture of the Accord. The sole occupant (driver) of the Honda, a 27 year old male died from fourth degree burns and smoke inhalation according to the death certificate. (Since no photos were available detailed crash conditions were unknown)

CASE NO. 223 A 1986 Chevrolet Nova, four door sedan drifted into the emergency lane and impacted the rear of a parked unoccupied 1976 Dodge Van. A major fire consumed both vehicles and the sole occupant/driver of the Nova, a 31 year old male, died two days after the incident

from thermal burns over 80% of his body. This finding is summarized from a very detailed and thorough autopsy report which was provided. According to sketch in PAR appeared to be a left offset rear impact to van which caused the fuel spillage and fire. (Since no photos were available exact crash conditions were unknown)

CASE NO. 224 V1, a '88 Pontiac with T top turned left into path of V2, an '85 Ford PU. V2 STRUCK V1 at the right front wheel at approximately 2:00 O'clock position. V1 then spun counter-clockwise and turned over. Both vehicles came to rest with the rear of V1 against the right side of V2. The filler cap on V1 was missing and the filler and tank was intact on V2 (left side filler and tank). It was therefore concluded that only gasoline spillage resulting from rupture of the fuel tank could produce such an intense fire as seen in photos. Therefore cause was attributed to the secondary impact between the rear of the Pontiac and the right side of the PU. The secondary collision between the rear of V1 and the side of V2 caused significant distortion in the rear of V1 and likewise caused the breech of the fuel system. There were three occupants in V1. In V1, D1 and P1 were extricated before being consumed by fire while P2 was able to extricate himself. All were teenagers. The two occupants of V2 however, were trapped inside the overturned vehicle and died from asphyxiation. The autopsy listed 12% Carbon Monoxide in D2 and P2. The closing speed of the first impact was approximately 50 mph with the secondary impact speed unknown as part of the damage and buckling may have been due to the side impact. Impact could best be simulated by hitting the rear of the Pontiac at an oblique angle with MDB. (Specific simulation of this crash is difficult due to its complexity)

CASE NO. 219 This was a rear impact between a 1986 Pontiac Sunbird (V1) and a 1981 Chevy Citation 4 dr (V2). V1 was traveling at a speed estimated at 60 mph when striking V2 at 5 mph (stopping for red light). The impact was approx. 70% overlap to the left side. Even though PAR indicated collinear impact, estimate angle of impact appears to be approximately 200 degrees. Closing speed approx. 55 mph. The Citation, V2, immediately caught fire and the sole two front seated occupants of the vehicle burned. Fire was determined to be the cause of death from the evidence pictures. (55 mph, 70%, 20 degrees)

CASE NO. 201 Five Vehicle collision. V1 - '92 International Cabover Tractor/trailer; V2 - '91 Honda Accord 4 dr.; V3 - '92 Dodge Dynasty 4 dr.; V4 - '86 Chevrolet Caprice Classic 4 dr.; V5 - '92 Dodge Dynasty 4 dr. V1 failed to stop for a changing light (yellow/red) and ran into the back of V2, pushing it through the intersection. V1/V2 combination also struck right side of V4 and left side of V3 as driver of truck attempted to find an opening. V2 was pushed across intersection into V5 who was waiting to make a left turn from the opposing direction of travel. V2 was wedged under V1 and caught fire from rupture of the fuel tank. V1, V2 and V5 were all engulfed in flames. There were drivers in all vehicle and all but the driver of V2 escaped without injury. It is unknown if the driver of V2 died from the fire or from the impact, but fire would have been fatal if he had survived the impact and the photos show survivable space for the driver. Therefore this is assumed to be a burn related fatality. It appears that the impact was offset to the right side and would be equivalent to hitting with a 3000 pound moving deformable at 55-60 mph. (58 mph, 70%, 0 degrees)

CASE NO. 198 Two vehicle collision where V2, a westbound '76 Chev Monte Carlo went out of control, spun out and entered the eastbound lanes backwards and struck V1, a '90 Ford F-150 who was towing a car trailer with a '67 Chevy Nova SS. The Trailer apparently under-rode the Ford and caused puncture to the fuel tank which resulted in immediate fire. Both drivers were killed. Autopsy was performed on the driver of vehicle #2 showing blunt trauma injuries as cause of death. This was confirmed by photographs. No mention was made in the report of cause of death of V1 driver, nor were photos available. Due to the nature of the fire and vehicle damage it was assumed that fire was the cause of the death. The Ford was equipped with dual fuel tanks with one of the tanks behind the rear axle. The fire was extensive and burnt both tanks as seen from the photos where the filler cap was blown outward. Though this was not a fire from the initial rear impact, the resulting impact of the trailer to the rear of the pickup truck is very similar to a rear impact with a narrow object. (Specific simulation of this crash is difficult due to its complexity)

CASE NO. 75 A 1991 Dodge Dynasty stopped in traffic was impacted in the right rear by a tractor trailer in a collinear direction. The Dynasty was pushed into another vehicle which in turn was pushed into a stopped tractor/trailer. These secondary impacts did not result in fatalities. There was a major fire in the Dynasty and tractor/trailer and the sole occupant of the Dynasty, a 38 year old male was killed. There was no coroner's or autopsy report, but from the photos the crash appeared survivable for the driver. There was however significant intrusion on the passenger side. From the damage the speed of impact is estimated at 45 mph. (60 mph MDB, right 50% overlap, 0 degree)

CASE NO. 86 This was a vehicle-to-vehicle rear impact into a 1982 Ford Mustang, V1. All three occupants died in the Mustang including driver, right front passenger and rear center passenger (all were in teens). The driver of V2, an '88 Chev Camaro, was charged with 3 counts of homicide and was driving under influence of alcohol. Photos were compared to a crash test conducted at similar conditions and the crash was judged to be a 70% right overlap at approximately 60 mph. No autopsy or witness reports were furnished. Determination of conflagration fatalities was based on examination of damage from photos, age of occupants and apparently rapid fire spread. (55 mph MDB, right 70% overlap, 15 degree from right)

CASE NO. 218 V1, a '90 Ford Econoline impacted the rear of a slow moving '84 Nissan Sentra 4 door sedan. On impact, V2 burst into flames according to eye witness accounts. V2 was traveling on a four lane divided highway with flashers on, apparently due to some vehicle defect. V1 failed to see V2 and impacted the rear end of V2 at full highway speed (55 mph limit), probably around 65 mph with V2 traveling around 15 mph for a closing vel. of 50 mph. There was severe damage to the rear of V2 with moderate damage to the front of V1. Though it was difficult to determine from photos, appears to be sightly offset to left of V2 (70-90% overlap). The sole occupant/driver in V2, a 26 yr. old female was consumed by the fire and burned beyond recognition (dental records were used for ID). There was no coroner's report included, but the crash appeared survivable in the absence of fire. (50 mph MDB, 80% left overlap, 0 degrees)

CASE NO. 24 This was a five vehicle collision which resulted in four vehicle fires and eight fatalities. Incident occurred when V1, a 1979 Dodge Aspen, stopped in traffic, was struck in rear by a Tractor/Trailer hauling cars which failed to stop due to defective brakes. The Dodge Aspen which immediately caught on fire from a ruptured fuel tank then hit the rear of an '88 Plymouth Colt. Subsequently the Tractor hit the Colt and pushed it into a parked construction vehicle. Also the Colt was damaged from a car which became dislodged from the car carrier. The death certificate listed conflagration as the cause of death for all 3 occupants of the Aspen and all 5 occupants from the Colt. All vehicles except the construction vehicle burned. This was a very catastrophic crash and although conflagration was listed as cause of death, there would certainly have been serious injuries without fires.

Frontal Crashes

CASE NO. 173 Single vehicle crash occurred on a state highway. The vehicle, a 1988 Toyota pickup, traveling at a high rate of speed ran off the roadway. It hit an earth embankment, became air borne, and nosed-down into the ground. Then went through an end-to-end rotation, crushing the roof and came to rest on its wheels and caught fire. The lone driver, a 21-year old male, was found lying face up across the seat with his head partially outside, pinned between the door and roof. Certificate of death, based on autopsy stated he died of acute carbon monoxide poisoning and generalized (100%) body burns. There was evidence at the scene that the driver had been drinking.

CASE NO. 87 Two-vehicle frontal collision occurred on a U.S. highway. Vehicle #1, a 1988 Ford pickup, crossed the center dividing line and collided head-on with vehicle #2, a 1989 tractor-trailer traveling in the opposite direction. Vehicle #1 sustained heavy damage to the left front end and was totally consumed by the ensuing fire. The lone driver, a 19-year old male, died at the scene. Medical examiner report listed soot in bronchi and trachea and blood alcohol concentration (BAC) of 0.18 and carboxyhemoglobin. Cause of death was listed as incineration and smoke inhalation. Medical examination was performed without autopsy. Prior to the fatal crash, vehicle #1 was allegedly involved in an crash earlier in the day resulting in damage to its left front end and left front wheel assembly. The collision forced vehicle #2 off the roadway into the dirt shoulder, causing the trailer to overturn onto its right side. Vehicle #2 sustained heavy front end damage and damage to the right side of the trailer. The lone driver suffered minor bruises and blunt chest trauma.

CASE NO. 95 Single vehicle crash occurred on a state highway. The vehicle, a 1986 Ford pickup, ran off the right side of roadway and hit a concrete culvert. It sustained heavy crush damage to its front and the entire cab. After the impact the vehicle flipped onto its roof and caught fire. A medical examiner's's report for the 32 year old male stated he died of "severe flame burns" inside the vehicle. There was no autopsy or detailed medical examination. The 19-year old male passenger received broken ankles and leg, minor cuts, bruises and burns. Based on statement given by this passenger, both he and the driver had been consuming alcohol since 5 PM in the day.

CASE NO. 189 Two-vehicle side collision occurred at an intersection of a state highway. Vehicle #2, a 1983 tractor-trailer, failed to stop at stop sign and was struck at the left side by vehicle #1, a 1984 Chevrolet van towing a house trailer. After the impact vehicle #2 partially jack-knifed

and came to rest inside the intersection. Vehicle #1, severely damaged by the impact, caught fire and was completely destroyed. There was also fire damage to the front of the house trailer. Medical report stated that the lone driver of vehicle #1, a 58-year old male, died of partial incineration, extensive pharynx and hypopharynx, and was found to have tracheal soot deposition. An autopsy was performed. The driver and two passengers in vehicle #2 suffered no injury.

CASE NO. 188 Single vehicle crash occurred on a state highway. The vehicle, a 1986 Ford pickup, ran off the right side of the roadway and struck a large tree with its left front. Upon impact the vehicle rotated counter-clockwise and burst into flames. The 22-year old male driver, ejected upon impact, fell under the rear of vehicle and suffered serious injury. The medical report stated that the 16-year old male passenger was partially ejected out left door and died of asphyxia and conflagration. An autopsy and toxicology test was performed. Tests showed that the driver and the passenger each had a BAC of 0.14 and 0.18, respectively.

CASE NO. 180 Two-vehicle frontal collision occurred on a state highway. Vehicle #1, a 1991 Toyota Celica, crossed the center line into the path of vehicle #2, a 1987 Ford pickup. Vehicle #2, struck by the front of vehicle #1 at left front, went off the roadway, overturned and caught fire. It came to final rest laying on its right side and was completely destroyed by the fire. The center seat passenger, a 70-year old female, died of carbon monoxide asphyxia at the scene. This finding was stated in a certificate of death, but no autopsy was performed to support findings. The driver and the right seat passenger suffered serious injuries. Vehicle #1 came to final rest on the roadway after the collision. The lone driver, a 20-year old male, died the following day in a hospital of central nervous system trauma and basilar skull fractures. Tests showed he had a BAC of 0.20.

CASE NO. 182 Two-car frontal collision occurred on a state highway. Vehicle #1, a 1986 BMW, traveling wrong way collided head-on with vehicle #2, a 1989 Cadillac. Upon impact vehicle #1 burst into flames and came to rest against a utility pole in the median with its right side. According to medical examiners report, the 38-year old female driver and the 37-year old male passenger both died of fire burns inside vehicle. An autopsy was performed. The lone driver of vehicle #2, a 52-year old male, suffered serious injuries.

CASE NO. 168 Single-car crash occurred on a state highway. The vehicle, a 1986 Ford Taurus, traveling at a very high rate of speed ran off the roadway and struck a concrete median. It then burst into flames, flipped down an embankment and landed on its top. The lone driver, a 23-year old male, was trapped in the car and died of total body burns according to the coroner's report. Tests showed that he had a BAC of 0.301 and a CO of 10%.

CASE NO. 120 Two-vehicle front to side collision occurred on a state highway. Vehicle #1, a 1988 Chevrolet S-10 pickup, crossed the centerline in a right curve and struck the driver side of vehicle #2, a 1979 Mercury Zephyr. After the impact, vehicle #1 rolled to its right, landed on its top and caught fire, trapping the driver inside. The lone driver, a 21-year old male, died at the scene. Coroners report stated he had a 12% CO in his blood and a BAC of 0.150. No autopsy report was provided and it is unknown whether one was conducted. The lone driver of vehicle #2, a 54-year old male, was ejected from the vehicle and died of injuries at the scene.

CASE NO. 138 Two-car frontal collision occurred on a U.S. highway. Vehicle #1, a 1984 Honda Accord, crossed the center dividing line into the path of vehicle #2, a 1986 Toyota Celica, and struck vehicle #2 head-on. After the impact vehicle #1 went off the roadway into a ditch, overturned and caught fire. The lone driver, a 24-year old male, was burned to death beyond recognition. The coroners report stated that he had a BAC of 0.291 and a 4% CO in blood. The driver of vehicle #2 was seriously injured and the right front seat passenger suffered minor injury.

CASE NO. 172 Single-car crash occurred on an interstate highway. The lone 36-year old female driver of a 1990 Cadillac Seville had a seizure causing her to loss control of the vehicle. The vehicle ran off the right side of the roadway and struck several trees before coming to rest. It then caught fire trapping the driver inside. The driver died 27 days after the crash in a hospital of sepsis due to major thermal burns.

CASE NO. 174 Single-car crash occurred on a U.S. highway. The vehicle, a 1985 Oldsmobile Delta 88 Royale, failed to stop at stop sign at an intersection. It ran off the roadway and struck an earth embankment before crashing into a building. Upon impact, both the vehicle and the building caught fire. The lone driver of the vehicle, a 84-year old male, died of smoke inhalation at the scene. An autopsy was performed.

CASE NO. 171 Single-car crash occurred on a U.S. highway. The vehicle, a 1983 Chevrolet Citation, traveling

at a high rate of speed went out of control after passing a vehicle in a no-passing zone. It swerved to the left, crossed the centerline, ran off the roadway and struck a drain culvert. The vehicle then went airborne, flipped in the air, and exploded upon landing upright in a ditch. According to the certificate of Death, the lone driver, a 38-year old male, was trapped in the vehicle and died of asphyxiation due to smoke inhalation at the scene. No autopsy was performed. One witness who had seen the driver at a restaurant just prior to the crash stated that the victim appeared to be intoxicated then.

CASE NO. 79 Single-car crash occurred on a city street. The vehicle, a 1984 Chevrolet Citation, traveling at a high rate of speed struck the right curb. It then hit a steel utility pole and caught fire. The impact resulted in crush to the center hood area. The 17-year old male driver was partially ejected and died of blunt impact to trunk with skeletal, visceral and vascular injuries. One 18-year old male passenger was found dead on the right front seat with fourth degree thermal burns of head, neck, trunk and extremities. A detailed autopsy report was included from the coroner's office. The three rear seat passengers, found outside the vehicle, were transported to hospitals. Among them a 19-year old male, died of blunt impact to head, trunk and extremities with visceral and vascular injuries upon the arrival at the hospital. The other two passengers suffered serious injuries and burns.

Other Crashes

CASE NO. 183 Single-car crash occurred on a state highway. The vehicle, a 1984 Lincoln Town Car, struck a large metal object on the roadway and caught fire due to severed fuel lines. The two rear seat passengers, a 35-year old female and a one-year old girl, died of fire burns at the scene. Autopsies were performed on both occupants to confirm cause of death from fire. Another rear seat passenger, a 5-year old boy, died of asphyxia and third degree burns at a burns institute the following day (no autopsy). The front center seat passenger and the rear center seat passenger suffered serious injuries. The driver, the right front seat passenger, and the right rear seat passenger suffered no injury in the crash.

Rollover Crashes

CASE NO. 161 Single-car crash occurred on a state highway. The vehicle, a 1981 Mercury Cougar, failed to stop at an intersection, struck the median curbing and became airborne. After striking a guard rail the vehicle landed on its top and burst into flames. The lone driver, a 27-year old male, was trapped in the vehicle and died of fire burns according to coroner's report (no autopsy). Tests showed that he had a 39.2% CO in blood and a BAC of 0.220.

CASE NO. 163 Single-car crash occurred on an interstate highway. The vehicle, a 1992 Toyota Tercel, traveling on the left outside lane ran into several construction barricades on the left and fell into a pit, landing on its right side. The lone driver, a 54-year old male, was trapped inside the vehicle when it exploded into flames. The victim died of fire burns at the scene according to PAR (no autopsy or coroner's report).

CASE NO.19 Single-car crash occurred on an interstate highway. The vehicle, a 1989 Mitsubishi, traveling at a high rate of speed went out of control during a passing maneuver when approaching a bridge. It struck the centerline dividing concrete barrier, hit the guardrail on the right, then climbed up the superstructure of the bridge. After striking the cross beam of the bridge, the vehicle fell back onto the bridge surface on its top and caught fire. Three rear seat passengers, all females ranging in age from 17 to 22, died of "body burns", according to medical examiner's report. Autopsies were performed on these three passengers. The male driver was able to climb out of the vehicle and moved around. The right front seat male passenger who was pulled out of the vehicle suffered serious injuries.

CASE NO. 85 Single-car crash occurred on an interstate highway. The vehicle, a 1990 Dodge Daytona, traveling at an estimated speed of 78 mph, ran off the right side of roadway and struck a concrete culvert with its right front. The vehicle then overturned into a stream, caught fire and burned. The lone driver, a 65-year old male, was found dead inside the vehicle and died of burns according to the PAR (no autopsy or medical report).

CASE NO. 60 Single-car crash occurred on a suburban road. The vehicle, a 1981 Oldsmobile Omega, failing to negotiate a left curve, ran off the right side of the roadway and struck a wooden utility pole head-on. The vehicle then rolled over onto its top and caught fire. The lone driver, a 31-year old male, was trapped in the vehicle and died of fire burns at the scene. He was found to have a 32% CO in his blood (a coroner's report was provided and an autopsy was performed).

Side Impact Crashes

CASE NO. 1 Two-vehicle side collision occurred on a U.S.

highway. Vehicle #1, a 1981 Chevrolet pickup, was struck on the passenger side by the front of vehicle #2, a 1975 Mazda pickup, at an intersection. The collision forced vehicle #1 into the dirt median, struck a delineator and caught fire before coming to rest in a ditch. The damage to the vehicle indicated that it had overturned. A large puncture was found in the vehicle's gas tank on the passenger side. The lone driver, a 61-year old male, died inside the vehicle of "thermal burns", according to medical examiner. No autopsy was performed, but the trachea was opened to examine for soot and none was found. Therefore cause of death is somewhat questionable. The front end of vehicle #2 also caught fire after the impact. The female driver of vehicle #2 and three children ranging from 1 to 6 in age sustained different degrees of injuries and burns.

CASE NO. 6 Two-vehicle side collision occurred on an interstate highway. Vehicle #1, a stolen 1986 Chevrolet C-10 pickup, was traveling at a high rate of speed when it went out of control. The vehicle left the southbound lane, crossed the grass median, struck a concrete drainage ditch, and entered into the path of vehicle #2, a 1990 Ford F-350 U-Haul panel truck traveling in the northbound lane. Vehicle #1 was struck by the front of vehicle #2 on the driver's side and caught fire. The collision forced vehicle #2 into the right lanes where it was struck in the right side and right rear corner by two passenger cars traveling behind in the northbound lanes. The lone driver of vehicle #1, a 27-year old male, was burned beyond recognition at the scene. The certificate of death stated cause of the death as inhalation of combustion products (CO 17.7%), thermal burns, and multiple blunt force injuries. An autopsy was performed. The driver and passenger in vehicle #2, as well as, the driver and two passengers in one of the other two passenger cars sustained various degrees of injuries.

CASE NO. 178 Single-car crash occurred on a state highway. The vehicle, a stolen 1987 Chevrolet Monte Carlo, went out of control, crossed the centerline into opposite traffic lane and then struck a tree at the roadside with the passenger side. Upon impact the vehicle rolled over onto its right side and caught fire. The 37-year old lone driver was trapped in the burning vehicle and died of conflagration, according to certificate of death. An autopsy was performed.

CASE NO. 190 Single-car crash occurred on a state highway. The vehicle, a 1987 BMW, traveling at a high rate of speed failed to negotiate a right curve. It went out of control and crossed over to the grass shoulder of opposite traffic lane. After striking three trees with its right side it rolled over onto the passenger side and caught fire. The vehicle was completely destroyed by the impact and the fire. The driver and the right front seat passenger, both 28-year old male, died of "subtotal incineration, auto crash followed by fire", according to certificate of death. An autopsy was performed.

CASE NO. 159 Two-vehicle collision occurred at the intersection of an exit ramp from an interstate highway. Vehicle #1, a 1986 Chevrolet Camaro, clipped the front end of vehicle #2, a 1979 semi-trailer truck. After bouncing off the truck vehicle #1 struck a curb and became airborne before landing astride a guard rail and burst into flames. The right rear seat passenger, a 16-year old male, was pinned in the wreckage and died of fire burns, according to PAR. No medical report was provided. The driver and the right front seat passenger both suffered serious injuries.

CASE NO. 148 Single-car crash occurred on an interstate highway. The vehicle, a 1990 Volvo 740, ran off the roadway on a left curve when the driver fell asleep at the wheel. The vehicle struck a guard rail with the left front, went down an embankment and struck a tree with its driver side. A fire started under the front of the car quickly spread to the entire vehicle. The driver was able to crawl out of the vehicle and pull the right front seat passenger from the burning car. The two rear seat passengers, a 7-year old boy and a 3-year old girl, died of fire burns in the vehicle, according to PAR. No medical examiner's report was provided.

CASE NO. 116 Two-car side collision occurred on a state highway. Vehicle #1, a 1990 Ford Escort, went out of control and crossed center line into the path of vehicle #2, a 1988 Chevrolet Celebrity. It was struck by the front of vehicle #2 on the passenger side and knocked into a ditch where it was destroyed by the ensuing fire. The lone driver of vehicle #1, a 60-year old male, died of fire burns according to coroner's report. Test showed he had a BAC of 0.165 and 10% or less CO in his blood. The lone driver of vehicle #1 suffered serious injuries.

CASE NO. 102 Two-car frontal collision occurred on an intersection of a city road. Vehicle #1, a 1991 Volkswagen Caravelle van, was struck on the left front by vehicle #2, a 1989 Plymouth Sundance, which was speeding and ran the red light. The lone driver of vehicle #1, a 21-year old female, died of over 80% charring burns, according to medical examiner's report. Test showed the victim has soot in her trachea by a vertical incision. No autopsy was performed. The lone driver of vehicle #2 was seriously injured.