FIRE STUDY

IMPACT INDUCED FIRES: PICKUP DESIGN FEATURE ANALYSIS

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ACKNOWLEDGEMENTS

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INTRODUCTION

This study was designed as a follow up investigation to the previous study, *Impact Induced Fires: Statistical Analysis of FARS and State Data Files (1978-2001)* (Friedman, Holloway, and Kenney, 2004; 2005)[1 2]. The purpose of this follow up study was to determine the incidence of post-collision fires in select pickup trucks and the relation of these fires to design features. The state accident databases used in this study included Minnesota (1993-2002), Maryland (1989-2000), Illinois (1996-2001), and Pennsylvania ((1980-2000). FARS data was analyzed for the periods of 1994-1996 and 2001-2003. The specific pickup trucks were specified by MVFRI for this analysis due to the change in fire rates that had been observed in the previous study. Model years from 1991-2001 were included in current initial analyses; for some vehicles the analyses were expanded to 1981-2001 subsequently. The vehicle groups chosen were the Chevy/GMC S10 Chevy/GMC 1500, Dodge Dakota, Dodge Ram 1500, Ford Ranger, Ford F150, Nissan Frontier, Toyota Tacoma and Toyota Tundra.

Analyses looked at the effects of particular design features with Biokinetics[3 4] providing the characterization of these features. Additional analyses looked at the fire rates observed by particular underhood features for three vehicles, the Chevy/GMC S10, Ford F150, and Ford Ranger vehicle groups. Particular analyses were conducted examining design features by impact mode. An analysis of FARS[5] fire rates by state was compared with previous analyses of state rankings by fire rates.

This report includes a discussion of analytical methods including databases and analysis, findings and graphical presentation of significant results, conclusions with recommendations for further research, and appendices with relevant primary data.

[1] Friedman, K.D., Holloway, E. L., & Kenney, T. A. (2005). *Impact induced fires: Statistical analysis of FARS and state data files (1978-2001)* Report prepared for the Motor Vehicle Fire Research Institute, George Washington University, 2004.

[2] Friedman, K.D., Holloway, E. L., & Kenney, T. A. (2005). *Impact induced fires: Statistical analysis of FARS and state data files (1978-2001)* Society for Automotive Engineers World Congress, April, 2005

[3] Fournier, E. (2004). *Summary Report: Expansion of the Vehicle Fuel System Database and overview of pickup truck history*, Biokinetics and Associates Ltd., Report No. R04-02-v02, May, 10.

[4] Fournier, E., Bayne, T. (2005). *Cone Calorimeter Testing of Underhood Insulation*, Biokinetics and Associates Ltd., Report No. R05-13b, Aug. 23.

[5] Griffin, L. I., Davies, B. T., & Flowers, F. J. (2002). *Studying passenger vehicle fires with existing databases* (NHTSA 98-3588-169). College Station, TX: Safety and Structural Systems Institute, Texas Transportation Institute, Texas A & M University System.

METHODS

DATA

FARS and State Accident Files

The Fatal Accident Reporting System (FARS) accident files from NHTSA for the accident period 2001-2003 were utilized. For examination of the selected vehicle groups, the state accident data files from Pennsylvania, Maryland, Illinois, and Minnesota were utilized for the years presented in Table 1. The number of cases for each state is shown in Appendix 5.

STATE	ACCIDENT YEARS OF DATA ANALYSIS
PENNSYLVANIA	1980 -2000
MARYLAND	1989-2000
ILLINOIS	1996-2001
MINNESOTA	1993-2002

Table 1: State Accident Data for Vehicle Group Analysis

The vehicles selected by MVFRI are presented in Table 2 for the period 1991-2001. The vehicles can be grouped into "smaller" (Group 1) or "larger" (Group 2) based on market segment characteristics. While the initial specification of vehicle groups and design elements was based on recent vehicles studied by Biokinetics (e.g. 2003 model year), it was necessary to project back into time to try to select vehicles with similar names to be consistent with the design element categorization characterized by Biokinetics. The selection of R.L. Polk VINA vehicle codes put into each vehicle group is shown in Appendix 1. Due to name changes over time some minor misclassifications are likely to have occurred.

VEHICLE GROUP 1: SMALLER	VEHICLE GROUP 2: LARGER
Chevy S10	Chevy/GMC 1500
Dodge Dakota	Dodge Ram 1500
Ford Ranger	Ford F-150
Nissan Frontier	Toyota Tundra
Toyota Tacoma	

Table 2: Pickup Vehicle groups for Analysis

DATAANALYSES

FARS STATE RANK COMPARISONS

Overview by State

Accident vehicles that were coded as having fire for Most Harmful Event or those being coded has having a fire were selected and compared with the overall number of vehicles. The rates were computed by dividing the number of fire involved (either MHE or Fire Involved) accident vehicles by the total number of accident vehicles for the respective periods by State. Thus, those vehicles involved in fatal accidents that had fire reported were studied. This analysis does not address the under reporting issue as has been discussed previously (Friedman, Holloway & Kenney, 2005)[6] [7] and further, a smaller subset would be involved if only those vehicles that had a fatality had been selected. The fire rates were then rank ordered and compared with those reported in Griffin (2002)[8].

Data Analysis by State

The state accident files were converted into vehicle level files. Fire rates were determined for each state taking into consideration the idiosyncrasies of the states' coding systems for the fire variable. These considerations are detailed as follows.

Maryland (MD):

For accident years 1993 and later, there were three fields used, a FIRE field, a first event field, and the vehicle Most Harmful Event field. If the first event was fire, it was deemed a pre-collision fire. If not, and the fire field indicated 'Y' then the fire was deemed a post-collision.

For accident years prior to 1993, the vehicle damage fields and the cause of accident fields were used. If the cause was fire, it was coded as a pre-collision fire. If not, and any vehicle damage field was fire damage, then a post-collision fire was indicated.

Pennsylvania (PA):

For all accident years the determining field was Harmful Event. If Harmful Event was coded as a fire, and if it was the first harmful event in the sequence of events, then pre-collision fire was indicated. If it was an event other than the first, then post-collision fire was indicated.

Illinois (IL):

For all accident years the determining fields were a fire indication field and the event fields. If a fire was indicated as the first event, then a pre-collision fire was indicated, if fire was indicated on any subsequent event, then a post-collision fire was indicated.

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[6] Friedman, K.D., Holloway, E. L., & Kenney, T. A. (2005). *Impact induced fires: Statistical analysis of FARS and state data files (1978-2001)* Report prepared for the Motor Vehicle Fire Research Institute, George Washington University, 2004

[7] Friedman, K.D., Holloway, E. L., & Kenney, T. A. (2005). *Impact induced fires: Statistical analysis of FARS and state data files (1978-2001)* Society for Automotive Engineers World Congress, April, 2005

[8] Griffin, L. I., Davies, B. T., & Flowers, F. J. (2002). *Studying passenger vehicle fires with existing databases* (NHTSA 98-3588-169). College Station, TX: Safety and Structural Systems Institute, Texas Transportation Institute, Texas A & M University System.

Minnesota (MN):

For all accident years, the event fields were used to determine fire status. If a fire event follows a collision event, then a post-collision fire is indicated. If the first event is a fire event, then a pre-collision fire is indicated.

Impact Mode Variable

Damage areas were consistent with Friedman, Holloway and Kenney (1, 2) definitions for Maryland, Pennsylvania, and Illinois. For Minnesota, damage areas were defined as DAMAREA with values of 1,2 and 8 were defined as Front; 4,5,6 were defined as Rear; 3 and 7 were defined as Side; and, Rollover was defined by examining the four event fields on the vehicle record (SEQ_EVENT_CODE1 through 4). If any of the four events is equal to the code '11', then a rollover is indicated, and the rollover flag is set to true (1) for that vehicle in that accident.

VINA Codes

Based on the vehicles specified for use by MVFRI and further defined by Biokinetics, R. L Polk's VINA[9] vehicle codes were selected. VINA provided 3711 codes identifying various vehicles. Of the 3711, 325 were selected and used. Those selected are listed in Appendix 1 including manufacturer and vehicle group within the manufacturer identified for each code.

Two proprietary software packages were used extensively to generate results in this study. The primary tool was SAS Release 8.2(TS2M0)[10]. Within this product, much use was made of the macro language, the basic data step, and descriptive procedures. The other tool used extensively was PcVina from POLK, currently at version 2.32. PcVina will interpret a VIN from a vehicle and return extensive descriptive information about that vehicle.

A stand alone module, named the PcVina subroutine, was used repetitively to allow batch processing of state accident records. The module was invoked from SAS. In this fashion the state files could be processed efficiently, rather than using the PcVina product which is configured to process one record at a time.

PcVina Version 2.32 was applied to multiple records using the methodology described in "PC VINA for Windows" (R. L Polk & Co., October 2002). VIN correction (character substitution, or CSUB) and retry logic were implemented as described in the above reference (CSUB is described in chapter 4, page 38, Retry is described in chapter 3, pages 21-22). In short, the CSUB feature of PcVina will attempt to correct common data entry errors in VINs, such as substituting a 'O' for a '0'. The retry feature will process a record twice, first trying to categorize the vehicle as a passenger car, then repeating the attempt, if the first failed, as a truck. Once again, these features are explained fully in the product documentation, as well as how to implement them in the calling subroutine, which was carried out in the module used by FRC.

Before passing the vehicle record to PcVina, the VIN code was checked by a SAS program to see if it included a full 17 Characters. The state data received does not supply the entire 17 characters, so VINs were 0 padded to the right to complete the incomplete VIN. The file was then written out from SAS to a text file, and passed to PcVina, which returns a number of text files, depending on what class of vehicle

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[9] R.L. Polk, VINA Program Manual, PC VINA for Windows", R. L Polk & Co., October 2002.

[10] SAS North Carolina SAS Institute Inc., SAS Campus Drive, Cary, NC 27513

PcVina determines the record belongs. These files are then reprocessed back into SAS data sets and merged back onto the original file by a record number key, maintained throughout the process.

There are instances where PcVina does not correctly associate the proper vehicle attributes with the vehicle it identifies. We found this with engine configurations, where, for instance, a Ford Ranger could be associated with a 5 liter V8, which is not a possible manufacturing combination. After discussion with Polk staff, it was determined that this was a 'feature' of the current software, and we resolved the problem by only allowing vehicles into subsequent analysis that had engine configurations conforming to our external control tables.

In general, analysis of underhood attributes was driven from two sources, one, output from PcVina, and two, project control tables that were indexed by the unique PcVina identifier for a make/model combination. Those analyses that looked at specific underhood attributes were always data and table driven, to exclude as much as possible poorly behaving data from entering the results.

Design Features[11]	Underhood Characteristics of S10, F150, Ranger[12]
Check Valve	Engine Type
Battery Location	Generalized Location of Specific Attributes
Cut off Switch Type	Engine Size
Tank Location	Underhood Insulation
Fuel Tank Type	
Battery Cover	
Fuel Line Routing	
IIHS Structural Performance	

Table 3: Design and Underhood Factors

The analysis was conducted using the previously described data for overall *Fire Rates by Model Year* and *Fire Rates by Design Group*. Additionally, specific factors related to General Design and Underhood Characteristics were extensively analyzed and are presented in Table 3.

A series of analyses were conducted during the project. Initially the analyses utilized data from Pennsylvania, Maryland, and Illinois. When the Minnesota data was obtained the analyses were redone in various ways ultimately with all the states included. Based on the preliminary results, the analyses were expanded to consider the underhood characteristics provided by Biokinetics[13] for three of the vehicle groups. The analyses were then expanded to include the earlier model years and the analyses were redone to include these earlier model years. Appendix 2 contains the specifications for the design features by vehicle group and model year; the tables are labeled to indicate major change in the design features and utilize colors to indicate changes in part numbers. If no change is indicated in the design feature other than the color then the design feature was assumed to have the same functionality identified for the model year next up the chart until a clear change was identified.

[11] The specifications available for these factors are shown in Appendix 2.

[12] The specifications available for these factors are shown in Appendix 3.

[13] Fournier, E. (2004). Personal correspondence. Biokinetics, Ottawa, Ontario, Canada.

RESULTS

FARS STATE RANK COMPARISON

Overview by State

The rank order comparisons between the 1994-1996 results (see Griffin this report page 9) and the 2001-2003 results are shown in Figure 1. The Griffin 1994-1996 rankings are shown in blue with the present results shown comparing the state's present relative rankings to the previous rankings. As can be seen,

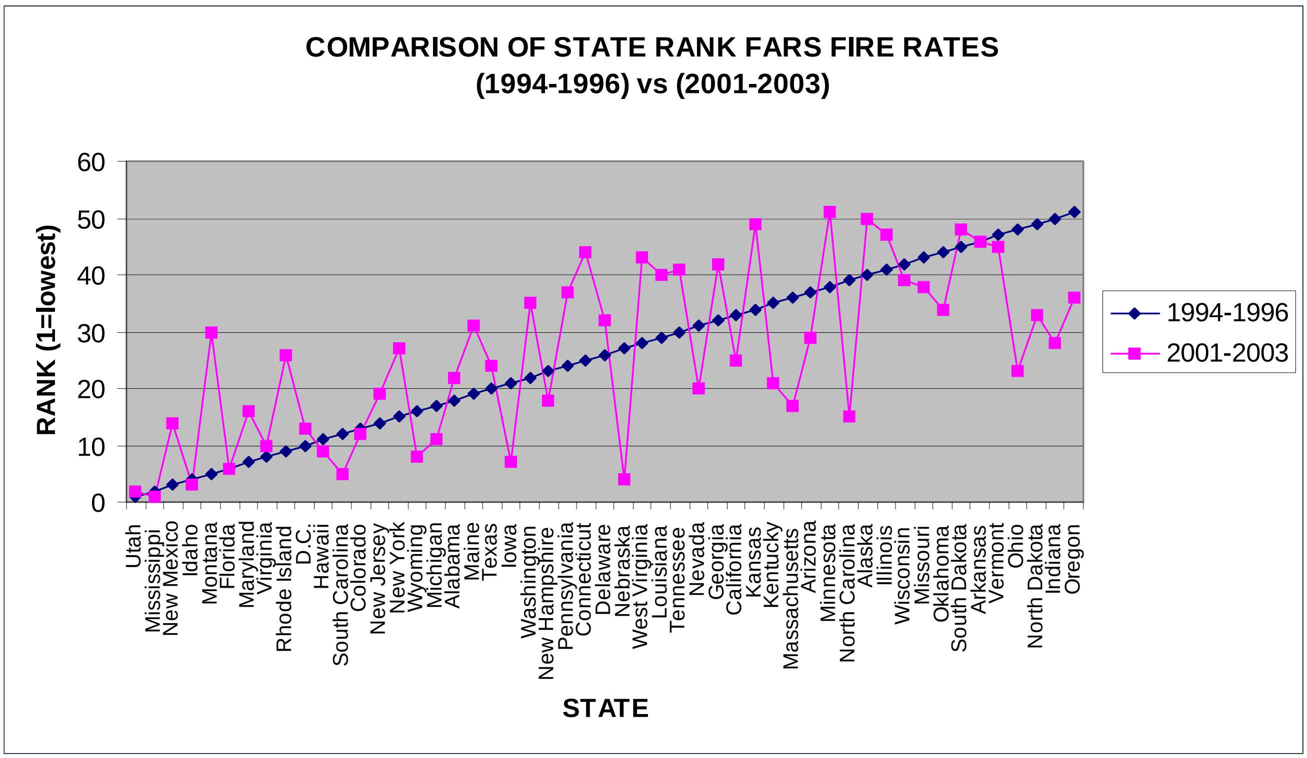

Figure 1 Comparison of Fire Rate Rank by State 2001-2003 v 1994-1996

substantial changes have occurred in the rank order of the states since the 1994-1996 period. It is also the case that police forms have been revised in many states since that period. An examination of the effect of changes in the police forms utilized would help explain the rank order changes in the fire rates by states. Of note, Utah continues to be the lowest fire rate state because the police accident form does not provide any means for indicating a fire to a FARS analyst. There is no discussion section, or any variable that would indicate the presence of a fire and hence it is not surprising that Utah continues to have the lowest fire

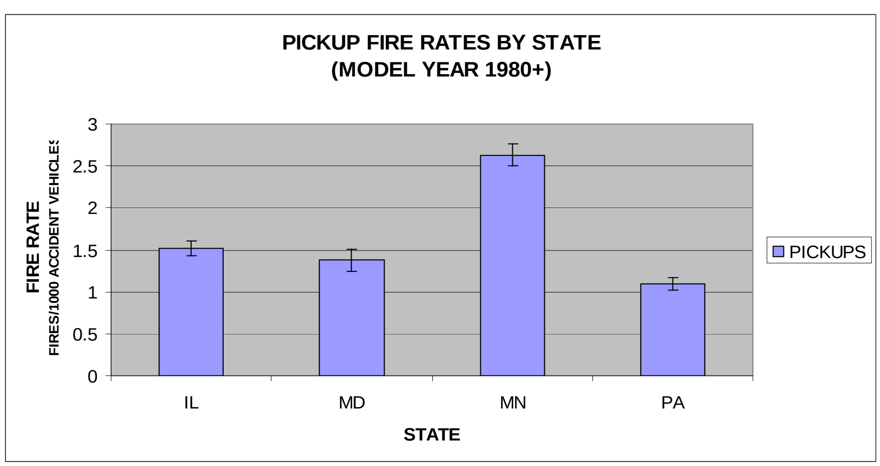

Figure 2: Pickup Fire Rates by State (Model Year 1980+)

rate in the country. On the other end, examination of Vermont, whose fire rate rank dropped considerably, was found to have dropped the fire variable that had been on its police form, and hence indications of a fire would only be available to the FARS analyst if reference to a fire had been included in the discussion section of the police report. Graphs of the percentages and counts of fires by state for the 2001-2003 period are contained in Appendix 4

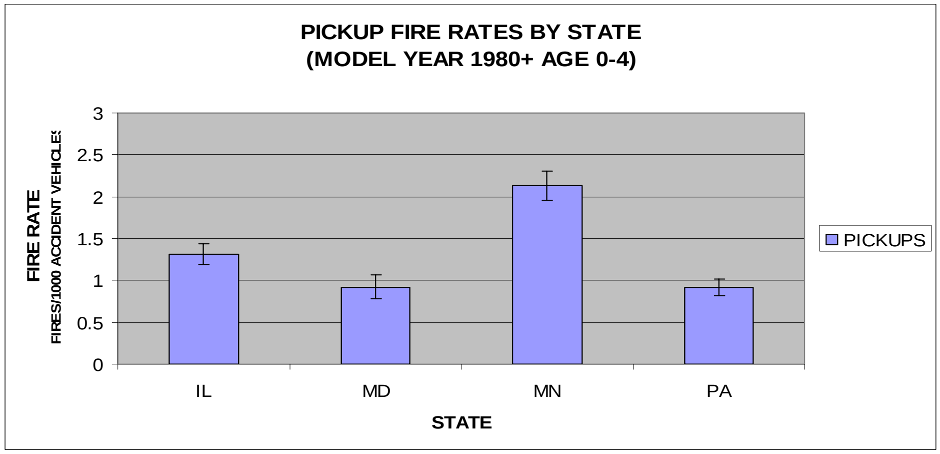

Figure 3: Pickup Fire Rates by State (Model Year 1980+ Age 0-4)

An overview of the fire rates for the pickups of interest by state for model years 1980 or newer are shown in Figure 2 while the added restriction of the vehicle being 0-4 years old is shown in Figure 3. Of interest are the substantially higher fire rates observed in the Minnesota data, but well within variations shown in Figure 1. Minnesota has the most detailed event recording of these four states with four events per vehicle on the police form. Also, these figures are consistent with findings that fire rates for younger vehicles are lower than those for older vehicles. Appendix 5 contains the data tables for Figures 2 and 3.

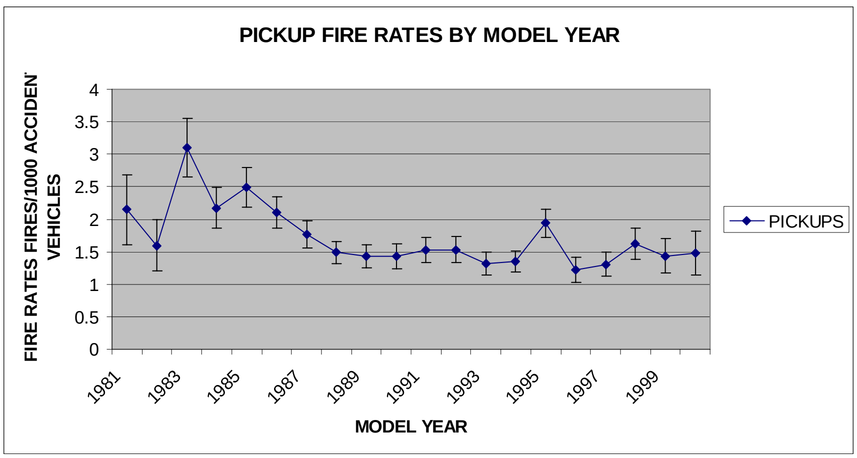

Figure 4: : Pickup Rates by Model Year

The fire rates observed for the vehicle groups of interest with the combined data are shown in Figure 4. The data show a decline to a fairly constant level over the past 12 years. However, in the limited data for the 2001 model year a higher fire rate was observed. The 2001 model year uptick needs to be investigated with additional data.

Examination of the effects of controlling for vehicle age (0-4 years) illustrates the expected reduction in fire rates for vehicles while they are fairly new (see Figure 5).

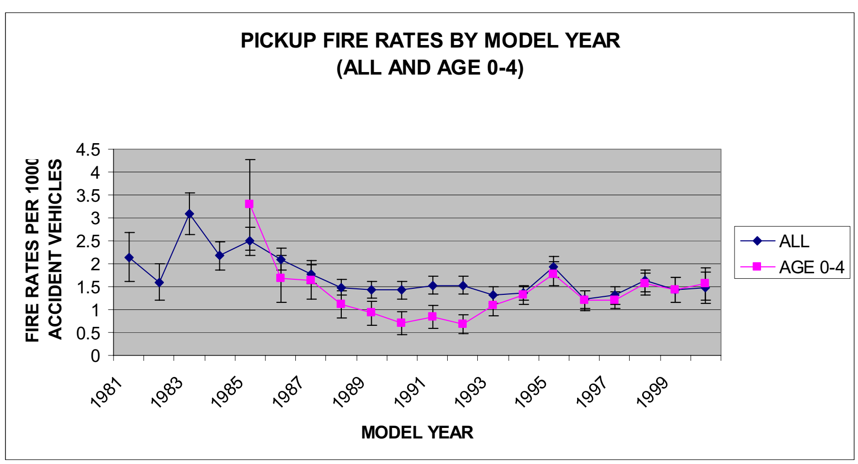

Figure 5: Pickup Fire Rates by Model Year (0-4)

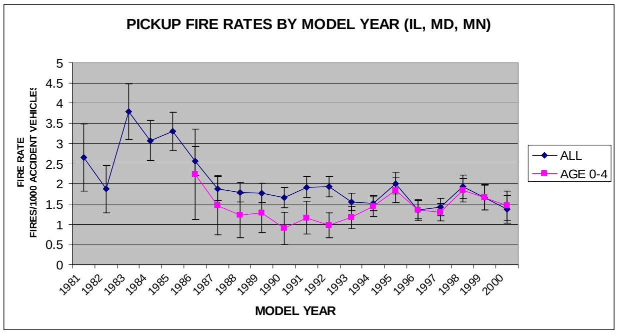

Figure 6: Pickup Fire Rates by Model Year (IL, MD, MN)

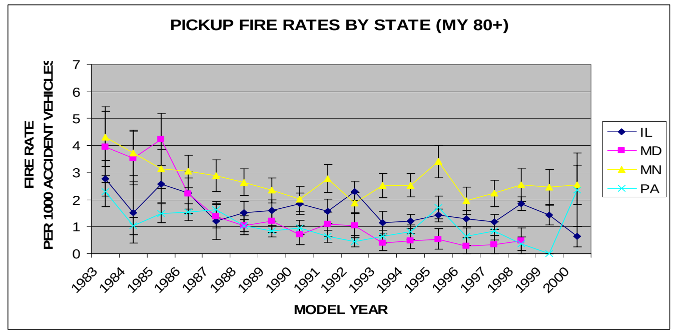

Figure 7: Pickup Fire Rates by State (MY 80+)

Eliminating the Pennsylvania data (with its low fire rate that has been fairly constant across the entire time its data has been collected) from the mix of states results in an increase in the fire rates across model years (Figure 6).

Overall examination of the fire rates by model year for the vehicle groups of interest shows fairly consistent trends across states, with basic offsets that likely reflect the reporting capabilities within the states (Figure 7). However, basically, there appears a decline from earlier levels to a fairly constant fire rate level in the 1990's.

Fire Rates by Design Group

Looking at the vehicle groups across states it can be seen that that the highest fire rates are observed in the larger pickups shown in red in the figures above (see Table 2 on page 8) and that consistently within a manufacturer group the smaller pickups (see Table 2 on page 8) had lower fire rates. Figure 8 illustrates this for all the vehicle ages, while Figure 9 illustrates this for vehicles ages restricted to 0-4 years old. The Tundra group is omitted due to paucity of cases for this group in the resulting data.

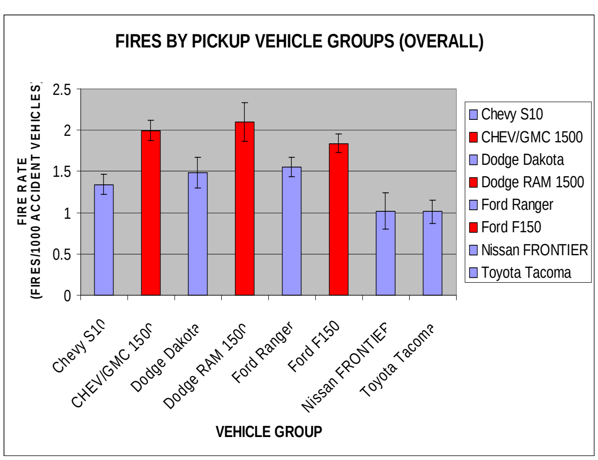

Figure 8: Fires by Pickup Vehicle Groups (Overall)

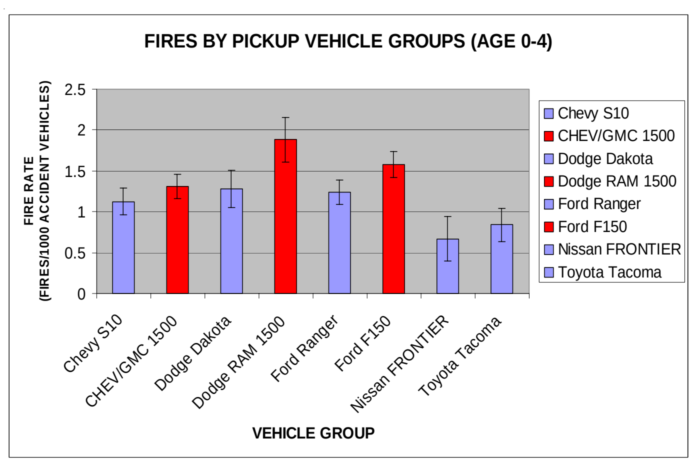

Figure 9: Fires by Pickup Vehicle Groups (Age 0-4)

Fire Rates by Vehicle Group and Model Year

The fire rates by model year for each vehicle in the four state data are shown in Figures 10 through 16. Of interest are the rapid declines observed after the 1987 model year for the Chevy/GMC 1500 pickup (see Figure 10) and the declines observed in the Ranger pickup (see Figure 14), among other features. In general the smaller vehicles have lower fire rates than the larger vehicles across model years. It is reported

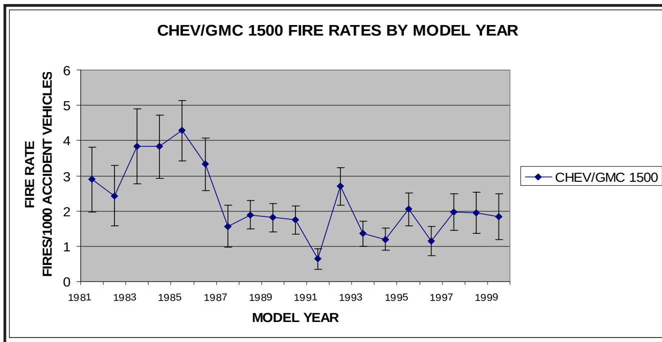

Figure 10: Chevy/GMC 1500 Fire Rates by Model Year

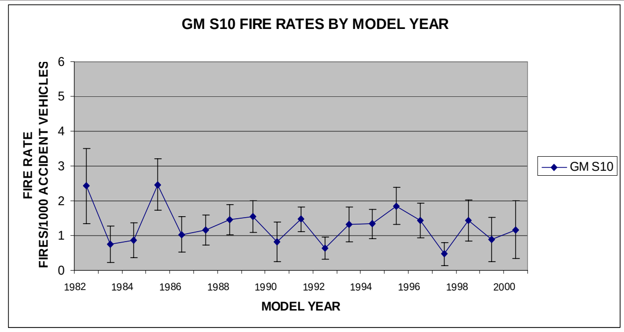

Figure 11: GM S10 Fire Rates by Model Year

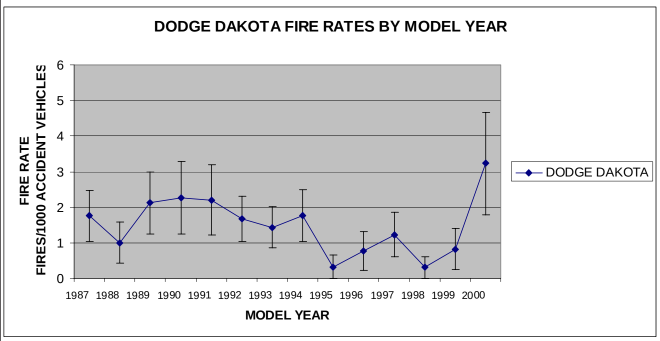

Figure 12: Dodge Dakota Fire Rates by Model Year

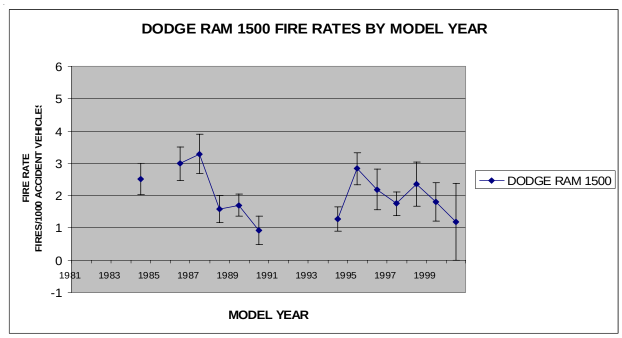

Figure 12a: Dodge Ram 1500 Fire Rates by Model Year

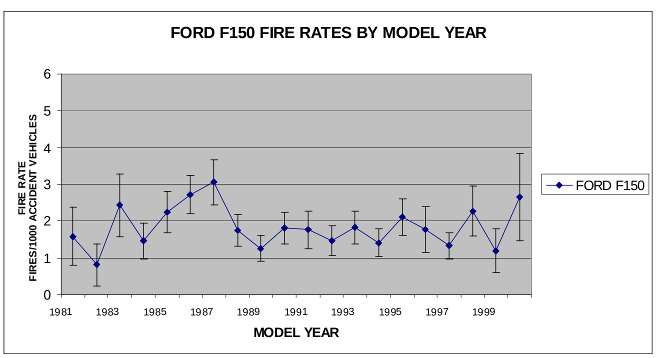

Figure 13: Ford F150 Fire Rates by Model Year

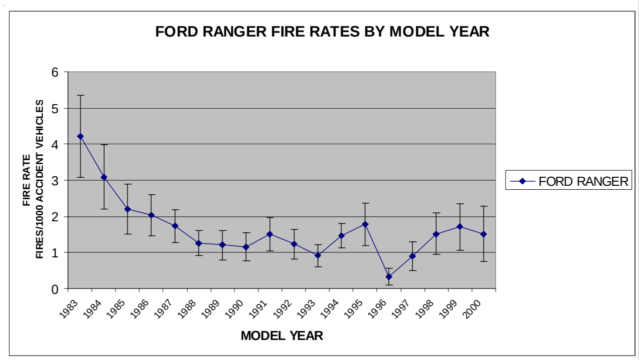

Figure 14: Ford Ranger Fire Rates by Model Year

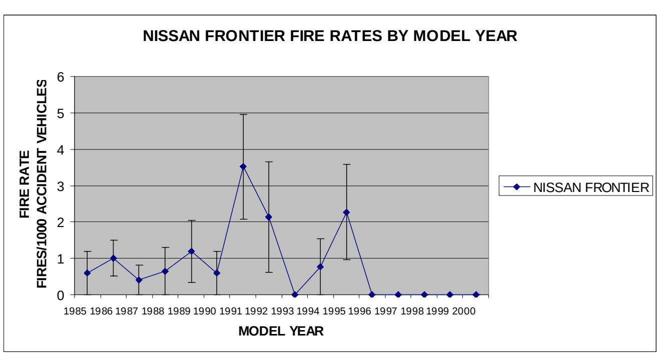

Figure 15: Nissan Frontier Rates by Model Year

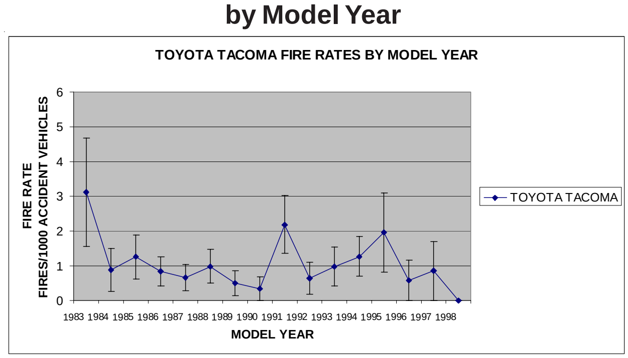

Figure 16: Toyota Tacoma fire Rates by Model Year

that the major change that occurred in the Chevy/GMC 1500 for the 1987 model year was a conversion from carburetion to fuel injection; the vehicle structure had a substantial change for the 1988 model year. With regard to the Ford Ranger in the 1983-1988 time frame, a transition was occurring from carburetion to fuel injection. With regard to the Ford F150 between 1987 and 1988, there was a vehicle design change and the engines went from carburetion to fuel injection. The Toyota Tundra is not shown due to a lack of cases.

Pickup Fire Rates by Design Feature

The observed fire rates for those vehicles with particular design features are shown in this section. The factors examined were: a) check valve, b) battery location, c) cutoff switch type, d) tank location, e) tank type, f) battery cover, g) fuel line routing, and h) IIHS structural performance. The model years used were the ones specified in Appendix 2 which are typically model year 1991-2000; the accident data years are those specified in the Methods Section. Appendix 2 illustrates how the design features changed over time within a vehicle group; the analyses take account of the changes within a vehicle group to allocate that appropriate model year to the vehicle design feature characteristic under study. The population values for each graphic are contained in Appendix 4.

Design Feature: Check Valve

In this discussion we are referring to the check valve in the filler line. .Examination of the effect of the presence (Y) or absence (N) of check valve alone did not indicate a change in the observed fire rates for

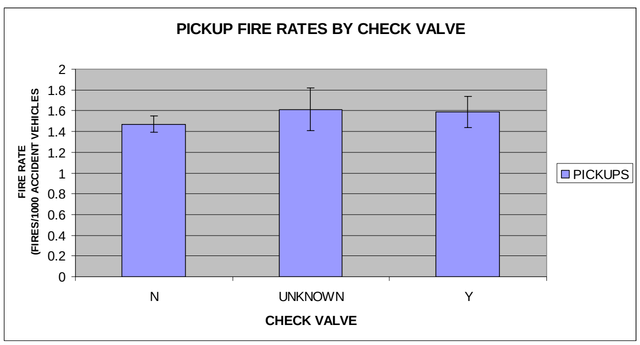

Figure 17: Pickup Fire Rates by Check Valve

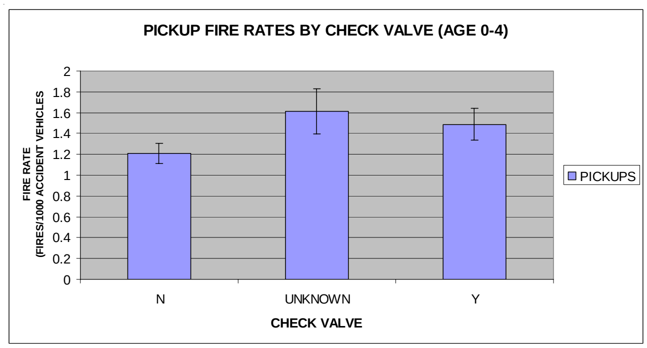

Figure 18: Pickup Fire Rates by Check Valve (Age 0-4)

these vehicles (see Figure 17) without regard to vehicle age. The fire rates observed were similar when distinguishing vehicles simply on this factor. However, vehicles with age (0-4) without a check valve were observed to have a slightly lower fire rate (Figure 18).

Design Feature: Battery Location

Location of the battery in the engine compartment (EC) on the front left (F/L), front right (F/R) or on the middle right (M/R) by itself did not predict differences in the observed fire rates for these vehicles (Figure 19).

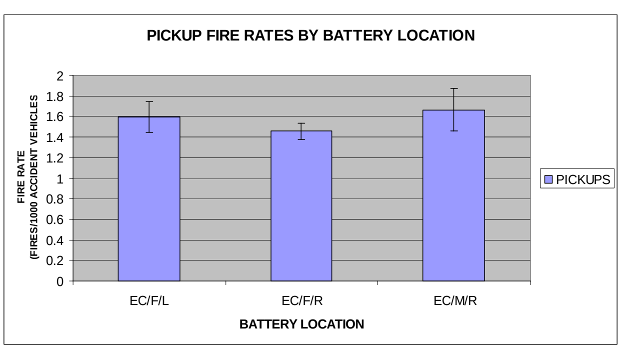

Figure 19: Pickup Fire Rates by Battery Location

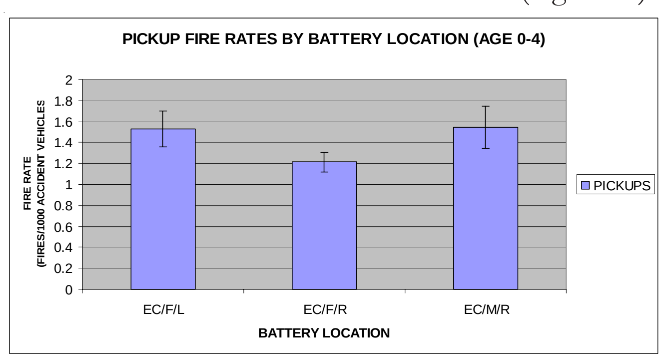

Figure 20: Pickup Fire Rates by Battery Location (Age 0-4)

For newer vehicles with a battery location that was in the engine compartment on the front right had slightly lower observed fire rates (Figure 20).

Design Feature: Cutoff Switch Type

The fires rates controlled for cutoff switch type between inertial types and relay types are shown in Figure 21. The fire rates observed were similar when distinguishing vehicles simply on this factor. While

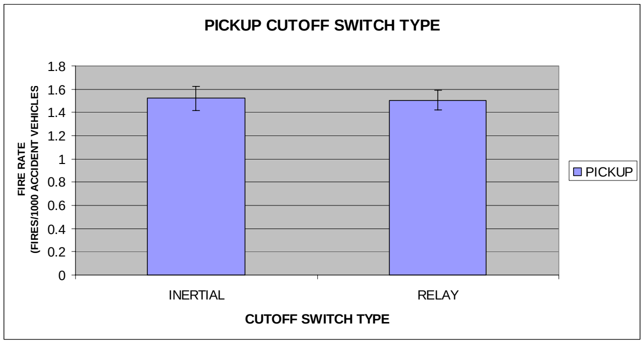

Figure 21: Pickup Cutoff Switch Type

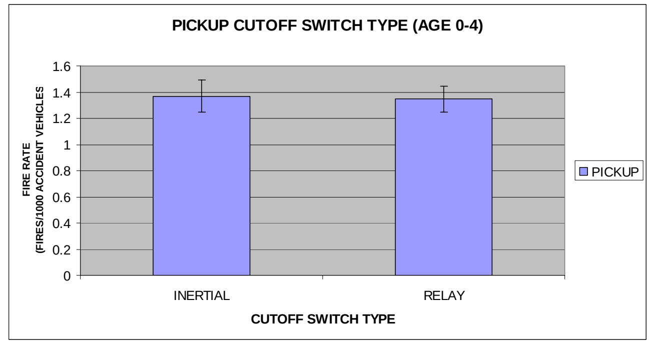

Figure 22: Pickup Cutoff Switch Type (Age 0-4)

the fire rates were lower for younger vehicles (0-4 years old), the fire rates were still similar between vehicles with one or the other type (see Figure 22). All vehicles had a fuel pump cutoff switch; however, the type was not known for one of the vehicles.

Design Feature: Tank Location

The overall fire rates controlled for tank location are shown in Figure 23 and Figure 24 for overall and vehicle age controlled groups, respectively. The vehicles selected with tank locations that were inside the frame rail (I) and on the front left (I/FR/L) and inside the frame rail and on the front right (I/FR/R), had similar fire rates without controlling for impact configuration for these vehicle groups and when

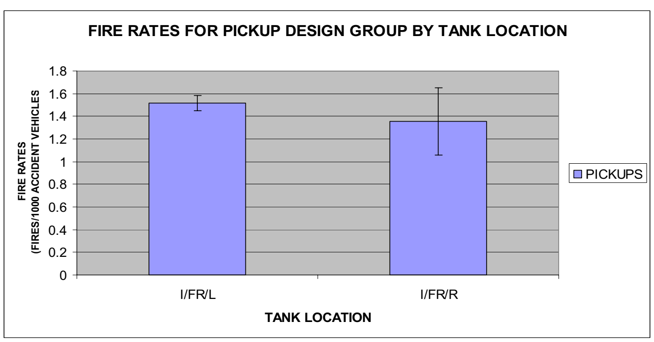

Figure 23: Fire Rates for Pickup Design Group by Tank Location

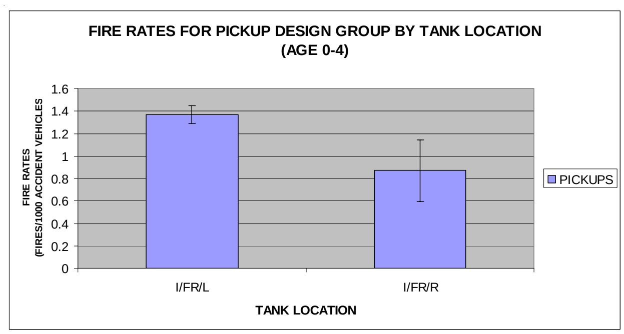

Figure 24: Fire Rates for Pickup Design Group by Tank Location (Age 0-4)

controlling simply for this factor alone. Locations that were inside the frame rail on the front right can be seen to have slightly lower overall fire rates particularly for the newer vehicles (vehicles ages 0-4). However, only one vehicle had this design so the number of cases is lower as indicated by the standard error bar. The data counts are contained Appendix 5.

Design Feature: Tank Type

Examination of fuel tank type indicates that the vehicles with plastic tanks have slightly higher observed fire rates than the vehicles with steel fuel tanks with the difference in the observed rates being a little less (not significant) with all vehicles ages than in the newer vehicles as shown in Figure 25 and

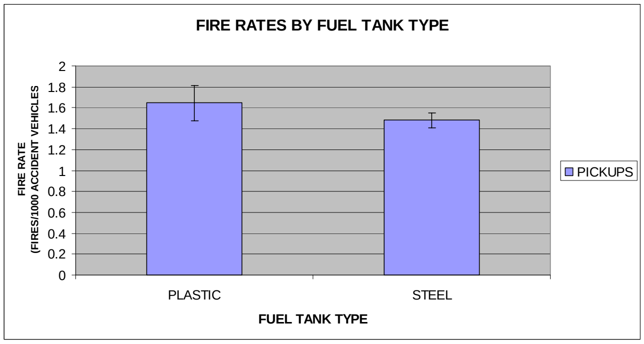

Figure 25: Fire Rates by Fuel Tank Type

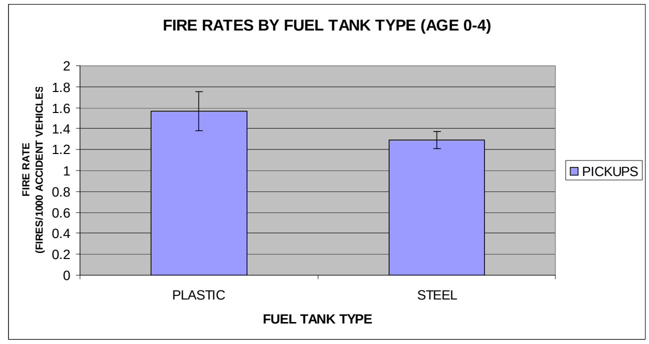

Figure 26: Fire Rates by Fuel Tank Type (Age 0-4)

Figure 26 respectively. The data counts are contained in Appendix 5. Further analysis of the tank type effects are discussed under Tank Type Analysis by Impact Mode later in the report.

Design Feature: Battery Terminal Cover

The design group vehicles without battery covers had lower observed fire rates than those with battery covers both for vehicles of all ages and for vehicles 0-4 years old as shown in Figure 27and Figure 28,

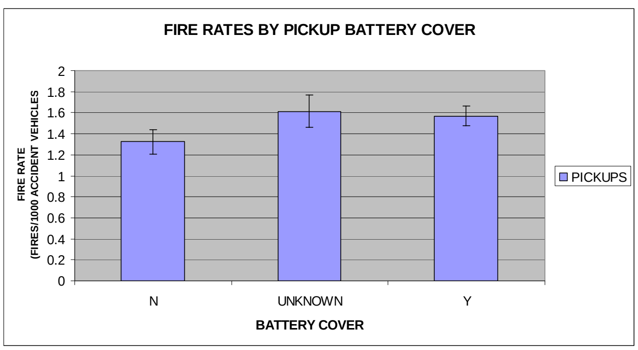

Figure 27: Fire Rates by Pickup Battery Cover

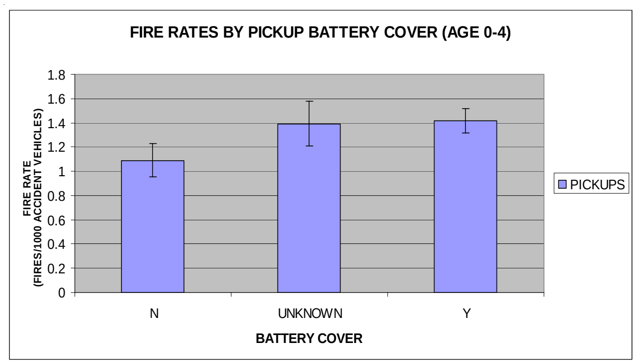

Figure 28: Fire Rates by Pickup Battery Cover (Age 0-4)

respectively. The unknowns correspond to the Chevy/GMC 1500 for model years 1991-1998 and the Toyota Tacoma model years 1991-1994. Recall that the Dynamic Science report from 1974 indicated that a battery terminal cover was thought to be an important factor in the prevention of fires. Battery terminal covers as defined by Biokinetics indicated either an insulating cap over the positive terminal or a box around the entire battery.

Design Feature: Fuel Line Routing

Selected vehicles with fuel line routing characterized as being to the Left or the Right were found to have similar observed fire rates for vehicles of all ages (Figure 29) although for vehicles 0-4 years old (Figure 30)

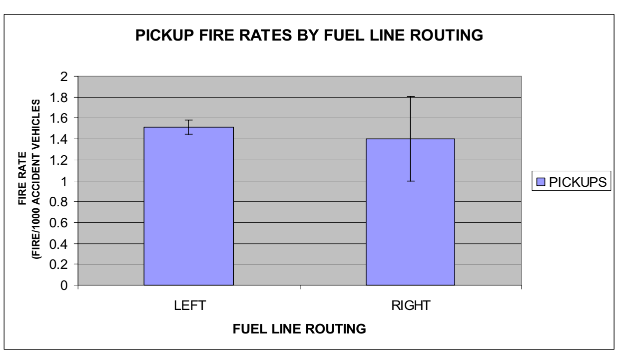

Figure 29: Pickup Fire Rates by Fuel Line Routing

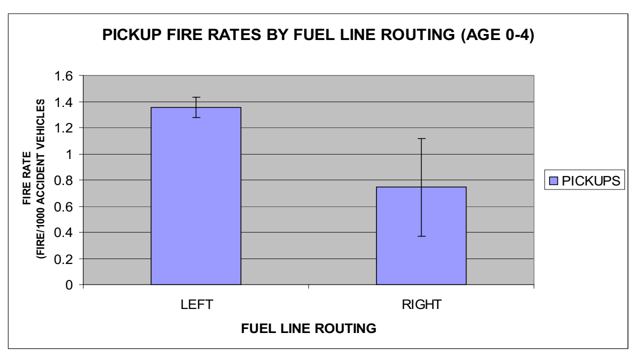

Figure 30: Pickup Fire Rates by Fuel Line Routing (Age 0-4)

the right side the observed fire rate was substantially reduced again, however there was only one design group (Nissan Frontier) with this feature. Based on the Biokinetics information it was not possible to determine whether the fuel line routing is on the opposite side of an inline engine exhaust manifold.

Design Feature: IIHS Structure

Consideration was given to the observed fire rates based on the Insurance Institute for Highway Safety (IIHS) offset impact test classification. The data were filtered to include only the model years consistent with the crash test results. Since the vehicles of interest had been tested in the fairly recent past, the overall vehicle age results and the 0-4 year old vehicle results are very similar (Figure 31and Figure 32, respectively). The categorization utilized by IIHS is that (A) stands for Acceptable, (M) stands for

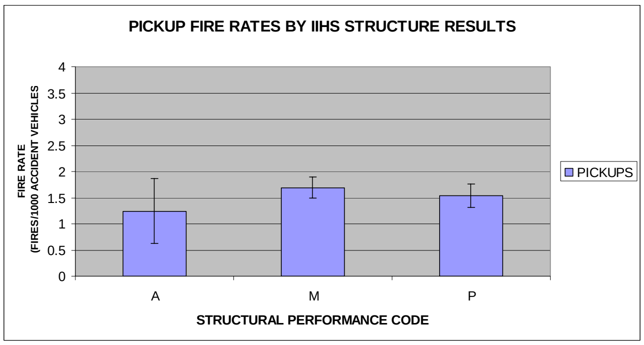

Figure 31: Pickup Fire Rates by IIHS Structure Results

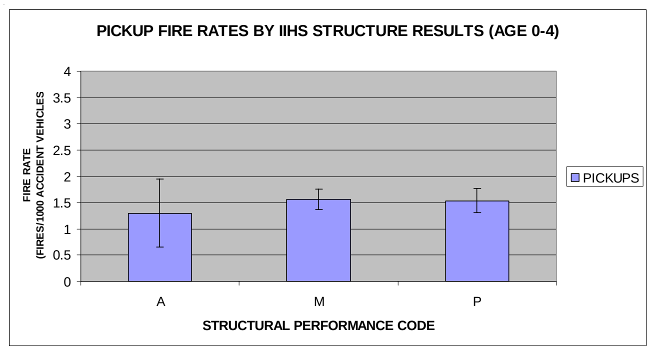

Figure 32: Pickup Fire Rates by IIHS Structure Results (Age 0-4) .

Marginal, and (P) stands for Poor. There were not enough cases in the (A) group to expect meaningful comparisons between the (A) group and the (M) and (P) groups. There was no difference between the (M) and (P) groups in this analysis.

Summary of Initial Design Feature Analysis

The results of the initial design feature analysis indicated areas of interest for further work particularly with regard to tank type, tank location, check valve and battery location. Subsequent results in these areas found differences in fire incidence associated with some of these design features under particular conditions as discussed later in the report under comparative analyses of design features controlled for impact mode.

Underhood Characteristics of S10, F150, Ranger

Further analyses were done on a selected subset of the vehicle groups. During the initial work it was observed that the smaller vehicles had lower observed fire rates within a manufacturer and across manu-

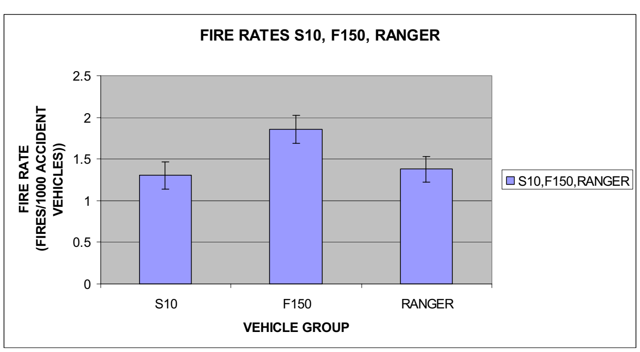

Figure 33: Fire Rates S10, F150, Ranger

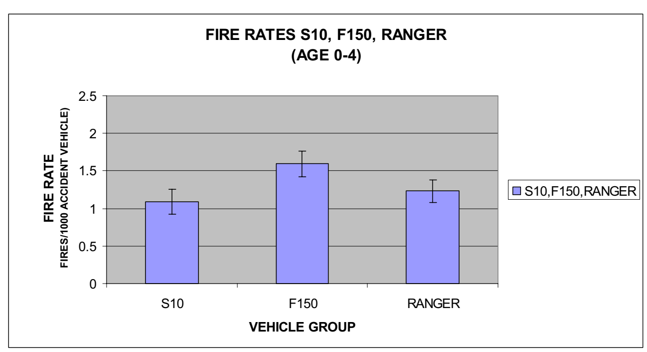

Figure 34: Fire Rates S10, F150, Ranger (Age 0-4)

facturers. Some fuel system design features were selected for examination. However, the data supplied indicated for the most part that they either did not discriminate between the 3 vehicles, or the data could not be obtained sufficiently. However, engine characteristics sizes and cylinders were available. Hence an analysis of the engine features was conducted. The results are described in this section. The counts for these cases are slightly lower than the initial analyses due to control for known engine characteristics.

The overall fire rates for these vehicle groups are shown in Figure 33 and Figure 34 for the all vehicles characterized and those that were 0-4 years old respectively. As is familiar the younger vehicles had lower fire rates than when all ages were considered. However, we can also see that the larger vehicle had observed fire rates that were higher than the two smaller vehicle groups.

Fire Rates by Model Year, Engine Type, and Size

The results shown below indicate that smaller powertrains result in lower fire rates than larger powertains within a particular design in general. Inline engines generally appear to result in lower fire rates than V engines within a vehicle group controlled for the range of model years with the same structural design.

F150

The F150 results for the 0-4 year old vehicles are shown in Figure 35. The categories are by engine size (Liters), model year range with similar vehicle design (e.g. 1987-1991), and engine type [(e.g. I6 (inline 6), V6, or V8].

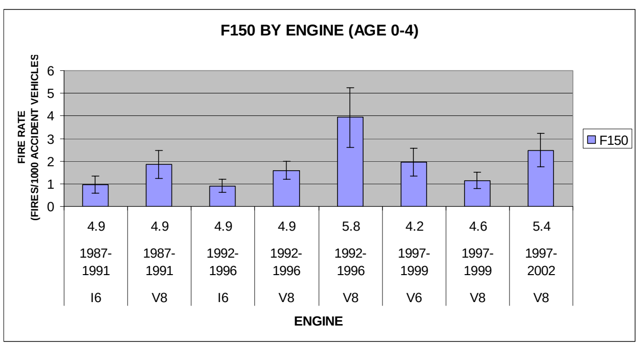

Figure 35: F150 by Engine (Age 0-4)

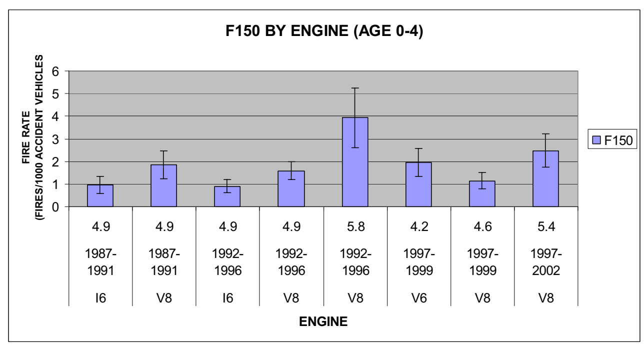

Figure 36: 1987-1991 F150 Fire Rates by Engine Size (Age 0-4)

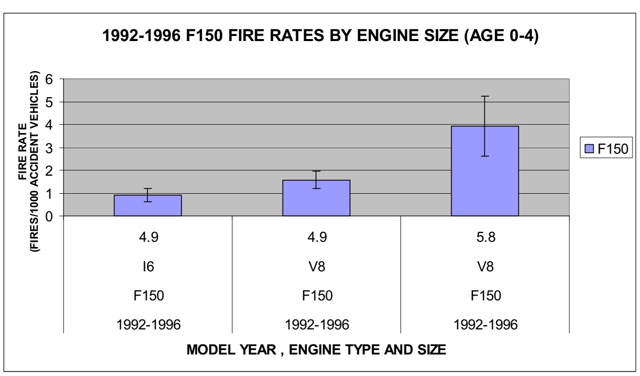

Figure 37: 1992-1996 F150 Fire Rates by Engine Size (Age 0-4)

Figure 36 shows the observed fire rates for the 1987-1991 F-150 vehicles. The observed fire rates for the Inline 6 engine with a displacement of about 4.9 liters had observed fire rates lower than the V8, 4.9 liter engine.

Figure 37 shows the observed fire rates for the 1992-1996 F-150 vehicles. Again the observed fire rates for the Inline 6 engine with a displacement of about 4.9 liters had observed fire rates lower than the V8, 4.9 liter engine and the V8, 5.8 liter engine. Two of the engines in the 1992-1996 time frame have the same size as the 1987-1991 vehicle design in the Figure 36.

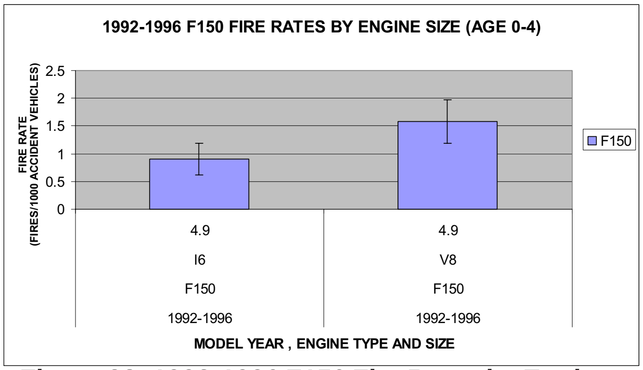

Figure 38: 1992-1996 F150 Fire Rates by Engine Size (Age 0-4)

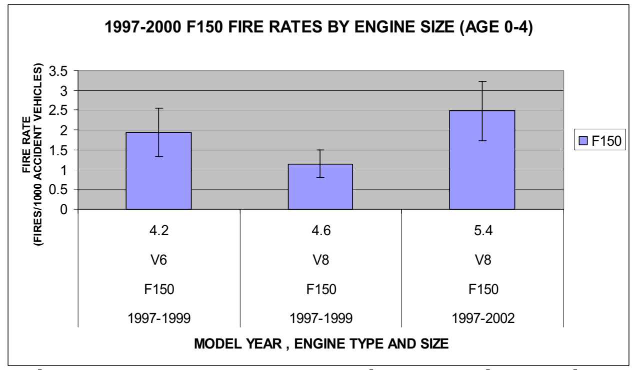

Figure 39: 1997-2000 F150 Fire Rates by Engine Size (Age 0-4)

Figure 38 shows the observed fire rates for the 1992-1996 F150 vehicles for two of the engines. The observed fire rates for the Inline 6 engine with a displacement of about 4.9 liters had observed fire rates lower than the V8, 4.9 liter engine.

Figure 39 shows the results for the 1997-2002 vehicle design with the three engines available. The V6 engine here had higher observed fire rates the previous I6 engine.

S10

Figure 40 provides an overview of the results for the observed S10 fire rates by engine size (e.g. 2.5 Liters), engine type (e.g. Inline 4 [I4]), and model year range (e.g. 1985-1993). It can be seen that the smaller engines basically have lower fire rates within a given model year range.

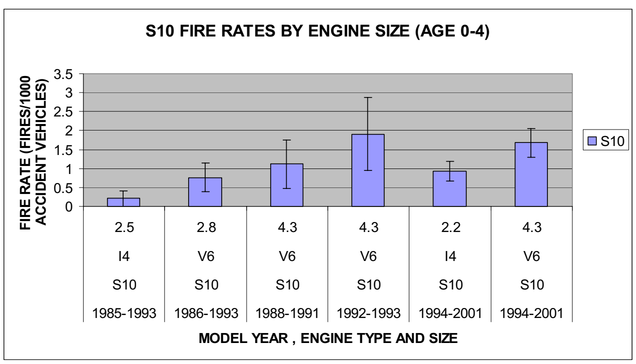

Figure 40: S10 Fire Rates by Engine Size (Age 0-4)

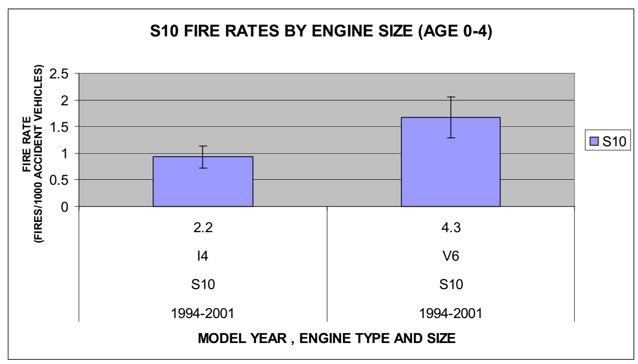

Figure 41: S10 Fire Rates by Engine Size (Age 0-4)

Figure 41 shows the observed fire rates for the 1994-2001 S10 vehicle design. The observed fire rates are lower for the Inline 4 2.2 Liter engine compared with the V6 4.3 liter engine.

Ranger

Figure 42_shows the observed fire rates for the Ranger vehicles 0-4 years old including the selected engine size (e.g. 2.9 Liter), model year range (e.g. 1983-1988), and engine type (e.g. V6 or I4). It has been reported that the 1998-2000 3 liter V6 had redesigned components compared to the previous 1993-1997 model year 3 liter V6 engine.

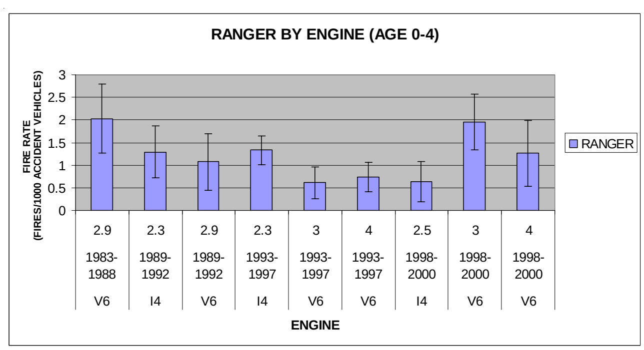

Figure 42: Ranger by Engine (Age 0-4)

For example, the fuel pressure regulator is located in the fuel tank with the fuel pump; there is a fuel pressure damper on the fuel rail whose purpose is to reduce fuel pulsations in the fuel fail; also the throttle body had been an integral part of the upper intake manifold. These changes occurred at the same time as the vehicle design change that occurred for model year 1998 was a redesign compared to the previous 1993-1997 model year 3 liter V6 engine.

Underhood Insulation: S10, F150, Ranger Vehicle Groups

Examination of the effect of underhood insulation shows that the vehicles with hood insulation (Y) had lower observed fire rates than those vehicles without it (N) as shown in Figure 43 and Figure 44. Although it might be thought that the underhood insulation might suppress fires, the mechanism by which the initiation of a fire would be reduced is not clear at the moment unless, for example, the presence of hood insulation has implications for other areas of the design with regard isolation of heat sources from flammable materials such as fluids or engine compartment materials or the likelihood of the presence of flammable engine compartment materials. Ongoing work at MVFRI is examining the ability of underhood liners to prevent/extinguish fires.

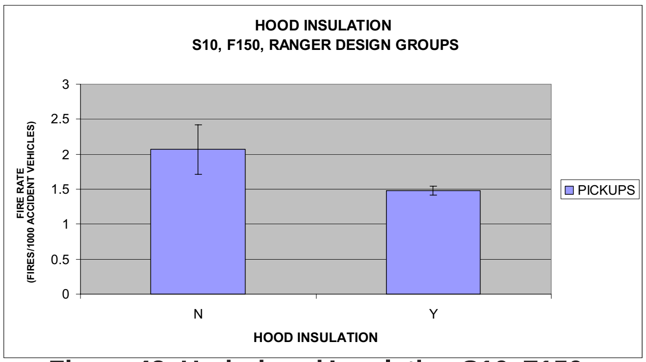

Figure 43: Underhood Insulation S10, F150, Ranger Vehicle Groups

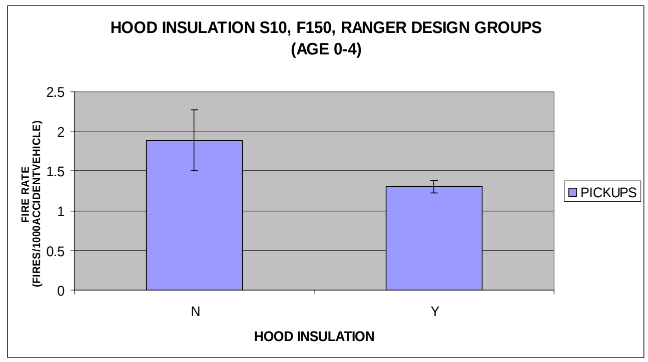

Figure 43: Underhood Insulation S10, F150, Ranger Vehicle Groups (Age 0-4)

Summary of Underhood Characteristics

The engine analysis results indicate that often smaller powertrains result in lower fire rates than larger powertains within a particular design in general. Inline engines generally appear to result in lower fire rates than V engines within a vehicle group controlled for the range of model years with the same structural design. There are some anomalies that may be explained by particular design features that exist within a particular design, for example, fuel rail design issues with a higher likelihood of failure. It can be recognized that the V configuration engines result in two manifolds and sometimes two catalytic converters to increase high temperature surface exposure probabilities, while the inline engines could be expected to have one exhaust manifold and one catalytic converter in these vehicles. Results of engine compartment temperature studies can be utilized to further investigate these effects[14]. In addition, effects related to fluid locations, volumes, and container characteristics as well as the characteristics, volumes and proximity of flammable engine compartment materials and their relative proximity to heat sources. The obstructions between fluids or flammable materials and heat sources should also be characterized to study their effects on the results. All of these factors may also correlate with the powertrain and vehicle size effects.

[14] Fourier, E., Bayne, T., Biokinetics, Inc. "Cone Calorimeter Testing of Underhood Insulation", R05-13b, 2005

Analyses Related to Impact Mode

The observed fire rates by impact mode and fuel tank type are shown in Figure 45 and Figure 46. The analysis considers the vehicle groups under study for model year 1991 on. The counts for these figures are contained in Appendix 5. A large difference is seen in the rollover impact mode. A more comprehensive investigation into the effects of tank type and location should utilize vehicles where there is no ambiguity in the tank location. Examples of vehicles having model years with the tank aft of the axle include the Ford Crown Victoria, Lincoln Towncar, Jeep Cherokee and Grand Cherokee, Dodge Caravan and sister vehicles, and Ford Mustangs. Inclusion of these vehicles would allow examination of the effects of tank locations aft of the rear axle. Fire rates in the rollover impact mode are higher as can be seen; fire rates by impact mode vary, with the rear impact mode having the lowest fire rate. Fire rates do increase for steel tanks with vehicle age as shown in Figure 46.

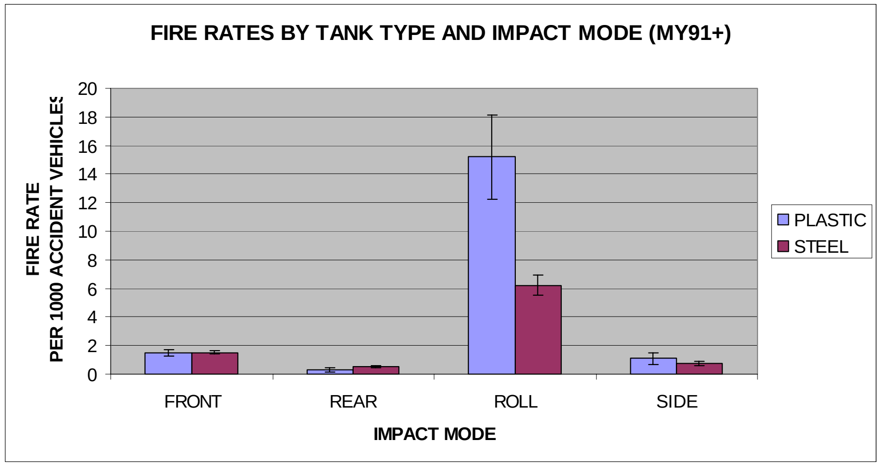

Figure 45 Fire Rate by Tank Type and Impact Mode (MY91+)

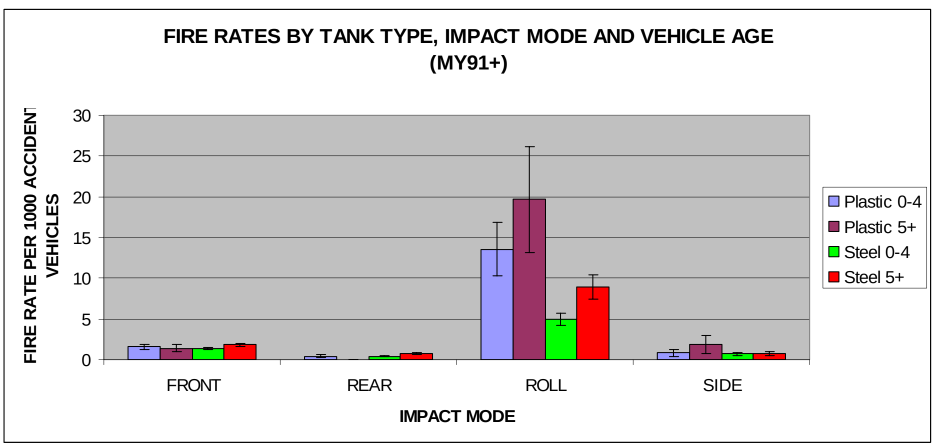

Figure 46: Fire Rates by Tank Type and Impact Mode and Vehicle Age

Figure 47 shows the fire rates controlled for the check valve by impact mode. The presence or absence of the check valve in these data is not indicative of overall fire rates.

Examination of battery location by impact mode (Figure 48) shows a slightly lower fire rate for those vehicles with age 0-4. The effect disappears for older vehicles.

Fuel line routing in these vehicles characterized as left and right did not distinguish fire rates as

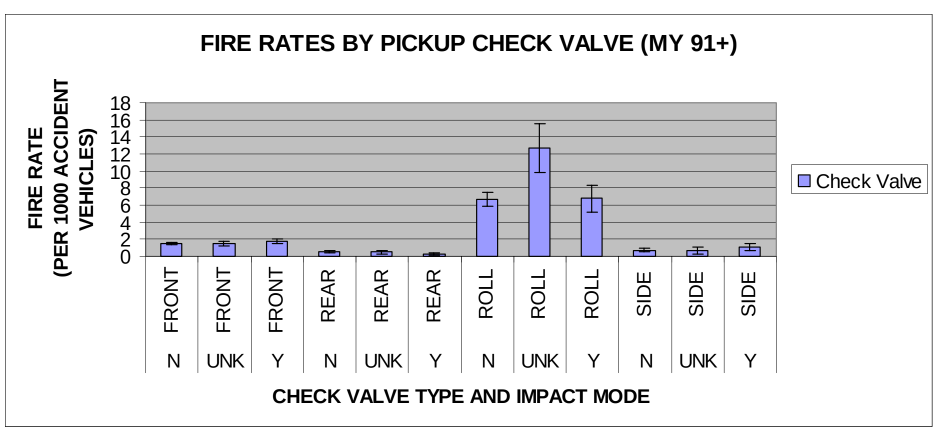

Figure 47. Fire Rates by Check Valve and Impact Model

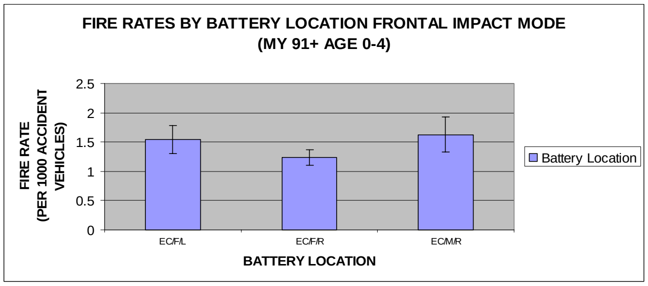

Figure 48 Fire Rates by Battery Location in Frontal Impacts for Vehicles 0-4 Years Old

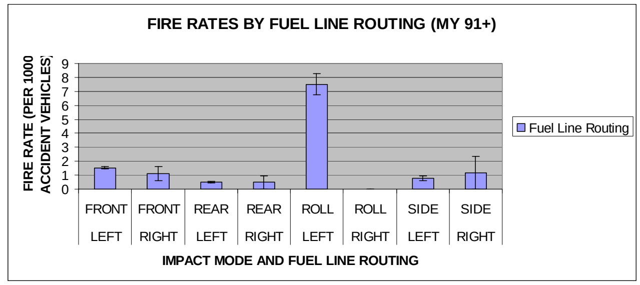

Figure 49 Fire Rates by Fuel Line Routing by Impact Mode

shown in Figure 49. Most of the vehicles had fuel lines and the distinction of left and right did not allow much discrimination in the nature of the routing.

The cutoff switch type produced different fire rates under rollover impact conditions as shown in Figure 50. The vehicles with the relay cutoff switches had higher fire rates under rollover conditions.

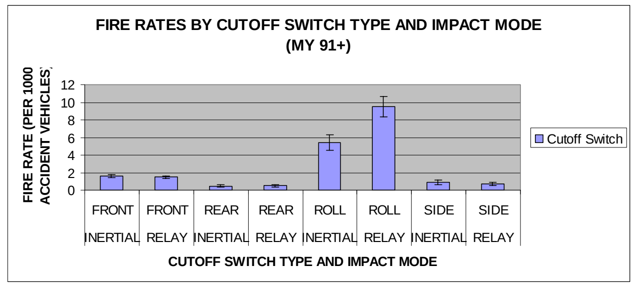

Figure 50 Fire Rates by Cutoff Swtich Type and Impact Mode

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Overall Fire Rates

The results suggest that the smaller pickup market segment vehicle groups have lower observed fire rates in this data set (Figure 8). The higher fire rates are observed within a manufacturer as well as between manufacturer design approaches. Fire rates for pickups have been fairly constant over the past decade. As additional data become available, increases associated with the 2001 model year for which only limited data was available should be investigated.

Fire Rates by State

Variations in observed fire rates between states can be large (Figure 2 and Figure 7). To examine sources of reported fire rates between states the distribution of collision types should be examined. It is possible that the differences simply have to do with reporting techniques and detail of coding as discussed earlier, for example, Minnesota records four events per vehicle. A study of the collision type distribution may suggest that some states may have a higher proportion of crashes that result in a higher likelihood of fires (e.g. fixed object impacts). Examining this distribution across the states available would provide a method to address this issue.

Rollover

The fire rates observed in rollover impacts continue to show a higher fire rate than other impact modes. These results are consistent with the earlier study[15.] Addressing why rollovers result in higher fire rates than other impact modes is of interest. Factors identified here have been the cutoff valve type and vehicle age.

Given engine compartment fluid leakage during rollovers other sources for ignition is likely a factor and indicators related to containment effectiveness, volumes and proximity to heat sources for the engine compartment fluids (e.g. transmission, engine oil, brake fluid, etc) when rolling would likely provide additional insight into the high rates observed in this impact mode.

Steel v Plastic Fuel Tanks

Rollover conditions distinguish the observed fire rates between pickups with steel and plastic fuel tanks (Figure 45 and Figure 46). The mechanisms related to this observation should be resolved. The increase in fire rates in pickups with steel tanks as they get older is not observed in the pickups with plastic tanks with the present data. Examination of more vehicles with plastic tanks would add to the database and allow more detailed evaluation of whether the increase in fire rates in vehicles with steel tanks is observed in the vehicles with plastic tanks. It would also allow resolution of whether the vehicles with plastic tanks have increased fire rates with age which is not established with the present data.

Interestingly, the pickups with steel tanks appear to have higher fire rates as they get older. Further examination to investigate the source of this difference is suggested.

In younger vehicles the fire rates between pickups with plastic tanks and those with steel tanks appear to be

[15] Friedman, Kenney, Holloway, 2003, 2004

similar except in the case of rollover impacts. The mechanisms related to these observations are of interest.

It is of note that the fire rates for the pickups with steel tanks increase with age in the front, rear and rollover modes, but this effect does not appear in side impacts. The mechanisms related to this observation should be resolved. For example, could it be that in the side impact mode where distortion of the engine compartment may not be so dominant, that age effects related to fluid containment systems may not be so easily damaged and that fluids are not being spilled in proximity of auto-ignition temperature surfaces?

Other Factors

The findings as reported herein indicate that there are a number of additional factors to be considered in the data. These factors include:

1. Pickups with check valves had lower fire rates than those without in rear impacts.

2. Battery location within the engine compartment did not have a strong effect on pickup fire rates.

3. Cutoff switch type appears to have effects in pickup rollover impacts

4. Tank location did not have sufficient variability defined within this group to see any differences inside the frame rails and forward of the rear axle. The F150 did have some vehicles with optional rear tanks but the vehicles with the option could not be identified within the F150 vehicles.

5. Battery terminal covers defined was not a factor related to the pickup fire rates.

6. Fuel line routing had insufficient variability or definition and did not have fire variation in these pickups.

7. The vehicle offset frontal structural ratings did not have sufficient variability to relate to pickup fire rates.

8. Pickups with hood insulation had lower fire rates within the limited vehicles studied.

9. The introduction of fuel injection in pickups appears to have lowered pickup fire rates.

Effects of Powertrain and Exhaust System Components

Engine and engine compartment characteristics appear to be related to observed fire rates. For example, within a design group vehicle, substantial variation is observed when engine size and type is considered. This becomes evident when looking at the observed fire rates for a constant vehicle design with various engine configurations as shown, for example, in Figure 37.

This raises the question of what factors explain the differences in fire rates within a given vehicle design with the same engine compartment, but different powertrain configurations.

Hypotheses for Future Research Regarding Engine Compartment Fires

From an exposure viewpoint, the volume of fluids available, and the probability they will contact a hot surface for auto-ignition is hypothesized as one of the available ignition processes. The probability that the fluids will contact a hot surface for auto-ignition is related in part to the fluids' initial proximity to a hot surface as well as the surface area presented by the component. The shielding provided for these surfaces may also be a factor, both from the viewpoint of how hot it will get (e.g. ventilation) as well as how easy it would be for an ignitable fluid to contact the surface. The engine manifold and catalytic converter temperatures and the auto-ignition temperatures for the fluids are likely to be important.

Thus, consideration of the engine compartment's ability to cool auto-ignition surfaces post crash (engine free space and airflow near auto-ignition surfaces), fluid surface proximity to auto-ignition temperature surfaces, proximity of fluids to auto-ignition surfaces, presented surface areas with auto-ignition temperatures, and the magnitude of auto-ignition fluids should be characterized.[16] [17] [18]

Variations that exist between the larger pickups and smaller pickups and various engine types, suggest consideration of the exhaust system (exhaust manifold, catalytic converters, etc) and the proximity of its components to fluids or other flammable materials. Inline engines may have only one exhaust manifold and one catalytic converter. These engine types generally had lower fire rates compared to V6 or V8 versions in the same truck for the F150 and S10 pickups, although not as clearly in the Ranger. Examinations of these exceptions are of interest.

In terms of future characterization, we should determine the surface areas of the exhaust manifolds and the catalytic converters, their temperatures, and proximity to auto-ignition fluids. The length of time after a crash that auto-ignition temperatures are present on these surfaces could be used as a metric indicating the ventilation effects.

We would suggest characterizing the amounts of auto-ignition fluids for the transmission, brake, engine oil, power steering, clutch, radiator coolant, and windshield washer fluid, etc. In addition, characterizing the proximity of other flammable materials to heat sources and their ignition temperatures, and volume could then be used in the analysis to find correlations with the observed fire rates. Lastly a metric for fluid containment effectiveness should be created to characterize how well the fluids are protected in any given vehicle group; for example, how is the oil cap secured, or the material of which the fluid reservoirs are made.

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[16] Tewarson, A., Quintiere, J. G. and Purser, D. A. (2005) *Post Collision Motor Vehicle Fires*- Volume I: FM Global Technical Report #0003018009, Volume I, October.

[17] Tewarson, A., Quintiere, J. G., and Purser, D. A. (2005) *Theory and Testing for the Fire Behavior of Materials for the Transportation Industry*- Volume II:, FM Global Technical Report #0003018009, Volume II, October.

[18] Tewarson (2005).*Thermophysical and Fire Properties of Automobile Plastic Parts and Engine Compartment Fluids*- Volume III: FM Global Technical Report #0003018009, Volume III, October.

APPENDIX 1: PICKUPS MAKE & CODE

Make	Code	Long Description
CHEV/GMC S10		
CHEV	TCHEVS1CS1C	S10
CHEV	TCHEVSS14	S10
CHEV	TCHEVSSL4	S10 LUXURY
GMCS	TGMCSONSGT	SONOMA GT
GMCS	TGMCSONSOL	SONOMA LUXURY
GMCS	TGMCSONSON	SONOMA
GMCS	TGMCSS10	S15
Make	**Code**	**Long Description**
CHEV/GMC 1500		
CHEV	TCHEVC10C10	C10
CHEV	TCHEVGM4GC1	C1500
CHEV	TCHEVGM4GK1	K1500
CHEV	TCHEVGM4LC1	C1500 LUXURY
CHEV	TCHEVK10K10	K10
CHEV	TCHEVR10R10	R10
CHEV	TCHEVSIL1CH	C1500HD SILVERADO
CHEV	TCHEVSIL1KH	K1500HD SILVERADO
CHEV	TCHEVSILCL1	C1500 SILVERADO LUXURY
CHEV	TCHEVSILKL1	K1500 SILVERADO LUXURY
CHEV	TCHEVSILSC1	C1500 SILVERADO
CHEV	TCHEVSILSK1	K1500 SILVERADO
CHEV	TCHEVV10V10	V10
GMC1	TGMC150150	1500
GMCC	TGMCC15C15	C1500
GMCC	TGMCC15C1A	C1500
GMCG	TGMCGM4GC1	C1500
GMCG	TGMCGM4GK1	K1500
GMCK	TGMCK15K15	K1500
GMCK	TGMCK15K1A	K1500 K1500
GMCR	TGMCR15R15	R1500
GMCS	TGMCSIE1CH	SIERRA C1500 HD
GMCS	TGMCSIE1KH	SIERRA K1500 HD
GMCS	TGMCSIECL1	SIERRA C1500 LUXURY
GMCS	TGMCSIEDNL	SIERRA K1500 DENALI
GMCS	TGMCSIEKC3	SIERRA K1500 C3
GMCS	TGMCSIEKL1	SIERRA K1500 LUXURY
GMCS	TGMCSIELC1	SIERRA C1500 LUXURY
GMCS	TGMCSIENC1	SIERRA C1500
GMCS	TGMCSIENK1	SIERRA K1500
GMCS	TGMCSIESC1	SIERRA C1500
GMCS	TGMCSIESK1	SIERRA K1500
GMCV	TGMCV15V15	V1500

Make	Code	Long Description
NISSAN FRONTIER		
DATS	TDATS620KCB	KING CAB
DATS	TDATS620LBD	LONG BED
DATS	TDATS620STB	STANDARD BED
DATS	TDATS7204WD	720 4X4
DATS	TDATS7204WK	720 KING CAB 4X4
DATS	TDATS72072C	720 CAB/CHASSIS
DATS	TDATS72072K	720 KING CAB
DATS	TDATS72072L	720 LONG BED
DATS	TDATS72072S	720 STANDARD BED
DATS	TDATS7207K4	720 KING CAB 4X4
DATS	TDATS7207L4	720 LONG BED 4X4
DATS	TDATS7207S4	720 SHORT BED 4X4
DATS	TDATS720K4U	720 KING CAB 4X4
DATS	TDATS720L4U	720 LONG BED 4X4
DATS	TDATS720S4U	720 STANDARD BED 4X4
DATS	TDATS720US4	720 4X4
DATS	TDATS720USC	720 CAB CHASSIS
DATS	TDATS720USK	720 KING CAB
DATS	TDATS720USL	720 LONG BED
DATS	TDATS720USS	720 STANDARD BED
DATS	TDATS72KUS4	720 KING CAB
DATS	TDATSC72CKC	720 KING CAB
DATS	TDATSC72CLB	720 LONG BED DLX
DATS	TDATSD21D2C	720 C/C
DATS	TDATSD21D2K	720 KING CAB
DATS	TDATSD21D2L	720 LONG BED
DATS	TDATSD21D2S	720 SHORT BED
DATS	TDATSD21DK4	720 KING CAB 4X4
DATS	TDATSD21DL4	720 LONG BED 4X4
DATS	TDATSD21DS4	720 SHORT BED 4X4
DATS	TDATSD21U2C	720 C/C
DATS	TDATSD21U2K	720 KING CAB
DATS	TDATSD21U2L	720 LONG BED
DATS	TDATSD21U2S	720 SHORT BED
DATS	TDATSD21U4K	720 KING CAB 4X4
DATS	TDATSD21U4L	720 LONG BED 4X4
DATS	TDATSD21U4S	720 SHORT BED 4X4
DATS	TDATSFRTCSC	FRONTIER SC
DATS	TDATSFRTF/X	FRONTIER/XE
DATS	TDATSFRTFCX	FRONTIER/XE V6
DATS	TDATSFRTFKX	FRONTIER KING CAB XE
DATS	TDATSFRTFXE	FRONTIER XE
DATS	TDATSFRTKSC	FRONTIER KING CAB SC
DATS	TDATSFRTKXE	KING CAB XE
DATS	TDATSFRTKXS	FRONTIER KING CAB XE/SE
DATS	TDATSFRTKXV	FRONTIER XE V6
DATS	TDATSFRTXSC	FRONTIER XE/SE
DATS	TDATSTRKEXE	STANDARD E/XE

(Nissan continued)

DATS	TDATSTRKKNG	KING CAB
DATS	TDATSTRKKSE	KING CAB SE
DATS	TDATSTRKKSX	KING CAB XE/SE
DATS	TDATSTRKKXE	KING CAB XE
DATS	TDATSTRKLWB	LONG BED
DATS	TDATSTRKLXE	LONG BED XE
DATS	TDATSTRKSTD	STANDARD
DATS	TDATSTRKSWB	SHORT BED
DATS	TDATSTRKTXE	STANDARD XE
DATS	TDATSTRKXES	STANDARD/XE
NISS	TNISS7204WK	720 KING CAB 4X4
NISS	TNISS72072C	720 CAB/CHASSIS
NISS	TNISS72072K	720 KING CAB
NISS	TNISS72072L	720 LONG BED
NISS	TNISS72072S	720 STANDARD BED
NISS	TNISS7207K4	720 KING CAB 4X4
NISS	TNISS7207L4	720 LONG BED 4X4
NISS	TNISS7207S4	720 SHORT BED 4X4
NISS	TNISS720K4U	720 KING CAB 4X4
NISS	TNISS720L4U	720 LONG BED 4X4
NISS	TNISS720S4U	720 STANDARD BED 4X4
NISS	TNISS720USC	720 CAB CHASSIS
NISS	TNISS720USK	720 KING CAB
NISS	TNISS720USL	720 LONG BED
NISS	TNISS720USS	720 STANDARD BED
NISS	TNISSC72CKC	720 KING CAB
NISS	TNISSC72CLB	720 LONG BED DLX
NISS	TNISSCD2CCC	D21 CAB CHASSIS
NISS	TNISSCD2CKB	D21 KING CAB
NISS	TNISSCD2LBC	D21 LONG BED
NISS	TNISSCD2RBC	D21 REGULAR CAB
NISS	TNISSD21D2C	720 C/C
NISS	TNISSD21D2K	720 KING CAB
NISS	TNISSD21D2L	720 LONG BED
NISS	TNISSD21D2S	720 SHORT BED
NISS	TNISSD21DK4	720 KING CAB 4X4
NISS	TNISSD21DL4	720 LONG BED 4X4
NISS	TNISSD21DS4	720 SHORT BED 4X4
NISS	TNISSD21U2C	720 C/C
NISS	TNISSD21U2K	720 KING CAB
NISS	TNISSD21U2L	720 LONG BED
NISS	TNISSD21U2S	720 SHORT BED
NISS	TNISSD21U4K	720 KING CAB 4X4
NISS	TNISSD21U4L	720 LONG BED 4X4
NISS	TNISSD21U4S	720 SHORT BED 4X4
NISS	TNISSFRTCSC	FRONTIER SC
NISS	TNISSFRTF/X	FRONTIER/XE
NISS	TNISSFRTFCX	FRONTIER/XE V6
NISS	TNISSFRTFKX	FRONTIER KING CAB XE
NISS	TNISSFRTFXE	FRONTIER XE
NISS	TNISSFRTKSC	FRONTIER KING CAB SC
NISS	TNISSFRTKXE	KING CAB XE

(Nissan continued)

NISS	TNISSFRTKXS	FRONTIER KING CAB XE/SE
NISS	TNISSFRTKXV	FRONTIER XE V6
NISS	TNISSFRTXSC	FRONTIER XE/SE
NISS	TNISSTRKEXE	STANDARD E/XE
NISS	TNISSTRKKNG	KING CAB
NISS	TNISSTRKKSE	KING CAB SE
NISS	TNISSTRKKSX	KING CAB XE/SE
NISS	TNISSTRKKXE	KING CAB XE
NISS	TNISSTRKLWB	LONG BED
NISS	TNISSTRKLXE	LONG BED XE
NISS	TNISSTRKSTD	STANDARD
NISS	TNISSTRKSWB	SHORT BED
NISS	TNISSTRKTXE	STANDARD XE
NISS	TNISSTRKXES	STANDARD/XE

Make	**Code**	**Long Description**
DODGE RAM 1500		
DODG	TDODGD0CD0C	D-100
DODG	TDODGD10D10	D-100
DODG	TDODGD15CLC	D-150 CLUB CAB
DODG	TDODGD15D15	D-150
DODG	TDODGD15D1S	D-150 S
DODG	TDODGD1CD1C	D-150
DODG	TDODGDOCDOC	D-100
DODG	TDODGRPC150	RAM 1500
DODG	TDODGRPCQ15	RAM 1500 QUAD
DODG	TDODGRPCQS1	RAM 1500 QUAD ST
DODG	TDODGRPCS1T	RAM 1500 ST
DODG	TDODGRPCSL1	RAM 1500 SLT
DODG	TDODGRPCSQ1	RAM 1500 QUAD ST/SLT
DODG	TDODGRPCSTR	RAM 1500 ST
DODG	TDODGW0CW0C	W100
DODG	TDODGW10W10	W-100
DODG	TDODGW15W15	W-150
DODG	TDODGW15W1S	W-150 S
DODG	TDODGW1CW1C	W-150
Make	**Code**	**Long Description**
DODGE DAKOTA		
DODG	TDODGCDKCDK	DAKOTA
DODG	TDODGCDKCST	DAKOTA SPORT
DODG	TDODGDAKDAK	DAKOTA
DODG	TDODGDAKDKR	DAKOTA RT
DODG	TDODGDAKDQS	DAKOTA QUAD CAB SLT
DODG	TDODGDAKDSL	DAKOTA SLT
DODG	TDODGDAKDSQ	DAKOTA QUADCAB SPORT/RT
DODG	TDODGDAKDSX	DAKOTA SPORT/RT
DODG	TDODGDAKDXT	DAKOTA/SXT
DODG	TDODGDAKQAD	DAKOTA
DODG	TDODGDAKQSP	DAKOTA QUADCAB SPORT
DODG	TDODGDAKSLT	DAKOTA SLT
DODG	TDODGDAKSPT	DAKOTA SPORT
DODG	TDODGDAKSXT	DAKOTA SXT

Make	Code	Long Description
FORD F150		
FORD	TFORDCLCF1C	LIGHT CONVENTIONAL F150
FORD	TFORDCLCFHC	F150 HERITAGE-CANADIAN
FORD	TFORDCOFF15	F150
FORD	TFORDCOFF1H	F150 SUPERCREW HARLEY
FORD	TFORDCOFF1S	F150 SUPERCREW
FORD	TFORDCOFHER	F150 HERITAGE
FORD	TFORDCRGCRG	RANGER
FORD	TFORDCRGCSB	RANGER SUPER
FORD	TFORDRNGRNG	RANGER
FORD	TFORDRNGRNS	RANGER SUPER

Make	Code	Long Description
TOYOTA TACOMA		
TOYT	TTOYT44P60S	STANDARD BED SR5 1/2 TON
TOYT	TTOYT44P63S	PICKUP SR5 4X4
TOYT	TTOYT44P64D	PICKUP DELUXE 4X4
TOYT	TTOYT44P64S	PICKUP SR5 4X4
TOYT	TTOYT44P65D	LONG BED DELUXE 1/2 TON
TOYT	TTOYT44P65S	LONG BED SR5 1/2 TON
TOYT	TTOYT44PR35	STD BED SR5 4X4
TOYT	TTOYT44PR37	STD BED 1/2 TON
TOYT	TTOYT44PR38	STANDARD BED 1/2 TON
TOYT	TTOYT44PR3T	STD BED TURBO 4X4
TOYT	TTOYT44PR47	LONG BED 1/2 TON
TOYT	TTOYT44PR48	STANDARD BED 1/2 TON
TOYT	TTOYT44PR60	STANDARD BED 1/2 TON
TOYT	TTOYT44PR63	SHORT BED 4X4
TOYT	TTOYT44PR6D	PICKUP DELUXE 4X4
TOYT	TTOYT44PR6S	PICKUP SR5 4X4
TOYT	TTOYTHLXR12	HI LUX RN12
TOYT	TTOYTHLXR14	HI LUX RN14
TOYT	TTOYTHLXR23	HI LUX RN23
TOYT	TTOYTHLXR28	HI LUX RN28
TOYT	TTOYTHLXRN2	HI LUX RN22
TOYT	TTOYTHLXRN7	HI LUX RN27
TOYT	TTOYTHPCC5D	1/2 TON PICKUP DELUX
TOYT	TTOYTHPCC6D	DELUXE 4X4
TOYT	TTOYTHPCCL6	1/2 TON
TOYT	TTOYTHPCCLB	1/2 TON LONG WB
TOYT	TTOYTHPCCR3	1/2 TON SHORT BED
TOYT	TTOYTHPCCR4	1/2 TON LONG BED
TOYT	TTOYTHPCCR6	1/2 TON SHORT BED DLX
TOYT	TTOYTHTP55R	LONG BED 1/2 TON
TOYT	TTOYTHTP55S	SR5 1/2 TON
TOYT	TTOYTHTPEL5	EXTRA LONG XCAB SR5
TOYT	TTOYTHTPELD	EXTRA LONG XCAB DELUXE
TOYT	TTOYTHTPELS	EXTRA LONG XCAB SR
TOYT	TTOYTHTPELX	EXTRA LONG WB DELUXE
TOYT	TTOYTHTPL50	STANDARD BED 1/2 TON
TOYT	TTOYTHTPLDX	LONG WB DELUXE 1/2 TON
TOYT	TTOYTHTPLN4	LONG BED 1/2 TON
TOYT	TTOYTHTPLWD	LONG BED DELUXE
TOYT	TTOYTHTPLWS	LONG BED SR

(Toyota continued)

TOYT	TTOYTHTPN44	STANDARD BED 1/2 TON
TOYT	TTOYTHTPR32	STANDARD BED 1/2 TON
TOYT	TTOYTHTPR34	STANDARD BED 1/2 TON
TOYT	TTOYTHTPR3D	DELUXE 1/2 TON
TOYT	TTOYTHTPR3S	SR5 1/2 TON
TOYT	TTOYTHTPR42	LONG BED
TOYT	TTOYTHTPR4S	SR5 1/2 TON
TOYT	TTOYTHTPR5D	LONG BED 1/2 TON
TOYT	TTOYTHTPR5S	SR5 1/2 TON
TOYT	TTOYTHTPRN3	STANDARD BED 1/2 TON
TOYT	TTOYTHTPRN5	STANDARD BED 1/2 TON
TOYT	TTOYTHTPRN8	STANDARD BED 1/2 TON
TOYT	TTOYTHTPSDX	SHORT WB DELUXE
TOYT	TTOYTHTPSR5	SHORT BED SR5
TOYT	TTOYTHTPSSR	SHORT BED SR
TOYT	TTOYTHTPSWD	SHORT BED DELUXE
TOYT	TTOYTHTPSWS	SHORT BED STD
TOYT	TTOYTHTPSWX	SHORT WB/DELUXE
TOYT	TTOYTHTPULX	XLONG W/B DX
TOYT	TTOYTHTPUSX	SHORT W/B DX
TOYT	TTOYTHTPXLX	1/2 TON XLONG WB DELUXE
TOYT	TTOYTLBDL44	LONG BED
TOYT	TTOYTLBDSR5	LONG BED SR5
TOYT	TTOYTLBXV64	LONG BED DELUXE
TOYT	TTOYTPCC4RN	LONG BED 1/2 TON
TOYT	TTOYTPCCR4D	DELUXE 1/2 TON
TOYT	TTOYTPCCR4S	SR5 1/2 TON
TOYT	TTOYTSB5675	SHORT BED SR5
TOYT	TTOYTSBSV63	SHORT BED STD
TOYT	TTOYTSXDV67	SHORT BED XTRACAB DELUXI
TOYT	TTOYTSXS67R	SHORT BED XTRACAB SR5
TOYT	TTOYTTACDCL	TACOMA DOUBLECAB
TOYT	TTOYTTACDCP	TACOMA PRERUNNERDOUBLE
TOYT	TTOYTTACREG	TACOMA
TOYT	TTOYTTACRRG	TACOMA PRERUNNER
TOYT	TTOYTTACTR5	TACOMA SR5
TOYT	TTOYTTACXL5	TACOMA XTRACAB LTD/SR5
TOYT	TTOYTTACXLM	TACOMA XTRACAB LIMITED
TOYT	TTOYTTACXPR	TACOMA XTRACAB PRERUNNI
TOYT	TTOYTTACXSR	TACOMA XTRACAB S-RUNNER
TOYT	TTOYTTACXTR	TACOMA XTRACAB
TOYT	TTOYTUHTU93	1/2T DELUXE
TOYT	TTOYTUHTULX	EXTRA LONG WB DELUXE
TOYT	TTOYTUHTUR3	1/2T DELUXE
TOYT	TTOYTUHTUSD	SHORT WB DELUXE
TOYT	TTOYTUHTUSS	SHORT WB STB
TOYT	TTOYTUHTUSX	SHORT WB DELUXE
TOYT	TTOYTX4466D	XTRACAB DELUXE
TOYT	TTOYTX4466S	XTRACAB SR5
TOYT	TTOYTX44N6D	XTRACAB LONG BED DELUXE
TOYT	TTOYTX44R6D	XTRACAB DELUXE 4X4
TOYT	TTOYTX44R6S	XTRACAB SR5 4X4
TOYT	TTOYTX44R6T	STD BED XTRACAB DELUX 4X4
TOYT	TTOYTX44R7S	XTRACAB SR5 4X4
TOYT	TTOYTXCBL56	XTRACAB DELUXE
TOYT	TTOYTXCBL70	XTRACAB
TOYT	TTOYTXCBR56	XTRACAB DELUXE

APPENDIX 2: VEHICLE FUEL SYSTEMS

Year	Model	Gas Tank	Tank Location	Filler Cap	Filler Neck/Tube (3)	Fuel Sender (2)	Sender Retainer	Roll-over Valve	Check Valve	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (1)	Fuel Line Routing	Carburetion/Fuel Injection
2003		p	I/					Y	Y	EC/	N	Y	Y	AF	FI
2002			FR/							F/					
2001		S	L						U	R					
2000									N						
1999															
1998															
1997															
1996															
1995															
1994															
1993												Y			C/FI
1992															
1991															

Note:
(1) The fuel pump was relay controlled.
(2) 1991 fuel tank sender seal was out of position and could leak in a rollover.
(3) 1994 tank filler pipes were improperly manufactured and could cause the fuel tank filler pipes and vent tube to crack.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A1: Chevy S-10 Pickup

Year	Model	Gas Tank	Tank Location (3)	Filler Cap	Filler Neck/Tube	Fuel Sender	Sender Retainer	Roll-over Valve	Check Valve	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (1)	Fuel Line Routing (2, 4)	Carburetion/Fuel Injection
2003		P	I/					Y	Y	EC/	Y	N	Y	AF/	FI
2002			FR/							F/				L	
2001			L							L		Y			
2000															
1999															
1998															
1997															
1996									U		N				
1995															
1994															
1993									N						
1992															
1991															

Note:
(1) The fuel pump was relay controlled.
(2) 1991 Contact between braided fuel hoses and the transmission wiring harness could cause damage to the fuel hose resulting in a fuel leak.
(3) 1994 Fuel tank mounting straps were improperly tightened and could allow the tank to shift or allow complete separation from the vehicle.
(4) 1997 131 inch wheelbase vehicles may have inadequate clearance between the fuel line and the cab underbody which could result in a perforation.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A2: Dodge Dakota

Year	Model	Gas Tank (1)	Tank Location (5)	Filler Cap	Filler Neck/Tube	Fuel Sender	Sender Retainer	Roll-over Valve (2, 3)	Check Valve	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (4)	Fuel Line Routing (6)	Carburetion/Fuel Injection
2003		P	I/					Y	Y	EC/	Y	Y	Y	AF/	FI
2002			FR/							F/				L	
2001			L						U	L					
2000															
1999															
1998															
1997									Y						
1996									N						
1995															
1994															
1993											N	N			
1992															
1991															

Note:
(1) Within each change there are various tank capacity options.
(2) Recall on 1994, 1995 and 1996 roll-over valves. Under certain vehicle operating conditions the rollover valve can allow fuel to leak. Rollover valves were replaced with float type valves.
(3) The roll-over valve was part of the sending unit.
(4) The fuel pump was relay controlled.
(5) 94 models did not meet FMVSS 301 rear impact requirements.
(6) 98 models had a heat shield screw that could rub on an underbody fuel line possibly causing fuel leaks.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A3: Dodge Ram 1500

Year	Model	Gas Tank	Tank Location (1)	Filler Cap	Filler Neck/Tube (2)	Fuel Sender (3) (6)	Sender Retainer	Roll-over Valve	Check Valve (4)	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (5)	Fuel Line Routing (7, 8)	Carburetion/Fuel Injection
2003		S	I/					Y	Y	EC/	Y	Y	Y	AF/	FI
2002			FR/							M/				L	
2001			L							R					
2000															
1999															
1998															
1997															
1996			I/						N	EC/					
1995			AR							F/					
1994										R					
1993															
1992															
1991															

Note:
(1) From 1991 to 1996 both a midship and aft axle tank were available. The midship tank was the same from 91-96. The aft axle tank changed between 91 and 92-96.
(2) The same filler neck/tube was used for the midship and the aft axle tank.
(3) The fuel pump was the same but the gage changed in 92.
(4) The check valve was located in the filler neck.
(5) The fuel pump shut-off is inertially activated.
(6) 1990 to 1993 a malfunctioning check valve within the fuel pump caused unused fuel to be returned to the second tank which could result in over filling and fuel spillage.
(7) 1999 possibility that a fuel pressure regulator O-ring may have been damage during installation in the fuel rail which may allow vapor or fuel to leak.
(8) 1997 In some vehicles rubbing on the fuel line may result in a fuel leak.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A4: Ford F-Ranger

Year	Model	Gas Tank	Tank Location (1)	Filler Cap	Filler Neck/Tube (2)	Fuel Sender (3) (6)	Sender Retainer	Roll-over Valve	Check Valve (4)	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (5)	Fuel Line Routing (7, 8)	Carburetion/Fuel Injection
2003		S	I/					Y	Y	EC/	Y	Y	Y	AF/	FI
2002			FR/							M/				L	
2001			L							R					
2000															
1999															
1998															
1997															
1996			I/						N	EC/					
1995			AR							F/					
1994										R					
1993															
1992															
1991															

Note:
(1) From 1991 to 1997 various tank capacities with different versions of the tank were available.
(2) The fuel pump shut-off is inertially activated.
(3) 1999 an O-ring seal in the fuel injector pulse damper to fuel rail joint could be damaged allowing fuel leakage.
(4) 1997 possibility of the fuel line coming into contact with the exhaust manifold.
(5) 1994 front fuel line flexible hose is susceptible to cracking allowing fuel to leak.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A6: GMC Sierra

Year	Model	Gas Tank	Tank Location	Filler Cap	Filler Neck/Tube (1)	Fuel Sender	Sender Retainer	Roll-over Valve	Check Valve	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (2)	Fuel Line Routing	Carburetion/Fuel Injection
2003		P	I/					Y	N	EC/	Y	Y	Y	AF/	FI
2002			FR/							F/				L	
2001		S	L						U	L					
2000									Y						
1999															
1998									U	EC/	U				
1997										F/					
1996									N	R					
1995															
1994															
1993															
1992															
1991															

Note:
(1) The filler tube varies depending on box style.
(2) The fuel pump was relay controlled.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A7: Nissan Frontier

Year	Model (1)	Gas Tank	Tank Location	Filler Cap	Filler Neck/Tube	Fuel Sender	Sender Retainer	Roll-over Valve	Check Valve	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (2)	Fuel Line Routing (3)	Carburetion/Fuel Injection
2003		S	I/					Y	Y	EC/	Y	Y	Y	AF	FI
2002			FR/							F/					
2001			R						U	R					
2000															
1999															
1998															
1997															
1996															
1995															
1994															
1993															
1992															
1991															

Note:
(1) The Tacoma replaced the Toyota pickup in 1995.
(2) The fuel pump was relay controlled.
(3) 2001-2003 during a side impact NCAP test, a fuel line inlet hose was damaged by a flange at the rear end of the double cab body which could result in fuel leakage.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A8: Toyota Tacoma

Year	Model (1)	Gas Tank	Tank Location	Filler Cap	Filler Neck/Tube	Fuel Sender	Sender Retainer	Roll-over Valve	Check Valve	Battery Location	Battery Terminal Cover	Under Hood Insulation	Fuel Pump Shut-off (1)	Fuel Line Routing	Carburetion/Fuel Injection
2003		S	I/					Y	Y	EC/	Y	Y	Y	AF	FI
2002			FR							F/					
2001										L					
2000															
1999															
1998															
1997															
1996															
1995															
1994															
1993															
1992															
1991															

Note:
(1) New truck. The first model year was 2000.

Legend:
AF - along frame
AR - aft of rear axle
C - carbureted
EC - engine compartment
F - front
FI - fuel injection
FR - forward rear axle
I - inside frame rail
L - left side
M - mid
N - none
O - outside frame rail
P - plastic
R - right side
S - steel
U - unknown
Y - yes

Figure A9: Toyota Tundra

APPENDIX 3: UNDERHOOD COMPONENT LOCATION

Under Hood Component Locations In Three Pickups

Vehicle	ENGINE	Year Range	Battery	Engine oil Filler	Dip Stick	Master Brake Cylinder	Tranny Dip Stick	Fuel line routing	Intake Manifold	Power Steering Reservoir	Fuel Rail (note12 to 16)	Exhaust manifold	Coolant fluid reservoir	Windshield Washer Reservoir	Fuel Filter	Oil Filter	Fuel Filler Cap
Ford F150	8 cyl **note 1**	2000-2003	M R	F R TVC	M L	RR L A	M R	L I	CEN	M LTVC	Y	R&L	F L	F R	L I	FL	L
	4.2 litre V6 cyl FI		M R	F L TVC	M L	RR L U	M R	L I	CEN	F L	Y	R&L	F L	F R	L I	FL	L
	8 cyl **note 1**	1997-1999	M R	F R TVC	F L	RR L U	M R	L I	CEN	F L	Y	R&L	F L	F R	L I	U	L
	4.2 litre V6 cyl FI		M R	F L TVC	M L	RR L U	M R	L I	CEN	F L	Y	R&L	F L	F R	L I	FL	L
	8 cyl **note 2**	1992-1996	F R	F L VC	M L	RR L U	U	L I	CEN	F L	Y	R&L	F L	F L	L I	FL	L
	4.9 litre inline 6 cyl		F R	F T VC	M L	RR L U	U	L I	R	F L	Y	R	F L	F L	L I	ML	L
	8 cyl **note 2, 3**	1987-1991	F R	F L VC	M L	RR L U	U	U	CEN	F L	U	R&L	F L	F L	U	FL	L
	4.9 litre inline 6 cyl FI		F R	F T VC	M L	RR L U	U	U	R	F L	U	R	F L	F L	U	ML	L
	8 cyl **note 3**	1980-1986	F R	F L VC	M L	RR L U	U	U	CEN	F L	N	R&L	F L	F L	U	FL	L
	4.9 litre inline 6 cyl Carb		F R	F T VC	M L	RR L U	U	U	R	F L	N	R	F L	F L	U	ML	L
Ford Ranger	6 cyl **note 4**	2001-2003	F L	8 R TVC	M L	RR L A	RR R	L I	CEN	F L	Y	R&L	M R	M R	L I	9	L
	2.3 litre 4 cyl FI		F L	F T VC	M L	RR L A	RR R	L I	L	F L	Y	R	M R	M R	L I	ML	L
	6 cyl **note 4**	1998-2000	F L	8 R TVC	M L	RR L A	RR R	L I	CEN	F L	Y	R&L	M R	M R	L I	9	L
	2.5 litre 4 cyl FI		F L	F T VC	M L	RR L A	RR R	L I	L	F L	Y	R	M R	M R	L I	ML	L
	6 cyl **note 4**	1993-1997	F R	8 R TVC	M L	RR L A	RR R	L I	CEN	F L	Y	R&L	F L	F L	L I	9	L
	2.3 litre 4 cyl FI		F R	F T VC	M L	RR L A	RR R	L I	L	F L	Y	R	F L	F L	L I	ML	L
	6 cyl **note 5**	1989-1992	F R	8 R TVC	M L	RR L U	RR R	L I	CEN	F L	Y	R&L	M L	M L	L I	9	L
	2.3 litre 4 cyl FI		F R	F T VC	M L	RR L U	RR R	L I	L	F L	Y	R	M L	M L	L I	ML	L
	6 cyl **note 6**	1983-1988	U U	8 R TVC	U U	RR L U	RR R	U	CEN	U U	N	R&L	U U	U U	U	RR	L
	4 cyl **note 7**		U U	U U VC	U U	RR L U	RR R	U	L	U U	N	R	U U	U U	U	ML	L
	4 cyl Diesel **note 10**		U U	U U U	U U	U U U	U U	U	U	U U	U	U	U U	U U	U	U	U
Chevy S-10	4.3 litre V-6 cyl FI	2002-2003	F R	M L TVC	M L	RR L A	M R	L I	CEN	U U	N	R&L	M R	M L	L I	U	L
	2.2 litre 4 cyl FI		F R	RR L TVC	U U	RR L N	U U	L I	R	F L	Y	L	M R	F L	L I	U	L
	4.3 litre V-6 cyl FI **Note 11**	1994-2001	F R	F L TVC	F R	RR L A	RR R	L I	R	U U	N	R&L	M R	F L	L I	U	L
	2.2 litre 4 cyl FI		F R	RR L TVC	U U	RR L N	U U	L I	R	F L	Y	L	M R	F L	L I	U	L
	2.2 litre 4 cyl Vortec		F R	RR L TVC	U U	RR L A	M R	L I	R	F L	Y	L	M R	F L	L I	U	L
	2.8 litre V-6 TBI 1986-1993	1986-1993	F R	M R TVC	F R	RR L N	U	L I	R	U U	N	R&L	M R	RR L	L I	U	L
	2.8 litre V-6 Carb 1983-1985		F R	M L TVC	M L	RR L N	U	L I	R	F L	N	R&L	F L	RR L	L I	U	L
	4.3 litre V-6 cyl FI **Note 11**		F R	M L TVC	F R	RR L A	RR R	L I	CEN	U U	N	R&L	M R	RR L	L I	U	L
	2.5 litre 4cyl TBI 1985-1993		F R	RR L TVC	U U	RR L A	M R	L I	R	F L	N	L	M R	F L	L I	U	L
	2.0 litre 4cyl Carb 1983-1984		U U	U U U	U U	U U U	U U	U	U	U U	U	U	U U	U U	U	U	U
	1.9 litre 4cyl Carb 1983-1985		U U	U U U	U U	U U U	U U	U	U	U U	U	U	U U	U U	U	U	U
	2.2 litre Diesel 1983-1985		U R	U U U	U U	U U U	U U	U	U	U U	U	U	U U	U U	U	U	U

Legend	
A -	ABS
CEN -	Centre
I -	Inside Frame Rail
L -	Left Side
M -	Mid
N -	None
R -	Right Side
RR -	Rear
T -	Top
TVC -	Top of Valve Cove
U -	Unknown
VC -	Valve Cover
Y -	Yes

Note 1	4.6L and 5.8L V8 fuel injected engines used.
Note 2	5.0L V8 fuel injected engine used 1987-1996. 5.8L V8 fuel injected engine used 1988-1996.
Note 3	5.0L V8 carbureted engine used 1980-1984. 5.8L V8 carbureted engine used 1980-1987.
Note 4	3.0L and 4.0L V6 fuel injected engines used.
Note 5	3.0L and 4.0L V6 fuel injected engines used in 1992. 2.9L, 3.0L and 4.0L V6 fuel injected engines used in 1991. 2.9L and 4.0L V6 fuel injected engines used in 1990. 2.9L V6 fuel injected engine used in 1989.
Note 6	2.9L V6 fuel injected engine used in 1986-1988. 2.8L V6 carbureted engine used 1983-1985.
Note 7	2.0L carbureted 1983-1988 and 2.3L fuel injected engines 1985-1988. 2.3L carbureted engine used 1983-1984 and 2.3L fuel injected engine 1985-1988.
Note 8	The oil filler is located on right side valve cover for 2.9L, 3.0L and 4.0L engines. It is on the left side for the 2.8L engine. The location on the valve cover varies for each engine type.
Note 9	The oil filter is located on the right side for 2.8L, 2.9L and 4.0L engines and on the left side for 3.0 litre engines.
Note 10	4 cyl FI Diesel 2.2L in 1983-1984 and 2.3L in 1985-1986.
Note 11	Two types of 4.3L engines were used: 4.3L TBI and 4.3L FI, 1992-1994.
Note 12	For the Ford V8s and V6s the fuel rail mounts on top of the manifold on the inside of the engine heads. The Ford straight 4 cylinder engine has the fuel rail mounted on the left side of the engine.
Note 13	The Chevy S-10 2.2L 4 cylinder engines have the fuel rail mounted on the intake manifold on the right side of the engine. The 2.8L carbureted and throttle injection have the fuel lines connected directly to the carburetor or the throttle body without the fuel rail.
Note 14	The Chevy 1993 4.3L has central multiport fuel injection - no fuel rail.
Note 15	The Chevy 1996 4.3L throttle body injection - no fuel rail.
Note 16	The Chevy 1992 to 2003 4.3L multiport fuel injection and throttle body injection did not have a fuel rail.
General note	High pressure fuel pump mounted inside LS frame rail for Fuel Injected vehicles Ford & GM Pick ups.

Table A1

APPENDIX 4: FREQUENCIES FOR FARS DATA FIGURE 1*

*Note: All Table and Figure captions refer to corresponding tables and figures in the report.

Data source: 2001-2003 FARS Data
Percent of Vehicles Experiencing Fires, by State
Percent of Vehicles Experiencing Fires, By State (FARS 2001-2003)
Eliminate cases where the fire_exp field is missing

The FREQ Procedure

Table of STATE by FIRE_EXP

STATE	Frequency / Percent / Row Pct / Col Pct	FIRE_EXP(FIRE OCCURRENCE): No Fire	Fire in Veh	Total
Alabama	Frequency	5666	135	5801
	Percent	2.29	0.05	2.34
	Row Pct	97.67	2.33	
	Col Pct	2.35	2.05	
Alaska	Frequency	454	28	482
	Percent	0.18	0.01	0.19
	Row Pct	94.19	5.81	
	Col Pct	0.19	0.42	
Arizona	Frequency	6924	203	7127
	Percent	2.79	0.08	2.88
	Row Pct	97.15	2.85	
	Col Pct	2.87	3.08	
Arkansas	Frequency	3250	144	3394
	Percent	1.31	0.06	1.37
	Row Pct	95.76	4.24	
	Col Pct	1.35	2.18	
California	Frequency	24938	659	25597
	Percent	10.06	0.27	10.33
	Row Pct	97.43	2.57	
	Col Pct	10.34	9.99	
Colorado	Frequency	4203	75	4278
	Percent	1.70	0.03	1.73
	Row Pct	98.25	1.75	
	Col Pct	1.74	1.14	
Connecticut	Frequency	1605	64	1669
	Percent	0.65	0.03	0.67
	Row Pct	96.17	3.83	
	Col Pct	0.67	0.97	
Total	Frequency	241214	6599	247813
	Percent	97.34	2.66	100.00

STATE	Frequency / Percent / Row Pct / Col Pct	FIRE_EXP(FIRE OCCURRENCE): No Fire	Fire in Veh	Total
Delaware	Frequency	877	28	905
	Percent	0.35	0.01	0.37
	Row Pct	96.91	3.09	
	Col Pct	0.36	0.42	
Dist of Columbia	Frequency	372	7	379
	Percent	0.15	0.00	0.15
	Row Pct	98.15	1.85	
	Col Pct	0.15	0.11	
Florida	Frequency	18175	240	18415
	Percent	7.33	0.10	7.43
	Row Pct	98.70	1.30	
	Col Pct	7.53	3.64	
Georgia	Frequency	9287	361	9648
	Percent	3.75	0.15	3.89
	Row Pct	96.26	3.74	
	Col Pct	3.85	5.47	
Hawaii	Frequency	740	12	752
	Percent	0.30	0.00	0.30
	Row Pct	98.40	1.60	
	Col Pct	0.31	0.18	
Idaho	Frequency	1621	17	1638
	Percent	0.65	0.01	0.66
	Row Pct	98.96	1.04	
	Col Pct	0.67	0.26	
Illinois	Frequency	7892	351	8243
	Percent	3.18	0.14	3.33
	Row Pct	95.74	4.26	
	Col Pct	3.27	5.32	
Total	Frequency	241214	6599	247813
	Percent	97.34	2.66	100.00

(Continued on next page)

("The FREQ Procedure" continued...)

STATE — FIRE_EXP(FIRE OCCURRENCE)

STATE	Frequency / Percent / Row Pct / Col Pct	No Fire	Fire in Veh	Total
Indiana	Frequency	4662	134	4796
	Percent	1.88	0.05	1.94
	Row Pct	97.21	2.79	
	Col Pct	1.93	2.03	
Iowa	Frequency	2345	32	2377
	Percent	0.95	0.01	0.96
	Row Pct	98.65	1.35	
	Col Pct	0.97	0.48	
Kansas	Frequency	2651	131	2782
	Percent	1.07	0.05	1.12
	Row Pct	95.29	4.71	
	Col Pct	1.10	1.99	
Kentucky	Frequency	4967	118	5085
	Percent	2.00	0.05	2.05
	Row Pct	97.68	2.32	
	Col Pct	2.06	1.79	
Louisiana	Frequency	4913	185	5098
	Percent	1.98	0.07	2.06
	Row Pct	96.37	3.63	
	Col Pct	2.04	2.80	
Maine	Frequency	1126	35	1161
	Percent	0.45	0.01	0.47
	Row Pct	96.99	3.01	
	Col Pct	0.47	0.53	
Maryland	Frequency	3802	86	3888
	Percent	1.53	0.03	1.57
	Row Pct	97.79	2.21	
	Col Pct	1.58	1.30	
Total		241214	6599	247813
		97.34	2.66	100.00

STATE — FIRE_EXP(FIRE OCCURRENCE)

STATE	Frequency / Percent / Row Pct / Col Pct	No Fire	Fire in Veh	Total
Massachusetts	Frequency	2459	56	2515
	Percent	0.99	0.02	1.01
	Row Pct	97.77	2.23	
	Col Pct	1.02	0.85	
Michigan	Frequency	7840	135	7975
	Percent	3.16	0.05	3.22
	Row Pct	98.31	1.69	
	Col Pct	3.25	2.05	
Minnesota	Frequency	3396	267	3663
	Percent	1.37	0.11	1.48
	Row Pct	92.71	7.29	
	Col Pct	1.41	4.05	
Mississippi	Frequency	4696	16	4712
	Percent	1.89	0.01	1.90
	Row Pct	99.66	0.34	
	Col Pct	1.95	0.24	
Missouri	Frequency	6581	245	6826
	Percent	2.66	0.10	2.75
	Row Pct	96.41	3.59	
	Col Pct	2.73	3.71	
Montana	Frequency	1304	39	1343
	Percent	0.53	0.02	0.54
	Row Pct	97.10	2.90	
	Col Pct	0.54	0.59	
Nebraska	Frequency	1594	17	1611
	Percent	0.64	0.01	0.65
	Row Pct	98.94	1.06	
	Col Pct	0.66	0.26	
Total		241214	6599	247813
		97.34	2.66	100.00

STATE — FIRE_EXP(FIRE OCCURRENCE)

STATE	Frequency / Percent / Row Pct / Col Pct	No Fire	Fire in Veh	Total
Nevada	Frequency	2121	50	2171
	Percent	0.86	0.02	0.88
	Row Pct	97.70	2.30	
	Col Pct	0.88	0.76	
New Hampshire	Frequency	700	16	716
	Percent	0.28	0.01	0.29
	Row Pct	97.77	2.23	
	Col Pct	0.29	0.24	
New Jersey	Frequency	3285	77	3362
	Percent	1.33	0.03	1.36
	Row Pct	97.71	2.29	
	Col Pct	1.36	1.17	
New Mexico	Frequency	2603	53	2656
	Percent	1.05	0.02	1.07
	Row Pct	98.00	2.00	
	Col Pct	1.08	0.80	
New York	Frequency	8097	225	8322
	Percent	3.27	0.09	3.36
	Row Pct	97.30	2.70	
	Col Pct	3.36	3.41	
North Carolina	Frequency	9048	194	9242
	Percent	3.65	0.08	3.73
	Row Pct	97.90	2.10	
	Col Pct	3.75	2.94	
North Dakota	Frequency	519	17	536
	Percent	0.21	0.01	0.22
	Row Pct	96.83	3.17	
	Col Pct	0.22	0.26	
Total		241214	6599	247813
		97.34	2.66	100.00

STATE — FIRE_EXP(FIRE OCCURRENCE)

STATE	Frequency / Percent / Row Pct / Col Pct	No Fire	Fire in Veh	Total
Ohio	Frequency	7549	184	7733
	Percent	3.05	0.07	3.12
	Row Pct	97.62	2.38	
	Col Pct	3.13	2.79	
Oklahoma	Frequency	3975	135	4110
	Percent	1.60	0.05	1.66
	Row Pct	96.72	3.28	
	Col Pct	1.65	2.05	
Oregon	Frequency	2579	92	2671
	Percent	1.04	0.04	1.08
	Row Pct	96.56	3.44	
	Col Pct	1.07	1.39	
Pennsylvania	Frequency	8179	297	8476
	Percent	3.30	0.12	3.42
	Row Pct	96.50	3.50	
	Col Pct	3.39	4.50	
Rhode Island	Frequency	523	14	537
	Percent	0.21	0.01	0.22
	Row Pct	97.39	2.61	
	Col Pct	0.22	0.21	
South Carolina	Frequency	5762	67	5829
	Percent	2.33	0.03	2.35
	Row Pct	98.85	1.15	
	Col Pct	2.39	1.02	
South Dakota	Frequency	968	46	1014
	Percent	0.39	0.02	0.41
	Row Pct	95.46	4.54	
	Col Pct	0.40	0.70	
Total		241214	6599	247813
		97.34	2.66	100.00

("The FREQ Procedure" continued...)

STATE	FIRE_EXP(FIRE OCCURRENCE)		
Frequency Percent Row Pct Col Pct	No Fire	Fire in Veh	Total
Tennessee	6705 2.71 96.27 2.78	260 0.10 3.73 3.94	6965 2.81
Texas	22102 8.92 97.54 9.16	558 0.23 2.46 8.46	22660 9.14
Utah	1968 0.79 99.60 0.82	8 0.00 0.40 0.12	1976 0.80
Vermont	415 0.17 96.06 0.17	17 0.01 3.94 0.26	432 0.17
Virginia	4886 1.97 98.31 2.03	84 0.03 1.69 1.27	4970 2.01
Washington	3568 1.44 96.56 1.48	127 0.05 3.44 1.92	3695 1.49
West Virginia	2142 0.86 96.18 0.89	85 0.03 3.82 1.29	2227 0.90
Total	241214 97.34	6599 2.66	247813 100.00

STATE	FIRE_EXP(FIRE OCCURRENCE)		
Frequency Percent Row Pct Col Pct	No Fire	Fire in Veh	Total
Wisconsin	4254 1.72 96.40 1.76	159 0.06 3.60 2.41	4413 1.78
Wyoming	926 0.37 98.51 0.38	14 0.01 1.49 0.21	940 0.38
Total	241214 97.34	6599 2.66	247813 100.00

APPENDIX 5: FREQUENCIES FOR SELECTED TABLES & FIGURES*

*Note: The numbers and captions refer to corresponding tables and figures in the this report.

	Overall Observations
Illinois	3567930
Maryland	2198566
Pennsylvania	4581883
Minnesota	1831318
Total	**12179697**

Table 1: State Accident Data for Vehicle Group Analysis

State	Pickups	Pickup Fires
IL	199926	304
MD	84954	117
MN	164102	432
PA	200783	219

Figure 2: Pickup Fire Rates by State (Model Year 1980+)

State	Pickups	Pickup Fires
IL	89657	118
MD	43405	40
MN	68446	146
PA	94271	86

Figure 3: Pickup Fire Rates by State (Model Year 1980+ Age 0-4)

Vehicle Group	Known	Fires
Chevy S10	96127	129
CHEV/GMC 1500	142257	284
Dodge Dakota	42482	63
Dodge RAM 1500	39065	82
Ford Ranger	119216	185
Ford F150	139103	256
Nissan Frontier	21596	22
Toyota Tacoma	49329	50
Toyota Tundra	590	1

Figure 8: Fires by Pickup Vehicle Groups (Overall)

Vehicle Group	known	fires
Chevy S10	42650	48
CHEV/GMC 1500	59654	78
Dodge Dakota	24292	31
Dodge Ram 1500	24957	47
Ford Ranger	54872	68
Ford F150	59615	94
Nissan Frontier	8969	6
Toyota Tacoma	20231	17

Figure 9: Fires by Pickup Vehicle Groups (Age 0-4)

Vehicle Group	Model Year	Known	Fires
CHEV/GMC 1500	1981	3457	10
CHEV/GMC 1500	1982	3293	8
CHEV/GMC 1500	1983	3392	13
CHEV/GMC 1500	1984	4706	18
CHEV/GMC 1500	1985	5835	25
CHEV/GMC 1500	1986	6005	20
CHEV/GMC 1500	1987	4465	7
CHEV/GMC 1500	1988	11608	22
CHEV/GMC 1500	1989	11057	20
CHEV/GMC 1500	1990	10321	18
CHEV/GMC 1500	1991	7766	5
CHEV/GMC 1500	1992	9270	25
CHEV/GMC 1500	1993	10326	14
CHEV/GMC 1500	1994	12513	15
CHEV/GMC 1500	1995	9281	19
CHEV/GMC 1500	1996	6944	8
CHEV/GMC 1500	1997	7124	14
CHEV/GMC 1500	1998	5628	11
CHEV/GMC 1500	1999	4339	8
CHEV/GMC 1500	2000	3330	0
CHEV/GMC 1500	2001	1198	3

Figure 10: Chevy/GMC 1500 Fire Rates by Model

Vehicle Group	Model Year	Known	Fires
Chevy S10	1982	2064	5
Chevy S10	1983	2672	2
Chevy S10	1984	3466	3
Chevy S10	1985	4466	11
Chevy S10	1986	3869	4
Chevy S10	1987	6031	7
Chevy S10	1988	7559	11
Chevy S10	1989	7770	12
Chevy S10	1990	2448	2
Chevy S10	1991	11594	17
Chevy S10	1992	6235	4
Chevy S10	1993	5294	7
Chevy S10	1994	7483	10
Chevy S10	1995	6479	12
Chevy S10	1996	5604	8
Chevy S10	1997	4279	2
Chevy S10	1998	4183	6
Chevy S10	1999	2252	2
Chevy S10	2000	1709	2
Chevy S10	2001	560	2

Figure 11: GM S10 Fire Rates by Model Year

Vehicle Group	Model Year	Known	Fires
Dodge Dakota	1987	3419	6
Dodge Dakota	1988	2978	3
Dodge Dakota	1989	2834	6
Dodge Dakota	1990	2204	5
Dodge Dakota	1991	2272	5
Dodge Dakota	1992	4185	7
Dodge Dakota	1993	4183	6
Dodge Dakota	1994	3401	6
Dodge Dakota	1995	3049	1
Dodge Dakota	1996	2596	2
Dodge Dakota	1997	3245	4
Dodge Dakota	1998	3264	1
Dodge Dakota	1999	2438	2
Dodge Dakota	2000	1548	5
Dodge Dakota	2001	709	4

Figure 12: Dodge Dakota Fire Rates by Model Year

Vehicle Group	Model Year	Known	Fires
Dodge RAM 1500	1981	598	2
Dodge RAM 1500	1982	848	1
Dodge RAM 1500	1983	873	5
Dodge RAM 1500	1984	1588	4
Dodge RAM 1500	1985	20	0
Dodge RAM 1500	1986	1671	5
Dodge RAM 1500	1987	1824	6
Dodge RAM 1500	1988	1264	2
Dodge RAM 1500	1989	1174	2
Dodge RAM 1500	1990	1083	1
Dodge RAM 1500	1991	689	0
Dodge RAM 1500	1992	493	0
Dodge RAM 1500	1993	435	2
Dodge RAM 1500	1994	3130	4
Dodge RAM 1500	1995	3521	10
Dodge RAM 1500	1996	5490	12
Dodge RAM 1500	1997	5139	9
Dodge RAM 1500	1998	4232	10
Dodge RAM 1500	1999	2782	5
Dodge RAM 1500	2000	847	1
Dodge RAM 1500	2001	1266	1

Figure 12a Dodge Ram 1500 Fire Rates by Model Year

Vehicle Group	Model Year	Known	Fires
Ford F150	1981	2533	4
Ford F150	1982	2465	2
Ford F150	1983	3293	8
Ford F150	1984	6167	9
Ford F150	1985	7111	16
Ford F150	1986	9939	27
Ford F150	1987	8185	25
Ford F150	1988	9730	17
Ford F150	1989	10313	13
Ford F150	1990	9367	17
Ford F150	1991	6801	12
Ford F150	1992	8890	13
Ford F150	1993	9279	17
Ford F150	1994	9957	14
Ford F150	1995	8513	18
Ford F150	1996	4532	8
Ford F150	1997	10484	14
Ford F150	1998	4835	11
Ford F150	1999	3351	4
Ford F150	2000	1879	5
Ford F150	2001	1232	2

Figure 13: Ford F150 Fire Rates by Model Year

Vehicle Group	Model Year	Known	Fires
Ford Ranger	1983	3318	14
Ford Ranger	1984	3880	12
Ford Ranger	1985	4560	10
Ford Ranger	1986	6400	13
Ford Ranger	1987	8635	15
Ford Ranger	1988	11033	14
Ford Ranger	1989	7447	9
Ford Ranger	1990	7777	9
Ford Ranger	1991	7290	11
Ford Ranger	1992	7326	9
Ford Ranger	1993	9804	9
Ford Ranger	1994	12257	18
Ford Ranger	1995	5049	9
Ford Ranger	1996	6139	2
Ford Ranger	1997	5539	5
Ford Ranger	1998	4603	7
Ford Ranger	1999	4094	7
Ford Ranger	2000	2635	4
Ford Ranger	2001	1177	5

Figure 14: Ford Ranger Fire Rates by Model Year

Vehicle Group	Model Year	Known	Fires
Toyota Tacoma	1983	1280	4
Toyota Tacoma	1984	2265	2
Toyota Tacoma	1985	3182	4
Toyota Tacoma	1986	4756	4
Toyota Tacoma	1987	4508	3
Toyota Tacoma	1988	4078	4
Toyota Tacoma	1989	3966	2
Toyota Tacoma	1990	2922	1
Toyota Tacoma	1991	3198	7
Toyota Tacoma	1992	3111	2
Toyota Tacoma	1993	3076	3
Toyota Tacoma	1994	3938	5
Toyota Tacoma	1995	1531	3
Toyota Tacoma	1996	1736	1
Toyota Tacoma	1997	1170	1
Toyota Tacoma	1998	1163	0
Toyota Tacoma	1999	793	1
Toyota Tacoma	2000	371	1
Toyota Tacoma	2001	146	2

Figure 16: Toyota Tacoma fire Rates by Model Year

Check Valve	Knowns	Fires
N	237993	350
UNKNOWN	39033	63
Y	68038	108

Figure 17: Pickup Fire Rates by Check Valve

Check Valve	Knowns	Fires
N	134824	163
UNKNOWN	34104	55
Y	61840	92

Figure 18: Pickup Fire Rates by Check Valve (Age 0-4)

Vehicle Group	Model Year	Known	Fires
Nissan FRONTIER	1985	1675	1
Nissan FRONTIER	1986	3986	4
Nissan FRONTIER	1987	2484	1
Nissan FRONTIER	1988	1537	1
Nissan FRONTIER	1989	1664	2
Nissan FRONTIER	1990	1674	1
Nissan FRONTIER	1991	1708	6
Nissan FRONTIER	1992	934	2
Nissan FRONTIER	1993	1508	0
Nissan FRONTIER	1994	1297	1
Nissan FRONTIER	1995	1320	3
Nissan FRONTIER	1996	561	0
Nissan FRONTIER	1997	491	0
Nissan FRONTIER	1998	323	0
Nissan FRONTIER	1999	128	0
Nissan FRONTIER	2000	178	0

Figure 15: Nissan Frontier Rates by Model Year

Battery Location	Knowns	Fires
EC/F/L	68935	110
EC/F/R	235910	344
EC/M/R	40219	67

Figure 19: Pickup Fire Rates by Battery Location

Battery Location	Knowns	Fires
EC/F/L	53608	82
EC/F/R	138999	169
EC/M/R	38161	59

Figure 20: Pickup Fire Rates by Battery Location (Age 0-4)

Cutoff Switch type	Knowns	Fires
INERTIAL	136056	207
RELAY	199875	301

Figure 21: Pickup Cutoff Switch Type

Cutoff Switch type	Knowns	Fires
INERTIAL	90517	124
RELAY	134346	181

Figure 22: Pickup Cutoff Switch Type (Age 0-4)

Tank Location	Knowns	Fires
I/FR/L	329593	500
I/FR/R	15471	21

Figure 23: Fire Rates for Pickup Design Group by Tank Location

Tank Location	Knowns	Fires
I/FR/L	219285	300
I/FR/R	11483	10

Figure 24: Fire Rates for Pickup Design Group by Tank Location (Age 0-4)

Tank Type	Knowns	Fires
PLASTIC	59562	98
STEEL	285502	423

Figure 25: Fire Rates by Fuel Tank Type

Tank Type	Knowns	Fires
PLASTIC	44714	70
STEEL	186054	240

Figure 26: Fire Rates by Fuel Tank Type (Age 0-4)

Battery Cover	Knowns	Fires
N	93739	124
UNKNOWN	68852	111
Y	182473	286

Figure 27: Fire Rates by Pickup Battery Cover

Battery Cover	Knowns	Fires
N	59210	66
UNKNOWN	40244	56
Y	131314	188

Figure 28: Fire Rates by Pickup Battery Cover (Age 0-4)

Fuel Line Routing	Knowns	Fires
LEFT	336515	509
RIGHT	8549	12

Figure 29: Pickup Fire Rates by Fuel Line Routing

Fuel Line Routing	Knowns	Fires
LEFT	225400	306
RIGHT	5368	4

Figure 30: Pickup Fire Rates by Fuel Line Routing (Age 0-4)

IIHS Rating	Knowns	Fires
A	3215	4
M	41995	71
P	31235	48

Figure 31: Pickup Fire Rates by IIHS Structure Results

IIHS Rating	Knowns	Fires
A	3080	4
M	40397	63
P	29291	45

Figure 32: Pickup Fire Rates by IIHS Structure Results (Age 0-4)

Tank Typ	Mode	Known	Fires
PLASTIC	FRONT	31057	47
PLASTIC	REAR	15124	5
PLASTIC	ROLL	1712	26
PLASTIC	SIDE	6365	7
STEEL	FRONT	143540	218
STEEL	REAR	71263	38
STEEL	ROLL	12079	75
STEEL	SIDE	31242	23

Figure 45: Fire Rate by Tank Type and Impact Mode (MY91+)

		0-4		5+	
Tank Type	Mode	Known	Fires	Known	Fires
PLASTIC	FRONT	23164	36	7893	11
PLASTIC	REAR	11616	5	3508	0
PLASTIC	ROLL	1255	17	457	9
PLASTIC	SIDE	4758	4	1607	3
STEEL	FRONT	91738	122	51802	96
STEEL	REAR	47118	20	24145	18
STEEL	ROLL	8271	41	3808	34
STEEL	SIDE	20668	15	10574	8

Figure 46: Fire Rates by Tank Type and Impact Mode and Vehicle Age

chekvalv	imode	N	Fires
N	FRONT	121894	178
UNK	FRONT	19190	28
Y	FRONT	33513	59
N	REAR	58160	33
UNK	REAR	10459	5
Y	REAR	17768	5
N	ROLL	9485	63
UNK	ROLL	1502	19
Y	ROLL	2804	19
N	SIDE	26193	19
UNK	SIDE	4273	3
Y	SIDE	7141	8

Figure 47: Fire Rates by Check Valve and Impact Model

fuelline	Mode	Known	Fires
LEFT	FRONT	170067	260
RIGHT	FRONT	4530	5
LEFT	REAR	84297	42
RIGHT	REAR	2090	1
LEFT	ROLL	13442	101
RIGHT	ROLL	349	0
LEFT	SIDE	36746	29
RIGHT	SIDE	861	1

Figure 49 Fire Rates by Fuel Line Routing by Impact Mode

batt_loc	Mode	Known	Fires
EC/F/L	FRONT	35313	53
EC/F/R	FRONT	119943	176
EC/M/R	FRONT	19341	36

Figure 48: Fire Rates by Battery Location in Frontal Impacts for Vehicles (Age 0-4)

cutoff	Mode	Known	Fires
INERTIAL	FRONT	44930	63
RELAY	FRONT	66969	92
INERTIAL	REAR	22531	9
RELAY	REAR	34671	15
INERTIAL	ROLL	4478	20
RELAY	ROLL	4793	38
INERTIAL	SIDE	9772	9
RELAY	SIDE	15042	10

Figure 50 Fire Rates by Cutoff Swtich Type and Impact Mode

FOOTNOTES

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