Motorcoach and School Bus Fire Safety Analysis

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

November 2016

FOREWORD

This final report documents a study analyzing motorcoach and school bus fire safety. Research was performed by the John A. Volpe National Transportation Systems Center (Volpe) for the U.S. Department of Transportation (USDOT), Federal Motor Carrier Safety Administration (FMCSA), Technology Division, Office of Analysis, Research, and Technology. The objective of this study was to identify the causes, frequency, and severity of motorcoach and school bus fires in the United States, and determine potential ways to prevent or reduce the severity of these incidents. This study updates the 2009 Motorcoach Fire Safety Analysis, which was based on reported motorcoach fires that occurred from 1995 to 2008, and expands the database to include all nationally reported motorcoach fires (i.e., spontaneous, intentional, or the result of a collision or rollover) that occurred from 2004 to 2013. In addition, this report evaluates school bus fire risk, further explores the use of indicators of future fire risk based on regulatory compliance data, and estimates the fire safety impacts of recent technology changes—including automatic fire detection and suppression systems—on motorcoaches and school buses. Recommendations are offered for improving the quality of reported data, training and outreach, vehicle design and equipment, and inspection standards. The findings and recommendations in this report are of interest to a broad spectrum of stakeholders in the arena of passenger carrier safety, including Government regulatory agencies, motorcoach operators and school bus service providers, industry associations, vehicle and vehicle equipment manufacturers, and the traveling public.

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16. Abstract

This report documents a motorcoach and school bus fire safety analysis performed by the John A. Volpe National Transportation Systems Center (Volpe) for the Federal Motor Carrier Safety Administration. This report aims to: 1) identify the causes, frequency, and severity of motorcoach and school bus fires in the United States, and 2) recommend ways to prevent or reduce the severity of these incidents, especially through improving the effectiveness of vehicle inspection practices. This report succeeds Volpe's 2009 Motorcoach Fire Safety Analysis (henceforth referred to as the 2009 study), and has been expanded to include school bus fires.

The 2009 study established a database of spontaneous motorcoach fires collecting information from U.S. Government, industry, and media sources and analyzed the safety risk of motorcoach fires. The study also sought to identify potential measures for risk reduction. The current report updates and expands on the 2009 study to include all motorcoach and school bus fires.

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SI* (MODERN METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		Length		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		Area		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	Acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		Volume (volumes greater than 1,000L shall be shown in m^3)		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		Mass		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
		Temperature (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		Illumination		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		Force and Pressure or Stress		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

Approximate Conversions from SI Units				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		Length		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		Area		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
Ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		Volume		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		Mass		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2,000 lb)	T
		Temperature (exact degrees)		
°C	Celsius	1.8c+32	Fahrenheit	°F
		Illumination		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		Force and Pressure or Stress		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003, Section 508-accessible version September 2009.)

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Acronym	Definition
ABA	American Bus Association
AFSS	automatic fire suppression system
BASIC	Behavior Analysis and Safety Improvement Category
BIC	Bus Industry Confederation
CDL	commercial driver’s license
CFR	Code of Federal Regulations
CMV	commercial motor vehicle
CR	compliance review
CVSA	Commercial Vehicle Safety Alliance
DPF	diesel particulate filters
DUNS	Data Universal Numbering System
DVIR	Driver Vehicle Inspection Report
ECE	Economic Commission of Europe
FAA	Federal Aviation Administration
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standard
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulation
FMVSS	Federal Motor Vehicle Safety Standard
FRA	Federal Railroad Administration
FRS	Fire Rescue Services
FTA	Federal Transit Administration
GPS	global positioning system

Acronym	Definition
GSA	General Services Administration
GVWR	gross vehicle weight rating
MAP-21	Moving Ahead for Progress in the 21st Century Act
MCI	Motorcoach Industries
MCMIS	Motor Carrier Management Information System
MMUCC	Model Minimum Uniform Crash Criteria
MSB	Swedish Civil Contingencies Agency
MY	model year
NAPT	National Association of Pupil Transportation
NAS	North American Standard
NCIC	National Crime Information Center
NCST	National Congress on School Transportation
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NHTSA	National Highway Traffic Safety Administration
NSTA	National School Transportation Association
NTSB	National Transportation Safety Board
ODI	Office of Defects Investigation (NHTSA)
OOS	out of service
PA	public address
SDS	State Data System
UL	Underwriters Laboratories
USDOT	U.S. Department of Transportation
USFA	U.S. Fire Administration
VIN	vehicle identification number
VMT	vehicle miles traveled

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EXECUTIVE SUMMARY

This final report documents a study analyzing motorcoach and school bus fire safety. The primary objective of this study was to update and expand upon the *2009 Motorcoach Fire Safety Analysis*[(1)] by gathering and analyzing information regarding the causes, frequency, and severity of motorcoach and school bus fires.

A motorcoach is a bus with integral construction designed for long-distance passenger transportation. It measures at least 35 feet long and can seat 30 or more passengers on an elevated passenger deck over a baggage compartment. A school bus is a bus that is sold or introduced into interstate commerce for the purpose of carrying students to and from school or related events. There are four main school bus types, which can carry 10–90 passengers.

Fires start when flammable or combustible materials with an adequate supply of oxygen are subjected to a source of ignition. Common ignition sources include arcing; radiated or conducted heat from the operating equipment of the vehicle; spark, ember, or flame from the operating equipment of the vehicle; and heat or spark from friction. Fires sustain themselves by the further release of heat energy in the process of combustion, and they may propagate, provided there is a continuous supply of oxygen and fuel. Most motorcoach and school bus fires start in the engine area, running gear, or wheel area of the vehicle.

Motorcoach and school bus fires can quickly consume a vehicle, causing hundreds of thousands of dollars in property damage. In the vast majority of reported cases, passengers were able to evacuate safely, thereby avoiding deaths and injuries. A 2005 fire on a motorcoach operated by Global Limo, which resulted in 23 fatalities and 15 injuries, and a 1988 school bus fire in Carrollton, Kentucky, which resulted in 27 fatalities and 34 injuries, are singular events that demonstrate the death and injury potential of these types of vehicle fires.

DATA DEVELOPMENT

Although there are credible estimates of the frequency of fires on all types of buses combined, motorcoach- and school bus-specific estimates are not easily found in State and Federal accident statistics, national fire databases, and general media sources.

Primary data sources for this study included the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the Federal Motor Carrier Safety Administration's (FMCSA's) Motor Carrier Management Information System (MCMIS). Other supplemental sources included insurance and media records, the National Highway Traffic Safety Administration's (NHTSA's) State Data System (SDS) for selected States, and the Federal Highway Administration's (FHWA's) *Highway Statistics*. Motorcoach and school bus population and characteristics data were obtained from R.L. Polk and Co. The analysis in this study relied more on the incident data from the Federal sources and from R.L. Polk than on the secondary sources, in comparison with the more extensive coverage of all sources in the 2009 study.

Data collection for this study involved the following:

- Querying the national public and industry data sources listed above for motorcoach and school bus fires.
- Verifying and classifying the query results.
- Determining vehicle population and mileage counts from which to normalize the counts of fire-involved vehicles, by make, model, and geographic location.
- Finding inspection and investigation histories pertaining to each vehicle and carrier represented in the data.

Collected data included incidents spanning the years 2004–13. These data were analyzed in an attempt to identify trends and common factors characterizing motorcoach and school bus fire safety risk.

Data attributable to each record were examined to:

- Identify the age, make, model, and other characteristics of each motorcoach and school bus.
- Characterize each vehicle's geographic location and its maintenance and inspection history.
- Describe each fire's ignition factors, property damage, and resultant injuries and fatalities.

The final data set used for analysis in this study had several limitations, including:

- Geographic and temporal skewing of some data.
- Missing or incomplete data for some fields.
- Issues with data completeness and quality, in some instances.

Despite these limitations, the data set was sufficiently comprehensive for analysis.

KEY FINDINGS

- School bus fires reportedly occur more frequently than motorcoach fires. On average, motorcoach fires in the United States occur slightly less than daily, while school bus fires occur slightly more than daily. The frequency trend for both motorcoach fires and school bus fires from 2004 to 2013 is similar, with a general downward trend over the 10-year period.
- Deaths and injuries resulting from motorcoach or school bus fires are rare, but can be severe in worst-case scenarios. The vast majority of the reported fires resulted in no direct injuries or fatalities, and the average reported property damage per incident was a fraction of the total cost of the vehicle.

- The ratio of motorcoach fires to billion highway vehicle miles traveled (VMT) is highest in the Eastern and Southern regions, compared to the Midwestern and Western regions of the United States. The greatest number of school bus fires occurred in the Southern and Midwestern regions.
- The most frequent cause of ignition was failure of equipment or heat source for both motorcoaches and school buses. Unlike motorcoach fires, a significant number of school bus fires were classified as intentional.
- The most frequent areas of origin for motorcoach and school bus fires were the engine area, running gear, or wheel area. Seventy-seven percent of motorcoach fires and 68 percent of school bus fires (with known areas of origin) originated in these areas. A significant number of these fires on motorcoaches cited a tire as the item first ignited; these were likely wheel area fires. A significant number of engine area, running gear, or wheel area fires on school buses cited an electrical wire as the item first ignited; these were likely electrical fires.
- The most frequent contributing factor for both motorcoaches and school buses was mechanical failure or malfunction, followed by electrical failure or malfunction. However, motorcoach fires were more likely to be mechanical in nature (rather than electrical) compared to school bus fires.
- About 50 percent of the motorcoach fire incident records involved vehicles with model years ranging from 1998 to 2003. These motorcoaches not only had a higher reported frequency of fire occurrences but also a substantially higher reported incident rate relative to their population. School bus fire records by model year were more evenly distributed than motorcoach fire records, but also had a period of higher frequency for model years 1996 to 2001. An analysis of vehicle age showed that the percent of newer vehicles that caught fire in 2005 was higher than the percent of newer vehicles that caught fire in 2009 or 2013, indicating that implementation of advanced technologies such as fire suppression systems may have a positive effect on fire prevention and mitigation of reportable fires.
- Much like the 2009 study, this analysis showed that vehicle out-of-service (OOS) rates for motorcoaches involved in a fire are generally higher than OOS rates for all buses inspected, and this difference seems to be increasing. The OOS rate for fire-involved motorcoaches from 2005 to 2009 increased each year from the level of all buses to the level of all commercial motor vehicles (CMVs), indicating that the OOS rate may be a reliable indicator of fire risk.
- For carrier safety ratings following investigations, motorcoach carriers involved in fires have a higher rate of operational or vehicle-related compliance problems than those without fire involvement, indicating that a less than satisfactory safety rating could be an indicator for fire risk.
- Motorcoach carriers involved in fires are more likely to have exceeded the safety intervention threshold in the “Vehicle Maintenance” Behavior Analysis and Safety Improvement Category (BASIC) than those without fire involvement, suggesting that

high percentiles in the Vehicle Maintenance BASIC are associated with increased fire involvement.

RECOMMENDATIONS

Analysis of the literature and data on motorcoach and school bus fire safety risk supports recommendations to FMCSA and the industry in the following areas: data quality; operational training and outreach; vehicle design and equipment development; and inspection and enforcement standards. These recommendations are outlined below.

Data Quality and Reporting

- Improve the quality, consistency, and completeness of the input of fire data.
- Identify and address reasons that fires are underreported or characterized as undetermined.
- Identify and link all relevant existing data systems.
- Develop a strategy for long-term maintenance of and future updates to NFIRS.
- Collaborate with USFA to enhance NFIRS data reporting structure and data element definitions relevant to highway vehicle fires.

Operational Training and Outreach

- Enhance safety procedures and training requirements for drivers, mechanics, and other maintenance personnel.
- Increase stakeholder commitment to prioritizing fire safety, avoidance, and prevention over other non-safety-related performance measures.
- Encourage companies to continually re-evaluate and incorporate into training the most up-to-date information relating to fire precursors, especially that which is associated with OOS criteria or recalls.
- Promote an industrywide culture of safety that prioritizes the role of drivers and mechanics relative to the frontline role they play in fire prevention and mitigation.

Vehicle Design and Equipment Development

- Consider design changes that could improve the fire safety of brakes, turbochargers, tires, electrical systems, and wheel/hub bearings.
- Include automatic failure warning systems and fire detection and suppression systems as standard on motorcoaches and school buses.
- Adopt a baseline standard for testing fire suppression systems to ensure a minimum level of protection.
- Support research and development in technologies for wheel area fire detection and suppression systems.

Inspection Standards

- Expand collaborative efforts to identify critical inspection items associated with fire risk.
- Increase inspection frequency.
- Increase training for inspectors.

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1. INTRODUCTION AND BACKGROUND

This report documents a study analyzing motorcoach and school bus fire safety. The primary objective of this study was to update and expand upon the *2009 Motorcoach Fire Safety Analysis*[(2)] by: 1) gathering and analyzing information regarding the causes, frequency, and severity of motorcoach and school bus fires, and 2) recommending ways to prevent or reduce the severity of these incidents, especially through improving the effectiveness of vehicle inspection practices. This report succeeds the *2009 Motorcoach Fire Safety Analysis* (henceforth referred to as the 2009 study), and has been expanded to include school bus fires.

The 2009 study established a database of spontaneous motorcoach fire records collected from U.S. Government, industry, and media sources, and analyzed the safety risk of motorcoach fires. The study also sought to identify potential measures for risk reduction. The 2009 study found that engine and wheel area fires accounted for almost 70 percent of all fires. The most frequently identified points of ignition were brakes, turbochargers, tires, electrical systems, and wheel/hub bearings; 95 percent of all reported fires resulted in no direct injuries or fatalities.

The current report updates and expands on the 2009 study to include all motorcoach fires (i.e., spontaneous, intentional, or the result of a collision or rollover) that occurred from 2004 to 2013. In addition, the report evaluates school bus fire risk, estimates the impacts of recent technology changes on motorcoaches and school buses, and expands on the evaluation of the effectiveness of automatic fire detection and suppression systems.

Section 1 of this report presents background information on motorcoach and school bus fires, providing a summary of the environment in which motorcoaches and school buses operate, the regulatory framework, fire risk measures, causal factors, and known countermeasures. It provides a context for understanding the quantitative data collected for the study's analysis and recommendations.

Section 2 describes the fire data sources used in this study and the methods used to select and compile the data.

Section 3 presents the data analysis, which quantitatively estimates the dimensions of motorcoach and school bus fire safety risk, and summarizes these findings. Taken individually and together, the various analyses are important in identifying trends related to motorcoach and school bus fires, and informing recommendations for the prevention or mitigation of these events. The analysis also looks at the role of compliance data indicators set forth by organizations described in this introduction as a predictor of fires, and explores the effectiveness of known countermeasures, particularly automatic suppression systems and component warning systems.

Section 4 suggests ways to target and reduce fire risk with recommendations for improving the data that support analysis, training and outreach, vehicle design enhancements, and inspection standards.

1.1 OPERATIONS SUMMARY

Table 1 summarizes the key elements of motorcoach and school bus operations and examines their similarities and differences. While both vehicle types are similar in their passenger volumes and distances traveled, it is important to note that motorcoach operations are largely regulated by FMCSA while school bus service mostly falls under State jurisdiction. Additionally, while the operations of motorcoaches are determined according to personal travel market forces, school bus transportation relies primarily on Government funding.

Table 1. Motorcoach and school bus industry.

Attribute	Motorcoaches	School Buses
Definition	• The American Bus Association (ABA) defines a motorcoach as a bus that: – Is designed for the long-distance transport of more than 30 passengers. – Has integral construction with an elevated passenger deck located over a baggage compartment. – Is at least 35 feet long. – Typically has a gross vehicle weight rating (GVWR) greater than 14,000 lb. • Motorcoaches are not specifically defined in the Federal Motor Carrier Safety Regulations (FMCSRs), but the regulations define a bus as meaning any motor vehicle designed, constructed, and/or used for the transportation of passengers.	• The National Highway Traffic Safety Administration (NHTSA) defines a school bus as a motor vehicle that: – Has a capacity of 11 or more people, including the driver. – Weighs at least 10,000 lb. – Is sold or introduced into interstate commerce for the purpose of carrying students to and from school or related events. • Intrastate school buses and vans are also defined as school buses, though vans are not included in this study. • Appendix A defines the four main types of school bus configurations. • School buses are defined in the FMCSRs as buses likely to be used significantly for the purpose of transporting pre-primary, primary, or secondary school students.
Annual Passenger Miles	• 1.7 million in 2013 (*2013 Motorcoach Survey*)	• 4.4 billion (*School Transportation News*)
Average Age of Vehicle	• 9 years in 2013 (*2013 Motorcoach Survey*)	• 9.3 years in 2013 (*School Bus Fleet*)
Industry Employment	• 133,200 full- and part-time in 2013 (*2013 Motorcoach Survey*)	• 600,000 (*National Association of Pupil Transportation*)
Financial Structure	• 5.8 percent leased. • 74.9 percent purchased. • 19.3 percent both. (*2013 Motorcoach Survey*)	• 66 percent owned and operated by districts. • 33 percent owned by contractors. (*School Bus Fleet*)
Fleet Information	• Three-quarters of motorcoaches operating in the United States and Canada in 2013 belonged to fleets of fewer than 100 vehicles. (*2013 Motorcoach Survey*)	• Vary widely from one or two to thousands, depending on district size or contractor.
Fuel Types	• Primarily diesel; also biofuel, hybrid, compressed natural gas (CNG).	• Primarily diesel; also biofuel, hybrid, CNG.

Attribute	Motorcoaches	School Buses
Operators	• The largest intercity bus operators, in terms of daily scheduled trips, are: – Greyhound Lines. – Megabus. – Coach USA, NY Network. – Peter Pan. – Bolt Bus. – Trailways-Adirondack/Pine Hill. – Martz Trailways.	• Many, largest of which is First Student.[†]
Industry Size (Sales in 2012)	• $3.1 billion (*U.S. Department of Commerce*)	• $9.4 billion (*2013 Census*)
Major Industry Associations	• United Motorcoach Association. • American Bus Association.	• National School Transportation Association. • National Association for Pupil Transportation. • National Association of State Directors of Pupil Transportation Services.
Operating Environment	• Primarily highway. • Longer trip lengths. • A majority of driving is done at higher, consistent speeds. • Longer time needed to stop in the event of an emergency.	• Mostly non-highway. • Shorter trips with frequent stops. • Less time needed to stop in the event of an emergency. • Variability in driving conditions necessitates geographically specific inspection regulations.
Procurement Guidelines	• None for motorcoach.	• National Congress for School Transportation.
Regulatory (Operations)	• FMCSA. • State.	• Primarily State.[(i)]
Regulatory (Vehicle Design and Equipment)	• NHTSA. • FMCSA.	• NHTSA. • FMCSA.
Services Offered	• 97.9 percent offer charter service. • 52.7 percent offer multiple services. • 43.4 percent offer fixed-route services. • 37.6 percent offer packaged tours. • 19.3 percent offer airport service. • 16.1 percent offer scheduled services. • 12.7 percent offer sightseeing. (*2013 Motorcoach Survey*)	• Primarily transportation of students to and from school or school-related events. • Religious and cultural organization travel. • Governmental services (e.g., prisoner transportation).
Vehicles on the Road	• 35,000 (*2012 Motorcoach Safety Action Plan*)	• 480,000 (*Yellow School Bus Paper*)

[†]Both Greyhound and First Student are divisions of First Group, a leading North American transport operator.

1.2 REGULATORY FRAMEWORK

States, Federal agencies, manufacturers, and carriers all play a role in ensuring passenger-carrier safety, from both an operational and an equipment perspective. Federal agencies determine

[i] While some standards may be Federally based operational requirements and restrictions, additional vehicle specifications and inspection standards are generated and enforced at the State level. States may lose Federal funding if they fail to comply with Federal regulations.

carriers' interstate operating authority, establish operational and design standards to ensure safety, and regulate and enforce carriers' adherence to these standards. States cooperate with the Federal agencies in conducting inspections, taking enforcement action, and setting inspection procedures and out-of-service (OOS) criteria. States may further expand on Federal regulations to address specific safety issues. The feedback gained through enforcement of these regulations—at the local, State, and Federal levels—is of significant value in gathering data and informing regulatory agencies of the need for safety criteria at a Federal level.

1.2.1 Commercial Vehicle Safety Alliance

The Commercial Vehicle Safety Alliance (CVSA) is a not-for-profit association of State, Provincial, Federal, and industry officials in the United States, Canada, and Mexico that provides guidelines for vehicle safety and enforcement. CVSA has established the North American Standard (NAS) Inspection Criteria to ensure that trucks and buses operate safely. The NAS includes a list of OOS criteria that assists the enforcement community in identifying safety hazards for commercial vehicles.

The OOS criteria are changed based on input and observations from CVSA members and associates. Standing committees, comprised mostly of enforcement officials and some industry representatives, must first vet these proposed changes. After the change clears the standing committee, it is then sent to the Executive Committee for review, after which it must then be voted on by all alliance members. Since industry members are associate members, they do not get to vote at this stage of the adoption process.

It is important to note that the NAS criteria for OOS violations apply to vehicles that fall under Federal inspection standards, which include motorcoaches, but rarely school buses. States define their own set of OOS criteria for school buses; however, these standards are similar to those used at the Federal level.

CVSA is increasingly involved in school bus and motorcoach fire safety issues. The CVSA Passenger Carrier Committee holds regular semi-annual meetings to review bus-specific inspection criteria and procedures to help reduce the risk of bus fires. These meetings have resulted in recommendations for the development of standards for fire detection, monitoring, and suppression; endorsement of research studies; enhancement of bus inspection training modules; and development of new and revised OOS criteria.

Appendix B illustrates the relationship between some operational inspection practices outlined in the April 1, 2016, NAS operations criteria and the motorcoach and school bus fire ignition points identified in this report.

1.2.2 National Highway Traffic Safety Administration

NHTSA issues and enforces Federal Motor Vehicle Safety Standards (FMVSSs) that establish performance criteria for new motor vehicles and vehicle equipment. NHTSA is responsible for establishing and enforcing FMVSSs 49 Code of Federal Regulations (CFR) 571.101 through 571.500, to which manufacturers of all motor vehicle and equipment items must conform and certify compliance with at the time of original manufacture.

Appendix C lists relevant standards and the level at which they pertain to motorcoach and school bus fire safety. The two FMVSSs most related to fire safety—FMVSS 217 and 302—as well as related standards, do not address all motorcoach and school bus fire safety needs. For instance, FMVSS 302 addresses the flammability of interior materials but does not address fires that originate outside the passenger compartment, such as those analyzed in this study. NHTSA standards also fail to address the flammability of many exterior components, which may allow fires to propagate quickly into the passenger compartment.

NHTSA sponsored a study on motorcoach flammability following the 2005 Wilmer, TX motorcoach fire in which 23 passengers died. The U.S. Department of Commerce's National Institute of Standards and Technology (NIST) conducted research and published a 2011 report(3) to support NHTSA's effort on improving motorcoach fire safety, but no further FMVSSs have been published based on the findings. In a 2013 rule requiring lap/shoulder seat belts in all new buses, NHTSA noted, "The initiative on fire safety is in a research phase. Rulemaking resulting from the research will not occur in the near term."(4)

NHTSA's Office of Defects Investigation (ODI) conducts safety defect investigations and responds to safety-related consumer complaints. To address safety-related defects in the design of vehicles and components, ODI has the authority to require manufacturers of motor vehicles and motor vehicle equipment to issue recalls based on safety issues identified during defect investigations. Technical Service Bulletins, available through NHTSA's publicly accessible Web site, may also be initiated by the manufacturer to identify problems or issues with vehicles. Major motorcoach and school bus manufacturers recall thousands of buses each year due to fire safety concerns such as fuel leaks, turbocharger failures, and electrical shorts.

1.2.3 Federal Motor Carrier Safety Administration

Pursuant to the Motor Carrier Safety Improvement Act of 1999 (49 U.S.C. 113), FMCSA regulates and enforces all registered commercial motor vehicles (CMVs) that operate interstate or that carry intrastate hazardous materials. The Agency is responsible for granting operating authority and assigning U.S. Department of Transportation (USDOT) numbers to all interstate, for-hire motor carriers—including most motorcoach carriers.(ii) Once a carrier completes the entry requirements of the New Entrant Safety Assurance Program, FMCSA grants permanent operating authority and monitors and enforces the carrier via the Agency's Compliance, Safety, Accountability (CSA) program.(iii) With regard to school buses, FMCSA's jurisdiction is limited. School bus operations are performed by State and local government entities, which are statutorily exempt from FMCSA safety rules concerning driver qualifications, hours of service, and vehicle maintenance. This exemption applies even for the interstate operation of school buses by a school district. However, when for-hire carriers transport students for extracurricular activities in interstate commerce, these carriers are subject to the Federal Motor Carrier Safety Regulations (FMCSRs), in most cases.(5)

[ii] FMCSRs also cover interstate transportation of hazardous materials by commercial motor carriers.

[iii] New motor carriers are monitored under the New Entrant Safety Assurance Program for their first 18 months of operations and are required to pass a Safety Audit to ensure they have basic safety management practices in place. Upon passing the Safety Audit and completing the 18-month evaluation period, new entrant motor carriers are granted permanent operating authority and their safety compliance is monitored and enforced under FMCSA's Compliance, Safety, Accountability (CSA) program.

1.2.3.1 Federal Motor Carrier Safety Regulations

FMCSA develops, maintains, and enforces the FMCSRs and requires demonstration of adequate safety management controls, including vehicle safety equipment and vehicle inspection, repair, and maintenance. School bus and motorcoach safety equipment is covered under 49 CFR 393, Parts and Accessories Necessary for Safe Operation, which details required components and their design and installation. Mandatory fire safety equipment includes either a fire extinguisher with an Underwriters Laboratories (UL) rating of 5 B:C or more, or two fire extinguishers, each of which has a UL rating of 4 B:C or more.(6)

49 CFR 396.13 requires that drivers ensure, through a pre-trip inspection, that a prescribed list of parts and accessories are in safe and proper operating condition. The pre-trip inspection must also include verification that emergency equipment, as required in 49 CFR 393.95 (e.g., fire extinguishers, spare fuses, and warning devices for stopped vehicles), is in place and ready to use. Furthermore, at the completion of each day's work, drivers of passenger-carrying CMVs must sign a written driver-vehicle inspection report (DVIR)—which covers a prescribed list of parts and accessories— for each vehicle operated.

49 CFR 396 also requires the inspection, repair, and maintenance of a prescribed list of items on all regulated interstate CMVs. Every carrier is responsible for maintaining, in safe operating condition, all vehicle parts specified in Part 393, as well as frame assemblies, suspension and steering systems, and axles, wheels, and rims. Motor carriers are also subject to periodic self-inspection and recordkeeping and to retention requirements that document proper preventive maintenance and repair. Inspection of most items is required at least every 12 months. Ninety-day inspections are required for certain motorcoach fire safety items, such as push-out windows, emergency doors, and emergency door marking lights. Inspectors conducting motorcoach carrier compliance reviews or investigations must certify that required DVIRs and any corrective maintenance resulting from those reports are kept for at least 3 months and that all copies of periodic inspection reports are kept for 14 months.

1.2.3.2 Inspections, Enforcement, and Compliance

FMCSA and its State partners perform roadside inspections(7) of motorcoaches, typically at terminal or destination locations, to monitor the compliance of motor carriers and drivers with safety regulations. While such inspections are termed "roadside inspections," except in the case of an imminent safety hazard, the majority of inspections for commercial passenger vehicles are conducted at terminals, border crossings, maintenance facilities, or planned stops. Roadside violations, including vehicle and driver violations, are recorded and maintained in the Motor Carrier Management Information System (MCMIS). If a roadside inspection indicates the condition of the vehicle is likely to cause an accident or breakdown, the vehicle is declared OOS and cannot be operated without verification of suitable repair.(8)

1.2.4 National Transportation Safety Board

The National Transportation Safety Board (NTSB) is an independent Federal agency charged by Congress with investigating significant accidents in the various transportation modes. NTSB conducts these investigations, convenes boards of inquiry, makes determinations of probable causes, and issues safety recommendations to regulatory agencies in an effort to prevent the occurrence of similar future accidents.

NTSB conducted an investigation into the probable causes surrounding the 2005 Wilmer, TX motorcoach fire in which 23 passengers died, and consequently issued five safety recommendations, which are listed in Appendix D. Four of those five safety recommendations remain classified as open.(9) Appendix D also lists nine recommendations that resulted from a 2015 special investigation into tire safety, as well as two recommendations that resulted from the 2015 California crash involving a motorcoach and a FedEx truck.

1.2.5 States

Each State institutes requirements, either by adopting the FMCSRs or by establishing its own rules, for intrastate passenger carriers operating within it. Many States have mandatory annual motorcoach and school bus inspection programs that apply to both interstate and intrastate motorcoach carriers.(iv) Due to the diverse nature of school bus operations based on locality, State legislatures individually strengthen Federal standards by passing tailored laws for school bus fire safety. The National Congress on School Transportation (NCST) recommends specifications for school buses and operational procedures that States consider when establishing their standards, specifications, recommendations, and guidelines.

1.2.6 Enforcement

Both State and Federal enforcement officers take limited action against passenger carriers found to be out of compliance with applicable State and Federal safety regulations. Violations discovered during inspections at limited roadside, destination, or terminal facilities are subject to fines, warnings, and OOS orders prescribed by the regulatory agency or jurisdiction. It is important to note that only FMCSRs pertaining to commercial driver's licenses (CDLs) and drug testing are applicable for school buses. School-to-school and some field trips fall under State regulations, as referenced in Section 1.2.1.

1.3 FIRE RISK MEASURES AND CAUSAL FACTORS

The following is a brief overview of the safety risk factors of motorcoach and school bus fires (i.e., their causes, indicators, frequency, and severity), based on information obtained from previous bus fire studies and media reports. The risk factors are discussed in detail in Section 3 of this report.

The methodology and findings of this report utilized a number of published bus fire studies, reports, and interviews.(v) A list of these sources may be found in Appendix E.

[iv] Many individual State school bus laws and inspection standards can be found online. For example, for Ohio's School Bus Minimum Standards, see http://codes.ohio.gov/oac/4501-5. For information on the Michigan School Bus Inspection Program, see http://www.michigan.gov/msp/0,4643,7-123-72297_59877_59878-267848--,00.html, and for the Indiana School Bus Inspection Manual, see http://www.in.gov/isp/files/2015_School_Bus_Inspection_Manual.pdf.

[v] For a comprehensive review of the mechanical factors associated with motorcoach fires, please see: *Why Motorcoaches May Burn (A Mechanical Analysis)*, Christopher W. Ferrone, 2007.

1.3.1 Frequency

Studies suggest that fires on all types of buses are reported as often as nine times per day. The 2009 study on motorcoach fires estimated that 160 motorcoach fires occurred per year, based on data from 2004 to 2006, and that there was no indication of an increasing or decreasing trend from 1995 to 2008. However, no reliable estimate of motorcoach- or school bus-only fire frequency is currently available because these fires were not routinely classified as accidents, for statistical purposes. This study aims to make more precise estimates based on data compiled over a longer and more recent time span.

1.3.2 Severity

Buses are rarely operable after a fire. Literature and media reports suggest that the cost of fire damage to a motorcoach or school bus is often high, ranging from tens of thousands of dollars up to the replacement value of the bus. On average, the cost to remanufacture a coach is $125,000, while a new coach will typically cost $400,000, according to statistics provided by CoachCrafters Inc.[(10)] The cost to replace a newer school bus is upwards of $50,000.[(vi)]

While property damage losses can be large, deaths and injuries related to motorcoach and school bus fires are rare.[(11)] However, any fire has the potential to cause significant injuries or loss of life, especially among children who are the primary riders of school buses. One catastrophic incident in particular highlighted the importance of regulating fire safety criteria for buses and bus equipment.

In 1988, a school bus transporting a church youth group and chaperones collided with a pickup truck traveling in the wrong direction on a rural interstate highway near Carrollton, Kentucky. While the initial crash did not cause any serious injuries, the impact ruptured the school bus's fuel tank, resulting in a deadly fire that engulfed the bus. The bus's narrow central aisle and inadequate emergency exit hindered the evacuation of the 66 passengers on board. Twenty-seven passengers, most between the ages of 12 and 13, were killed, and 34 more were injured in the fire.

1.3.3 Ignition Sources

A fire occurs when flammable or combustible material mixes with the correct amount of air in the presence of an ignition source (either sparks or heat).

Appendix F shows motorcoach ignition sources by location, ignition type, and the conditions under which the source may encounter air and combustible material. Ignition sources are generally shielded or contained. Heat or sparks are the result of component failure.

1.3.4 Combustible Materials

A large variety of combustible or flammable materials, including rubber, plastic, and fluids, is found on motorcoaches and school buses. These materials are present in the engine compartment, fuel system, bus interior, and wheel wells. Appendix G lists flammable materials

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[vi] Cost was derived after viewing multiple bids from various school districts.

by location, components involved, and conditions under which the materials encounter air and ignition sources.

Flammability of interior motorcoach and school bus components is regulated by NHTSA and individual States. NCST also recommends various specifications for combustible or flammable materials on school buses that States can choose to adopt. For more information on regulatory standards, see Section 1.2.3.1.

1.3.5 Unintentional Factors

Often items that are meant to have beneficial outcomes can have unintended consequences. An example is the use of diesel particulate filters (DPFs), which were mandated to control emissions on all diesel-fueled vehicles from model year (MY) 2007 and later. DPFs work by trapping and removing particulate matter from diesel emissions using a regeneration process that involves temperatures as high as 1,400 degrees Fahrenheit. The resulting high temperatures have the potential to ignite flammable materials that are nearby. While safeguards are in place to make sure the DPF system is protected, accidents and improper maintenance can increase fire risk. The California Environmental Protection Agency's Air Resource Board specifically advises that while undergoing regeneration, vehicles with DPFs should not be parked near flammable materials due to high temperatures and the fire risk to nearby combustibles.

1.4 KNOWN COUNTERMEASURES

Effective fire prevention and mitigation rely on a combination of key fire safety practices and design considerations. Stakeholders such as industry groups and associations have a significant role to play in the development of uniform standards and best practices for motorcoach and school bus fire safety.

1.4.1 Fire Safety Practices

Many different practices contribute to fire safety, from preventing fires through proper vehicle maintenance and driver training, to evacuating passengers safely during an emergency. Four types of practices that are frequently cited for their effectiveness in preventing, reducing the severity of, and mitigating the consequences of fires are: conducting pre-trip inspections; using fire-resistant materials; training staff; and installing automatic detection equipment. Numerous sources cite the importance of prevention by way of driver training and pre-trip inspections as the first line of defense in preventing fires.(vii) Examples of these practices are listed in Table 2.

[vii] For example, Lancer Insurance: http://busride.com/_ebooks/LancerEBook6May2013.pdf, and http://www.schoolbusfleet.com/article/611052/assume-a-bus-fire-is-in-your-future.

Table 2. Common motorcoach and school bus fire safety practices.

Type	Prevention	Severity Reduction and Consequence Mitigation
Pre-trip inspections	Identify and correct any vehicle safety issues, including those relating to fire safety.	Verify that the fire extinguisher is fully charged, and that there are no fluids leaking in or around the engine compartment.
Fire-resistant materials	Prevent fires from spreading from point of ignition when installed near high-temperature surfaces in and around the engine compartment.	Install materials in the engine firewall, wheel wells, and other shields between the passenger compartment and common fire origin locations.
Training	Provide maintenance staff and company inspectors with skills to identify motorcoach and school bus conditions that can lead to fires.	Train drivers, mechanics, and other maintenance personnel to address component warning indicators as soon as safety permits, and ensure that drivers are properly trained to make safety announcements and evacuate the bus in an emergency.
Automatic warning systems	Detect equipment failures and fires (e.g., turbocharger and tire failure sensors and warning lights).	Install fire detection and suppression systems, including automatic fire sensing and suppressant delivery.

While training and pre-trip inspections play an important role in the prevention and mitigation of fires, other practices and technologies that impact fire safety and the ability to reduce the frequency and severity of fires are available.

1.4.2 Industry Associations and Standards

Motorcoach and school bus industry associations, such as those referenced in Table 1, represent thousands of commercial motorcoach carriers and bus supplier organizations and can play a critical role in publishing procurement guidelines to help ensure a minimal level of safety. While there is no specific set of standards for motorcoaches, the American Public Transportation Association (APTA), which represents the bus, rapid transit, and commuter rail systems industries, offers the *2013 Standard Bus Procurement Guidelines* for transit buses. Several of these guidelines may be applicable to motorcoaches:

- ***Fire safety.*** The bus shall be designed and manufactured in accordance with all applicable fire safety and smoke emission regulations. These provisions shall include the use of fire-retardant/low-smoke materials, fire detection systems, bulkheads, and facilitation of passenger evacuation.[12]
- ***Fire-retardant/low-smoke materials.*** All materials used in the construction of the passenger compartment of the bus shall be in accordance with the Recommended Fire Safety Practices defined in FMVSS 302.
- ***Fire suppression systems.*** The bus shall have a fire suppression system installed per the manufacturer's recommendations.

- ***Firewalls.*** The passenger and engine compartment shall be separated by fire-resistant bulkheads. The engine compartment shall include areas where the engine and exhaust system are housed.
- ***Facilitation of passenger evacuation***. Two door exits, an escape hatch, and other evacuation features.

Motorcoach and school bus buyers can also specify fire-resistant materials on new vehicle orders, using standards written for other vehicles, such as aircraft, railcars, and transit buses, or those published by foreign governments and regulatory bodies.[viii]

1.4.3 Automatic Warning and Suppression Systems

Two types of automatic warning systems that have the potential to prevent or reduce the severity of motorcoach and school bus fires are currently available: component failure warning systems and fire detection systems. Some of these detection systems also include automatic fire suppression.

1.4.3.1 Component Failure Warning Systems

Component failure warning systems detect the imminent failure of a system and alert the driver. To identify turbocharger failures, some carriers (e.g., Adirondack-Trailways) have developed simple detectors on turbocharger waste gates to check the operation of the boost-limiting devices.[13] Some conditions leading to turbocharger failures, such as waste gate failures, cannot be detected during routine maintenance or pre-trip inspections.

Active tire pressure monitoring systems (TPMSs) can detect failures of multiple wheel area components. For instance, in 2005, Motor Coach Industries (MCI) introduced the SmarTire pressure temperature monitoring system as an option on its motorcoaches. Wheel-well and wheel-end heat sensors have been developed and are being introduced into the market. Indication of a potential fire can also be identified when the anti-lock braking system (ABS) warning light is on, indicating, among other things, a bearing failure.

1.4.3.2 Fire Detection/Suppression Systems

Currently available fire warning systems include sensors that detect the heat of a fire in the engine compartment and activate a warning to the driver. These are included in the APTA Standard Bus Procurement Guidelines described above. More advanced systems may extend temperature sensors to the wheel area. When these sensors detect high temperature and radiant energy indicative of a thermal hotspot or fire, an audible or visible alarm is triggered to alert the driver. In the event that the driver does not take immediate action, the vehicle control system may reduce engine power and trigger automatic engine shutdown.

Other fire warning systems focus on specific flammable agents or other ignition points surrounding the engine block. These include optical flame and smoke indicators and fuel vapor

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[viii] For example: Federal Aviation Administration (FAA), 49 CFR 25.853, Federal Railroad Administration (FRA) 49 CFR 238.103, Federal Transit Administration (FTA), Economic Commission of Europe (ECE) Regulation 118, ECE Regulation 36.

sensors that can be installed in the engine or passenger compartment. Some newer systems include pneumatic tubing that can quickly detect the heat of a small fire originating in any of several bus locations, alert the driver, and automatically release suppressant.

Fire suppression systems are classified as active or passive.

Active fire detection/suppression systems. When a fire sensor is activated, an automatic fire suppression system (AFSS) causes fire suppressant to be delivered to the fire's location. Currently, AFSS is available only for engine-compartment fires; other areas pose severe feasibility problems. No nozzles are available that meet the durability requirements of motorcoach and school bus wheel wells due to the potential damage of road debris.

Acceptance of AFSS is gaining ground. According to an article in *School Bus Fleet*, in recent years the number of inquiries to AFSS manufacturers from school bus operators and manufacturers has increased.(14) Some pertain to retrofitting existing vehicles, while some suppliers want AFSS installed prior to purchase. Though no national standards currently exist for the installation of this equipment on motorcoaches or school buses, some States require AFSS on wheelchair lift school or paratransit buses, recognizing that occupants may require additional evacuation time in the event of a fire.

Several motorcoach manufacturers now include AFSS as standard equipment. Pressure-oriented non-electric systems can provide an additional level of cost savings as they do not require electrical checks. Automatic systems also provide an ease-of-use benefit in that the driver does not need to activate a system. Instead, the driver can focus on the safe and timely evacuation of passengers. Automatic systems also offer protection in the event of a fire when the vehicle is unmanned, or if the driver should become incapacitated.

NHTSA conducted an important study to evaluate and study fire detection and suppression systems. The *2015 Motorcoach Fire Safety Final Report*,(15) compiled by Southwest Research Institute, examined the most common causes of motorcoach fires and the best ways in which to prevent those fires or mitigate damage. This study is significant in that it developed metrics to measure and assess current and future technologies associated with wheel-well warning and detection systems, engine compartment suppression systems, and fire-hardening technologies.

SP Technical Research Institute of Sweden (SP) has developed a new standard for fire suppression systems in engine compartments of buses and coaches: SP Method 4912, Edition 3, which is represented by an established, voluntary certification/quality mark for the industry—the P-mark.(16) Development of this standard included input from a wide variety of international sources: transit authorities, insurance companies, bus associations and manufacturers, and makers of fire suppression systems.

Passive fire suppression systems. Passive fire suppression measures include implementation of fire-resistant barriers, fuel tank fire protection, improved standards for flammability of interior materials, and improved wire insulation materials and techniques that may reduce the incidence of fires from electrical shorts.

The impact of component and warning systems on fire risk reduction is significant. Component systems are effective tools in preventing fires if drivers are trained to react in a way that allows the warning system to provide the greatest potential benefit. Automatic fire suppression systems have the potential to mitigate the consequences of fires that do occur. More importantly, these systems can provide protection in cases when a driver may be unable to act, or when a vehicle is left unattended or housed in an area where a fire may cause risk to other property or equipment.

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2. DATA DEVELOPMENT

This section describes the development of the database used for the evaluation of motorcoach and school bus fire safety risk documented later in this report. It includes summaries of the source data sets, their value and limitations for this research, and methods for the compilation of the analysis database. This section also discusses the differences in the scope and approaches for data development from the 2009 *Motorcoach Fire Safety Analysis* report.

2.1 DIFFERENCES FROM 2009 STUDY

The 2009 study assembled a data set of 899 motorcoach fire incident records, collected from a variety of government, industry, and media sources, for calendar years 1995–2008, with the 2004–06 data being the most complete. The database was constructed to facilitate analysis by location of origin, point of ignition, geographic location, vehicle damage, human injuries and fatalities, and vehicle characteristics, inspection, and maintenance histories. The collection and compilation of additional data used to measure risk exposure (i.e., vehicle population and mileage) also contributed to these analyses.

The U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) database and FMCSA's MCMIS database served as primary data sources for the 2009 study due to their breadth of motorcoach incident records. Additional data sources included: NHTSA's Fatality Analysis Reporting System (FARS); NHTSA's State Data System (SDS) and State police accident reports for selected States; a joint FMCSA and NHTSA bus fire analysis database; and news reports. Analysts obtained vehicle mileage data from the Federal Highway Administration's (FHWA's) *Highway Statistics* charts and motorcoach population and characteristics data from R.L. Polk and Co. Two major carriers and two insurance firms provided additional motorcoach fire records.

These same data sources were queried for the current study, now updated to include incidents involving both motorcoaches and school buses, spanning the years 2004–13. The current study, however, relied more heavily on the incident data from the Federal sources and from R.L. Polk than on the secondary sources, in comparison with their more equal treatment in the 2009 study.[ix] In addition, the current study does not include incident data from State police accident reports, motorcoach carriers, or school bus service providers. Not only were these data difficult to obtain at the time of data collection, their relative effectiveness, if they had been available, would be suspect given the broader scope of this study. Instead, there was an increased emphasis on mining, scrubbing, and validating the data provided by the non-commercial sources, which have a more national coverage and consistency of detail.

[ix] Compilation of the incident database for the 2009 study was based on the assumption that virtually all motorcoach fires could be identified by at least one of the selected sources. Also assumed was that single incidents reported by multiple sources could both enhance the descriptive detail on those incidents and validate the data that was common from each source. These assumptions are questionable in light of the broader scope of this study.

The remainder of this section describes the development of each of the data sets used for the analyses in the study, beginning with the primary data sources that are extracted from nationally reported, non-commercial sources.

2.2 PRIMARY INCIDENT DATA SOURCES

2.2.1 U.S. Fire Administration—National Fire Incident Reporting System

The NFIRS database was developed by the National Fire Data Center (NFDC), part of the U.S. Department of Homeland Security, as a means of assessing the nature and scope of fires within the United States. It is maintained and managed jointly by USFA, State agencies, and metropolitan fire departments. Although reporting to NFIRS is voluntary, the database is the single most comprehensive source of data for incidents requiring a fire department response, capturing incidents from all States and the District of Columbia. About 23,000 fire departments report into NFIRS each year, 30 of which have protected populations in excess of 500,000. Each year, around 22 million incidents and 1 million fires are reported to NFIRS. The database contains an estimated 75 percent of all fires reported annually.(17)

The structure and codes for the NFIRS database have remained the same as they were for the 2009 study. They capture general information on all fires reported in the system, including date, location, property type, injuries, fatalities, and property damage, as well as characteristics of the fire, including fire origin and causal factors for ignition, flame spread, and measures to control or extinguish the fire. The property type field is used to identify highway vehicle fires, which may be further delineated by specific vehicle identifiers in other fields (e.g., vehicle identification number [VIN], manufacturer [make], model, and model year). However, most of this information is available only as free-form textual inputs, with predictable gaps and inconsistencies. In addition, there are fields to indicate the presence and activation of fire suppression, but they were blank for all records found. The NFIRS report structure is illustrated in Appendix H.

NFIRS provides codes for entry of vehicle type and make. The closest vehicle type to motorcoach and school bus is a category including buses, recreational vehicles, trackless trolleys, and transit vehicles; therefore, identification as either a motorcoach or school bus requires further analysis of the incident record, preferably by vehicle make and model. While entries from the 'make' field are chosen from a fixed list, entries for model are entered into a free-text field. There are no pre-coded values for model.

As was found in the 2009 study, without the identification of model, 'make' was relatively useless for identification of the relevant vehicle type. Therefore, VINs were used to provide a more accurate classification of the fire-involved vehicle as either a motorcoach or school bus. Determined values for 'make' obtained from either the decoded VIN or from the model field included 31 recognized motorcoach and 18 school bus manufacturers; however, most of these manufacturers also produce other vehicle types, or are defunct or labeled as 'other.' While the large majority of records included VINs, errors were sometimes present, as fire responders face inherent challenges in recording 17-digit VINs with accuracy. These difficulties were further highlighted when it became evident that a significant number of known makes/models in NFIRS were classified as vehicle types other than buses, trackless trolleys, and transit vehicles. As a result, other sources and methods (e.g., VIN decoding using commercially available software) are needed to identify and distinguish between motorcoach and school bus incidents.

Data field names and code values for fire origin and causal factors for ignition are comprehensive, but not well aligned with the scheme used in the 2009 study for identifying and classifying the specific ignition point of motorcoach fires. In that study, values for these ignition points were derived primarily using the descriptive narratives in the "Remarks" field provided for NFIRS incidents from 2004 through 2006. This field allowed analysts to fill in missing data and especially allowed for the determination of whether a fire's point of origin was specific to the wheel or engine area of the motorcoach.[(x)] For this study, USFA was not able to make the 'Remarks' field available, thus limiting the identification of fire origin to whatever could be determined through analysis of the coded field values provided in the NFIRS records. Despite these limitations, NFIRS has been shown to provide a solid basis for a comprehensive analysis of motorcoach fires when additional sources and clean-up methods are applied.[(xi)]

2.2.2 Motor Carrier Management Information System

MCMIS is the central repository for State-reported motor carrier crash data. It also contains census data on motor carriers registered with FMCSA, government/field inspection data of vehicles and drivers, and company safety profiles combining histories of crashes, inspections, audits, and investigations. The crash file contains electronically submitted records from State accident reports on drivers, carriers, and vehicles involved in reportable crashes. Reportable crashes include fire incidents, but reporting is subject to certain threshold criteria that exclude some incidents from MCMIS.[(xii)] Fires are identified by having a value of "fire or explosion" in any one of four sequence-of-event fields..

In addition to detailing reportable crash events, MCMIS maintains regulatory compliance data for vehicles and registered carriers. The MCMIS inspection file contains detailed data on roadside inspections by State and Federal field enforcement agents on North American commercial carriers. Each inspection may find vehicle- or driver-related violations of FMCSRs, Hazardous Material Regulations (HMRs), and State regulations or statutes. Certain violations may result in the driver or vehicle being placed OOS until repairs or prescribed corrections are made.

MCMIS also maintains the dates and results of regulatory compliance reviews (CRs) or onsite focused or comprehensive investigations, which are performed on carriers prioritized for

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[x] The field "Area of Origin" provides a single category combining "engine, wheel area, and running gear."

[xi] This study devoted considerable attention to refining and implementing these measures as described earlier in the 2009 study.

[xii] Reportable crashes for MCMIS involve: Any truck that has a gross vehicle weight rating (GVWR) of more than 10,000 pounds or a gross combination weight rating (GCWR) of more than 10,000 pounds used on public highways; any motor vehicle with seating to transport nine (9) or more people, including the driver's seat; any motor vehicle displaying a hazardous materials placard (regardless of weight) AND that results in: a fatality — any person(s) killed in or outside of any vehicle (truck, bus, car, etc.) involved in the crash or who dies within 30 days of the crash as a result of an injury sustained in the crash; an injury — any person(s) injured as a result of the crash who immediately receives medical treatment away from the crash scene; or a tow-away — any motor vehicle (truck, bus, car, etc.) disabled as a result of the crash and transported away from the scene by a tow truck or other vehicle.

FMCSA intervention based on their safety performance relative to other carriers, as indicated by roadside inspections and serious violations cited from prior investigations. CRs and investigations can result in a carrier being assigned safety ratings in one of three categories—Satisfactory, Conditional, and Unsatisfactory—in five regulatory factors.(xiii)

The MCMIS database has some inherent limitations. Like NFIRS, MCMIS crash records do not provide a specific "motorcoach" or "school bus" value in the vehicle-type definitions. The closest coded vehicle configuration and cargo-body-type values cover all buses with seats for more than 15 passengers, with motorcoaches representing only a small fraction of that population. Vehicle type identification relies on identification of the carrier (which is accurately recorded according to the registered USDOT number); VIN, which—similar to NFIRS—is not provided with accuracy for every record; and/or license plate number.(xiv) For records beginning in 2010, MCMIS added a field for 'bus use,' but these values were found to be unreliable. MCMIS vehicle inspection records can specify a vehicle type as a bus or motorcoach or (general) bus, but the relatively small number of fire-involved vehicles that were inspected limits use of these records to identify them.

In addition, the MCMIS database is limited by underreporting. The database for this study includes 678 records in NFIRS that, based on an established threshold of property loss, fatalities, and injuries, should be represented in the MCMIS database. However, only 27 matching records were located in MCMIS. This leaves 651 records in NFIRS that should be reflected in the MCMIS database, indicating a significant amount of underreporting.

2.2.3 Fatality Analysis Reporting System

NHTSA maintains FARS as a census of highway incidents resulting in the death of an occupant of a vehicle or a non-motorist within 30 days of the incident. The vehicle types "school bus" and "cross-country/intercity bus" in FARS align well with those in the current study. Although NFIRS and MCMIS provide fatality data, FARS is presumed to provide a more thorough accounting of all fatal incidents identified in those sources, and could provide additional incidents that may not have been reported as fatal incidents by police or fire responders. The 2009 study found two fatal motorcoach fires in FARS, spanning the years 1995–2008. For that study and this expanded update, the Wilmer motorcoach fire was the only motorcoach or school bus fire recorded in FARS as occurring between the years 2004 and 2013. This record does not provide additional information on that fire not already contained in MCMIS and NFIRS. Consequently, FARS data did not contribute information to be used in the primary database.

[xiii] Ratings are as follows: Satisfactory—the carrier received an onsite investigation indicating that safety controls are sufficient to ensure compliance with the safety fitness standard; Conditional—the carrier received an onsite investigation indicating that safety controls are inadequate but have not yet resulted in violation of the safety fitness standard; Unsatisfactory—the carrier received an onsite investigation indicating that management controls are inadequate and have resulted in violations of the safety fitness standard. (49 CFR 385.3). A motor carrier with a final rating of "Unsatisfactory" is prohibited from operating a CMV in interstate commerce. (49 CFR 385.13(a)). The five regulatory factors are as follows: Factor 1 – General; Factor 2 – Driver; Factor 3 – Operational; Factor 4 – Vehicle; Factor 5 – Hazardous Materials.

[xiv] R.L. Polk provided make and model for instances matching their vehicle registration file.

2.3 PRIMARY DATABASE

The primary database for the current study consists of 3,635 fire incident records from NFIRS and MCMIS spanning the years 2004–13. Analysts constructed the database to facilitate evaluations of frequency, severity, geographic distribution, causal factors, vehicle model year, age, make/model characteristics, and safety compliance.

Appendix I shows the composition of motorcoach and school bus fire incidents in the primary database over the 10-year study timespan. The total national counts for each year were calculated by aggregating the MCMIS counts with the expanded NFIRS counts. Motorcoach fires are estimated to occur at an average rate of approximately 201 per year; school bus fires, 380 per year.

2.4 INDUSTRY, STATE, AND OTHER INCIDENT DATA SOURCES

2.4.1 Insurance Firms

Insurance companies that underwrite motorcoach carriers have a vested interest in accurate and precise measures of fire risk. Two major insurers of motorcoaches and school buses[(xv)] provided details on specific fire incidents (e.g., date, location, amount of the loss, vehicle make, model, and model year, and the fire origin area and ignition point); these companies are identified only as Insurance 1 and Insurance 2 in this report, at their request. The records were combined to allow for sorting by make, model, and model year. This allowed for summaries of counts by each attribute, and corresponding population totals from the R.L. Polk vehicle population data. Insurance 1 and Insurance 2 reported a total of 189 fires and 202 fires, respectively, for a total of 391 fires in the 10-year incident period. Only one insurance company provided school bus fire records (62); the remaining 329 records detail motorcoach fires.

Appendix J tabulates the counts of insurance records provided, by company, incident year, model year, make, and area of origin.

2.4.2 State Data System

NHTSA manages the SDS, which contains coded crash records from selected States. In many States, crash reports are generated for motorcoach fires and other non-collision incidents. Thirty-nine States make these records available to the public through SDS. There is no standard State crash report format, although most States strive to conform to the NHTSA Model Minimum Uniform Crash Criteria (MMUCC). MMUCC criteria (both current and proposed) related to motorcoach fires are shown in Appendix K.

SDS records contain data consistent with those appearing in MCMIS records because the States' inputs to MCMIS also rely on their police accident records. However, because the State SDS records contain data that are not entered into MCMIS or NFIRS for any number of reasons, it

[xv] Insurance data were not verified and were provided for summarization purposes only.

was expected that they would yield additional incidents, as well as supplementing the data for incidents already extracted from NFIRS and MCMIS.

SDS records were acquired from 11 States that were selected based on their availability, the extent of their coverage within the study's 2004–13 time span, geographic representativeness,[(xvi)] and having a minimum number of fires according to the primary incident counts. Data from nine States were usable.[(xvii)] These States, along with the resulting counts of bus fires identified by querying their SDS files, are tabulated in Appendix L. Also listed in Appendix L are the corresponding counts from the primary incident database, and the counts that matched incidents from NFIRS and MCMIS.

The SDS has a number of limitations. Currently, it offers no simple interface and requires all queries to be written in SQL code. Database fields in the SDS vary in structure and definition from State to State, reflecting the lack of a uniform traffic crash report used in all States. Because a vehicle fire may not be considered a crash according to State-specific definitions, it is unclear how many motorcoach fires occurring without a collision or rollover are included in each State's SDS records, and under what circumstances.

Furthermore, some State descriptors are more precise than others, due to different vehicle and crash type definitions. Descriptors for the 12 States are provided in Appendix M. For instance, California includes a value for "non-collision" in its vehicle definitions, but no "fire" value in its crash definitions. In other States, fire or fire/explosion must be specified as the first harmful event of the crash. In this study, only Pennsylvania was found to provide vehicle and crash details precise enough to identify fires related to motorcoaches (described as cross-country/intercity buses). In the other States, motorcoach identification required a review of each individual crash record and/or report.

Putting aside these limitations, 138 motorcoach or school bus fire incidents were found in the 9 States—30 motorcoach fires from 7 States and 108 school bus fires from 8 States. Thirteen of the 138 incidents matched incidents from the primary database, meaning that over 90 percent of them did not match. However, a sampling of these indicated that about 10 percent could be identified as either motorcoach or school bus fires; the remainder presumably involved other bus types not relevant to the study. Therefore, had these records been included as primary data, the totals for these States in the primary database would have increased by about 0.7 percent. Applying this estimated percentage increase to the primary data from all States would add approximately 14 motorcoach fires and 26 school bus fires to the national 10-year totals. While these additional fires may indicate that the primary data underestimates the number of fires as reported by the States, this difference is small and not verifiable. It does, however, indicate potential gaps in the primary source data.

[xvi] California was the sole representative from the Western region; the other Western States did not meet the 'extent of coverage' criteria.

[xvii] Records from California and Arkansas were not usable. Analysts were unable to extract any of the data from these two States relevant to the current study due to software incompatibility.

2.4.3 Media

In addition to statistical data, Volpe collected media reports from various sources for calendar year 2013,[xviii] capturing a variety of information on U.S. motorcoach and school bus fire incidents that relate the reported location, carrier, manufacturer, cause, and other factors. Due to the potential severity of motorcoach and school bus fires—including delays in traffic, damage to personal belongings, injuries, and loss of life—these incidents are well-reported on a daily basis. However, because these fires are often reported during or very shortly after an event, reports generally do not include the specific, accurate information that typically comes from investigation, such as the cause of the fire or ignition point. These reports are considered representative of fires in the most recent of the 10 years of this study and provide useful anecdotal information to supplement the statistical data, but cannot be used to estimate or corroborate trends over time. The media data is summarized in Appendix N.

2.5 EXPOSURE

2.5.1 Role of Exposure Data in Assessing Risk

A complete assessment of safety risk requires normalization of frequency of a harmful event, based on exposure to that event. For example, one's risk of being struck by a meteor is not only a function of the overall probability of a meteor shower, but also of the likelihood of being in its trajectory when it lands. Accordingly, the argument can be made that the risk of involvement in a bus fire in a given State is based not on the frequency of occurrence in that State, but the frequency as a ratio to the trips made or miles traveled by buses in that State. Likewise, the risk of a bus fire involving a vehicle of a given make and model can be considered proportional to the frequency of fires for that make/model normalized by the population of vehicles of the same make and model.

2.5.2 Vehicle Population from R.L. Polk

Each quarter, R.L. Polk and Co. compiles vehicle data from State vehicle registration records and manufacturer information. For this study, R.L. Polk provided two types of data. First, from its compilation of commercial vehicle registration data, it provided the number of vehicles on the road, in 2005, 2009, and 2013, by make and model name, year, and series, for model years 1980–2007. Also, for all complete VIN numbers in the primary database, it provided make; model name and year; engine make, model, and size; and brake type. The procurement of this data required a data-use agreement with R.L. Polk that restricts disclosure of the detailed records.

Obtaining accurate population counts of motorcoaches and school buses vehicles required judicious analysis of the R.L. Polk bus type classifications. Polk classified buses as either "bus school" or "bus non-school," but this was not sufficient to identify motorcoaches. By examining the make and model designations, the study analysts were able to research each combination with the designation of "bus non-school" to determine its identity as a motorcoach or other type of bus. Nearly all records labeled "bus school" could be verified as school bus makes/models.

[xviii] The original intent was to conduct the media search for all 10 years of the study, but preliminary scans showed that postings are usually available only for a 2–3 year period.

Surprisingly, some designated “bus non-school” were actually school buses. Appendix O displays the resulting vehicle population totals for each of the 3 years. The complete tally of counts and percentages of bus types researched by make/model appears in Table 30. Counts by manufacturer are shown in Table 31 and Table 32 in Appendix O for illustration purposes.

2.5.3 Vehicle Miles Traveled from Federal Highway Administration

Vehicle miles traveled (VMT) data were obtained from FHWA’s *2013 Highway Statistics*.(18) While this census provides VMT by functional highway category and not by vehicle characteristics, the breakout provides a useful measure of exposure for comparing motorcoach travel by States and regions. It is important to note that comparable VMT statistics are not available for school buses.

2.6 RECALLS

Data on all recalls since 2004 from three major motorcoach and two school bus manufacturers were obtained from NHTSA’s ODI database.(19) Records were selected if the description in any of four record fields referenced the possibility of fire occurrence. No applicable recalls were found from 2013 to present. From 2003 to 2012, there were 23 such recalls from 5 manufacturers, applying to 528 models. The peak annual numbers were 132 in 2006 and 155 in 2011. An estimated 184,000 vehicles may have been subject to these recalls. Engine coolant, electrical wiring, and brake disks represented the majority of the vehicle components listed. See Appendix P, which lists the details for these recalls.

2.7 MOTORCOACH SAFETY COMPLIANCE

Compliance data from carrier investigations—including OOS rates, carrier safety performance measurements, and violations and safety ratings—for 363 identified motorcoach operators and 487 vehicle inspections were extracted from MCMIS and SMS. Identification of the carriers required that the vehicle records in the primary database specify carrier name or have a VIN or license plate number that matched the MCMIS records for the vehicle and carrier.

Inspections of fire-involved vehicles that took place within 12 months of the fire were selected for determination of OOS violations and the carriers for which they operated. All investigations for those carriers were selected for the determination of critical and acute violations in Part 396 (Vehicle Maintenance and Repair) and safety ratings in Factor 3 (Operations) and Factor 4 (Vehicle). Carriers were also selected if they were prioritized for an intervention due to measurement of their Vehicle Maintenance BASIC within the 4 years (2010–13) during which it was measured.

OOS rates for all motorcoach inspections and safety ratings and Vehicle Maintenance BASIC percentiles for all motorcoach carriers were also obtained for comparison purposes.

2.8 SUMMARY

As was the case for the 2009 study, the updated and expanded database in this study combines incident reporting data sources to determine the frequency and severity of bus fires, and uses vehicle population and VMT data to establish normalized measures of their safety risk. Unlike that previous study, however, this study relies primarily on NFIRS and MCMIS as incident data sources for both motorcoach and school bus fire records. This study also uses the secondary sources to not only provide additional detail to those records, but also to provide the basis for comparison and further analysis of those incidents.

Like the 2009 study, this study inherits some of those sources' limitations, including geographic and temporal skewing of data and, in some instances, issues with data completeness and quality. NFIRS provided the most extensive coverage and depth, but inherently lacks the precision of data on vehicle fires because it was structured for the reporting of fixed property fires. For example, the field values for identifying the vehicle as a motorcoach (i.e., VIN, vehicle make, and vehicle model) are often conflicting, incomplete, or missing altogether, and there is no field for identifying the motor carrier. MCMIS, a crash reporting system, reliably identifies the carrier and its operator when there has been a collision meeting defined thresholds of severity.

Recognizing the limitations of the database, the study makes use of cross-sectional subsets of the data to provide insights into the frequency and severity of motorcoach fires, as well as causal and contributing factors. The analysis of the data also evaluates indicators of future fires based on compliance data, and sheds light on the effectiveness of measures offered to prevent motorcoach and school bus fires and reduce their severity.

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3. ANALYSIS AND DISCUSSION

This study analyzed the data described in Section 2 to estimate the scope of the motorcoach and school bus fire risk problem in the United States, as well as the potential of means to mitigate these risks. As such, it updates the analyses in the 2009 study and adds analyses for school bus fires. Unlike the 2009 study, the fires of interest for both motorcoaches and school buses include all fires, whether they occurred spontaneously due to mechanical failures and malfunctions, were the result of a crash, or were set intentionally or accidently. The study examines national trends in motorcoach and school bus fires, their known risk factors, and potential indicators of future fire risk.

Conclusions drawn in this section should not be interpreted as definitive or even verifiable within set boundaries of statistical certainty. Instead, they represent inferences suggested by extensive data analysis. Discussions within each topic area include an explanation of the assumptions associated with the data used in deriving the results.

This section introduces overall observations and trends, including the frequency and severity of motorcoach and school bus fires. It then explores the distribution of fires throughout the country by region and State. Several ignition factors—cause, area of origin, contributing factor, heat source, and item first ignited—characterize incidents by determining what started the fire. The section then examines characteristics of the vehicles that were involved in fire incidents, including model year, vehicle age, make, and model. Finally, it explores compliance data indicators and their relationship to motorcoach fires.

3.1 OVERALL OBSERVATIONS AND TRENDS

An analysis of the frequency and severity (including injuries, fatalities, and damages) of motorcoach fires was conducted in the 2009 study. The analysis noted that, at the time, there was no indication that the frequency of motorcoach fire incidents was significantly increasing or decreasing, and that the consequences of reported fire incidents appeared small when rare disastrous events were excluded. This study expanded on those conclusions, looking at fire frequency, injuries and fatalities, and property loss and damages due to fire incidents for both motorcoaches and school buses, in order to gain a comprehensive understanding of how prevalent fire occurrence is and how harmful it can be. It is important to take into account the limited number of sources available for the analysis of overall observations and trends, and the deficiencies of incident-reporting systems.

3.1.1 Frequency

Study data indicate that, on average, motorcoach fires occur slightly less than daily, with an average of 200.9 reportable fires per year, as indicated in Appendix I. Data indicate that the average for school buses is slightly more than one fire per day, with an average of 379.4 reportable fires per year.

Looking at Figure 1, the frequency trend for both motorcoach fires and school bus fires is similar, with a general downward trend over the 10-year period, sharp peaks in 2005, and slight increases in 2011. There are also notable decreases in reportable fires in the years 2012 and

2013, though it is too early to know whether this signifies a downward trend in fire frequency for motorcoaches and school buses.

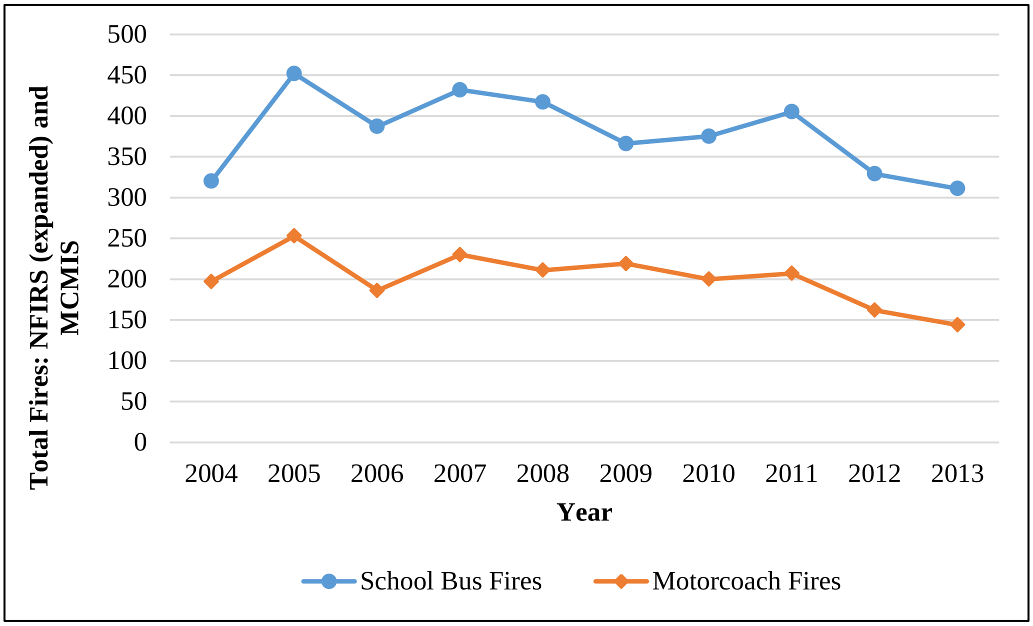

Figure 1. Line graph. Frequency of motorcoach and school bus fires, 2004–13.

Most motorcoach and school bus fires take place during high traffic times, as shown in Appendix Q. For motorcoaches, the majority of fires occur between 6–10 a.m. and 1–6 p.m. For school buses, the majority of fires occur between 6–9 a.m. and 2–5 p.m. These findings are consistent with motorcoach and school bus operations: motorcoaches often operate for longer stretches of time dispersed more evenly throughout the day than school buses, which most often operate in accordance with the school day.

As concluded in the 2009 study, actual fire occurrence may be far greater than the number of records collected per year suggests. Reporting criteria for motorcoach fires are less clear and less enforceable compared with the criteria for other types of roadway incident reporting. School bus fires may occur on secondary roadways and therefore may not be accurately captured in the reporting. Fires that are extinguished before they cause any injuries or fires that do not meet some arbitrary threshold of monetary damages are less likely to be documented by employers, insurance companies, or government authorities. It is understandable that fire incidents that meet the tow-away criteria but otherwise go unnoticed by the public would not be reported.

Even if incident reporting could be made more enforceable, data deficiencies lend uncertainty to the accounting of applicable fire incidents. As outlined in the previous section, considerable judgment was used to classify records, particularly those that do not have field values or reference data that accurately identify the involved vehicle as a motorcoach or school bus. Accordingly, this study’s database is not a precise sampling of all applicable incidents, and may under- or overestimate the total counts. Consistent data definitions and complete and accurate reporting by all sources could be perceived to yield a more accurate accounting of reported motorcoach and school bus fire frequency.

The 2009 study concluded that the estimated frequency of motorcoach fires was approximately 160 incidents per year. The study attempted to compensate for the uncertainties and inconsistencies in the national incident reporting databases by adding fire incident records from other sources. Because these sources were not complete for all States or years, a significant number of reportable incidents were undoubtedly omitted, even in the most complete period (2004–06). Moreover, NFIRS data used for that study did not account for incidents occurring in jurisdictions outside the NFIRS sample. In contrast, this study relies on the national incident reporting systems using NFPA expansion factors to estimate national totals of actual reportable incidents rather than adding records from other sources. It is not surprising that the new estimates for motorcoach incidents are considerably higher for the years 2004–06, which are considered the most complete in the 2009 study. Thus, the conclusion is that these current estimates are more accurate using the expansion methodology, even if other sources identify specific incidents that are not included in the reported data.

3.1.2 Injuries and Fatalities

Notwithstanding the frequency of harmful events, the severity of these events—in particular, the extent of injuries and fatalities to drivers and passengers—are usually considered the most important measures of passenger transportation safety risk.

Table 3 and Table 4 present the annual tallies of deaths and injuries that occurred during an event where a motorcoach or school bus caught fire, as reported in the national incident reporting systems. Fatalities and injuries recorded in NFIRS were expanded to represent a more accurate portrayal of their frequency. Total fatalities and injuries were calculated by adding the MCMIS counts to the expanded NFIRS counts. Appendix R expands these tables to show the number of reported incidents resulting in these counts of fatalities and injuries.

Table 3. Motorcoach fire deaths and injuries, 2004–13.

Year	NFIRS Fatalities	NFIRS Fatalities Expanded	MCMIS Fatalities	Total Fatalities	NFIRS Injuries	NFIRS Injuries Expanded	MCMIS Injuries	Total Injuries
2004	0	0	0	0	5	8	16	24
2005	0	0	23	23	4	7	19	26
2006	0	0	0	0	7	11	1	12
2007	0	0	1	1	0	0	1	1
2008	0	0	0	0	0	0	55	55
2009	0	0	0	0	0	0	6	6
2010	0	0	0	0	0	0	7	7
2011	0	0	1	1	2	3	42	45
2012	0	0	0	0	2	3	2	5
2013	0	0	0	0	1	2	3	5
Total	**0**	**0**	**25**	**25**	**21**	**34**	**152**	**186**
Annual Average	**0**	**0**	**2.5**	**2.5**	**2.1**	**3.4**	**15.2**	**18.6**

Table 4. School bus fire deaths and injuries, 2004–13.

Year	NFIRS Fatalities	NFIRS Fatalities Expanded	MCMIS Fatalities	Total Fatalities	NFIRS Injuries	NFIRS Injuries Expanded	MCMIS Injuries	Total Injuries
2004	0	0	0	0	3	5	0	5
2005	0	0	5	5	2	3	13	16
2006	0	0	1	1	3	5	7	12
2007	0	0	0	0	8	13	3	16
2008	0	0	1	1	11	18	28	46
2009	0	0	0	0	4	7	1	8
2010	0	0	0	0	2	3	4	7
2011	0	0	2	2	0	0	8	8
2012	0	0	1	1	1	2	10	12
2013	1	2	0	2	1	2	28	30
Total	**1**	**2**	**10**	**12**	**35**	**58**	**102**	**160**
Annual Average	**0.1**	**0.2**	**1**	**1.2**	**3.5**	**5.8**	**10.2**	**16**

3.1.2.1 Motorcoaches

As shown in Table 3, an average of 2.5 fatalities per year occur as a result of motorcoach fires. The 23 deaths that occurred during the 2005 fire in Wilmer, TX contribute significantly to this calculation. An average of 3.4 injuries per year occur as a result of motorcoach fires.

3.1.2.2 School Buses

Table 4 shows that an average of 1.2 fatalities per year occur as a result of school bus fires. The single fatality recorded in NFIRS occurred on a school bus that was parked in a storage space and had been converted into temporary housing. Media sources confirmed that the occupant who perished in the fire left a camp stove burning while he slept, which was likely the source of ignition.(20,21) An average of 5.8 injuries per year occur as a result of school bus fires. It is important to note that a number of the reported injuries and fatalities for motorcoach and school bus fires are actually associated with other vehicles involved in the incident itself, not the occupants of the motorcoach and school bus. While the data set for the 2009 study differentiated between deaths and injuries caused directly by the motorcoach or school bus fire, this data set does not. Additional media research found that four of the five fatalities associated with a school bus fire in 2005 actually occurred in another vehicle that caused the school bus to crash and catch on fire. The fatalities were not from occupants of the school bus. Therefore, it is important to consider that though reported in association with a motorcoach or school bus fire, the recorded fatalities and injuries do not always apply to the occupants of those vehicles.

The average consequences of reported fire incidents appear small, particularly in comparison with rare disastrous incidents that produce large numbers of casualties. These worst-case scenarios, like airline crashes and bridge collapses, represent a component of risk that needs to be considered in further analysis of the contributing factors underlying the incidence of motorcoach fires. Attendant injuries and fatalities that result only from passenger egress or the response of emergency personnel could be discounted because they may be considered random events or might be reduced by measures other than fire risk mitigation.

3.1.3 Property Loss and Damages

Property loss estimates of damages from fires on motorcoaches and school buses provide another measure of the severity component of transportation safety risk. For motorcoach and school bus fires, only NFIRS and insurance data sets provided a significant number of non-blank records—a total of 1,684 from NFIRS and 179 from one of the insurance carriers. Records from NFIRS with a damage value of less than $100 were excluded because low numbers were suspected of having been entered incorrectly.

For all sources, considering both motorcoaches and school buses, the positive-value damages range from $100 to $1,600,000. From NFIRS, the mean value was $37,024 with a median of $5,000. The insurance data indicates a mean value of $99,119 and a median value of $319,261. Table 5 and Table 6 show the individual breakdowns for motorcoaches and school buses.

Table 5. Motorcoach property loss/damage reported, by data source.

Data Source	Records	Damage Value Minimum	Damage Value Maximum	Damage Value Mean	Damage Value Median
NFIRS	590	$100	$1,600,000	$58,881	$10,000
Insurance	117	$798	$637,723	$136,465	$66,104

Table 6. School bus property loss/damage reported, by data source.

Data Source	Records	Damage Value Minimum	Damage Value Maximum	Damage Value Mean	Damage Value Median
NFIRS	1,094	$100	$1,500,000	$25,236	$4,000
Insurance	62	$857	$142,480	$28,644	$46,744

It should be noted that the damage to and loss of property on a motorcoach can be expected to be greater than on a school bus given that motorcoaches are, in general, more expensive than school buses, and also tend to carry more cargo and personal belongings.

3.1.4 Key Findings for Overall Observations and Trends

School bus fires reportedly occur more frequently than motorcoach fires. On average, motorcoach fires in the United States occur slightly less than daily, while school bus fires occur slightly more than daily. Annual counts of fire incidents involving motorcoaches and school buses from 2004 to 2013 show similar downward trends over those years, with notable decreases in reportable fires in the years 2012 and 2013. However, actual fire occurrence may be greater than the number of records collected per year would suggest.

Deaths and injuries as a result of a motorcoach or school bus fire are rare, but can be severe in worst-case scenarios such as the fire in Wilmer, TX in 2005. Approximately 98 percent of the reported fires resulted in no direct injuries or fatalities, and the average reported property damage per incident was a fraction of the total cost of the vehicle.

3.2 GEOGRAPHIC DISTRIBUTION

Because motorcoaches and school buses operate throughout the United States, the effects of these types of vehicle fires can be far-reaching. It is essential to recognize which geographic areas are most affected by motorcoach and school bus fire incidents, in order to prevent their occurrence. Since motorcoach and school bus operations vary greatly from State to State, this analysis attempted to normalize fire incident counts by a measure of relative exposure for each State using VMT. VMT by vehicle type are not readily available, but total VMT on roadways characterizing typical motorcoach routes provide a useful surrogate. A comparable proxy value for school buses was not readily available since the VMT for school buses cannot be considered proportional to the classifications by roadway type. The 2009 study also mentioned that a higher frequency of records for one State or region may indicate differing reporting standards or data definitions, which is important to keep in mind in the analysis that follows.

3.2.1 Motorcoaches

Counts of incidents by State and region during the 2004–13 time period are listed in Appendix S. The VMT data include only estimates for interstate highways, other freeways and major arterial roads, major collectors, and urban minor collectors. Travel on these roadways is estimated from State-provided data in the Highway Performance Monitoring System. Estimates are not included for rural/urban local roads and rural minor collector roads because they are not considered the primary portion of motorcoach routes.

Subtotals for each region and the national total provide insight into the rates of reported fire incidence. For these years, there were totals of 2,008 incidents and 27,679,976 VMT in the United States—an average of 7.25 incidents per 100 billion VMT. The proportions of motorcoach fire incident records to total applicable VMT (100 billion) for each region are as follows:

- East = 9.9.
- Midwest = 5.11.
- South = 7.95.
- West = 6.44.

The 16 States, including the District of Columbia, with the highest ratios of fire incident records relative to highway VMT for 2004–13 are shown in Table 7. Four of the States are in the East, two in the South, three in the Midwest, and six in the West. Of these 16 States, 12 were also named in the top 15 in the 2009 study, with the District of Columbia, Hawaii, Alaska, and Nevada claiming the top 4 highest records per billion highway VMT. South Dakota, Virginia, Ohio, and Georgia were not listed in the 2009 study.

Table 7: Motorcoach fire records by State: Top 16, by ratio of 2004–13 fires to vehicle highway/major arterial travel.

State*	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and NFIRS Expanded	VMT (in millions)	Records per VMT (in billions)
Nevada	22	36	3	**39**	197,647	0.2
Massachusetts	56	92	0	**92**	514,011	0.18
Hawaii	8	13	0	**13**	81,761	0.16
New Jersey	64	105	2	**107**	688,153	0.16
Florida	134	220	2	**222**	1,663,289	0.13
South Dakota	5	8	3	**11**	88,147	0.12
Alaska	3	5	0	**5**	44,247	0.11
Connecticut	21	34	0	**34**	307,697	0.11
New York	66	108	23	**131**	1,160,590	0.11
Virginia	52	85	1	**86**	786,440	0.11
North Dakota	5	8	0	**8**	76,975	0.1
Utah	12	20	3	**23**	230,044	0.1
District of Columbia	2	3	0	**3**	31,767	0.09
Ohio	50	82	3	**85**	992,377	0.09
Georgia	44	72	0	**72**	936,774	0.08
North Carolina	37	61	5	**66**	841,011	0.08

*Includes District of Columbia.

It is important to compare ratios of fire incident records per VMT rather than straight fire counts, considering the wide variability of motorcoach operations in each State. For example, while both California (169 fires) and Texas (164 fires) have high numbers of fires, they also have more VMT and therefore lower ratios: California had only 0.05 records per billion highway VMT; and Texas had only 0.07 records per billion highway VMT.

3.2.2 School Buses

Counts of the incidents by State and region for the 2004–13 reporting period are shown in Appendix T. Since there is no effective way to estimate VMT by State for school buses, only the counts for reported incidents are shown in Table 8.

The subtotals for each region and the national total provide insight into the rates of reported fires incidence. There were 3,794 incidents in the United States for these years. The proportions of school bus fire incident records in each region to total number of records are as follows:

- East = 22.85 percent.
- Midwest = 24.64 percent.
- South = 31.62 percent.
- West = 20.88 percent.

Table 8: School bus fire records by State: Top 16 for fires from 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and NFIRS Expanded
Texas	181	297	3	**300**
Florida	145	238	0	**238**
Ohio	126	207	4	**211**
Illinois	122	200	2	**202**
Georgia	114	187	1	**188**
South Carolina	112	184	0	**184**
Michigan	110	180	3	**183**
New York	108	177	4	**181**
Virginia	102	167	6	**173**
Massachusetts	100	164	1	**165**
North Carolina	88	144	10	**154**
California	88	144	7	**151**
Tennessee	74	121	1	**122**
Louisiana	62	102	1	**103**
Maryland	46	75	9	**84**
New Jersey	50	82	2	**84**

For either motorcoaches or school buses, given the limited number of records, a greater number of fire incident records may not necessarily indicate an issue; rather, it may indicate a higher or more thorough method of reporting standards or a confluence of data sources. An omission in reporting just a few incidents over a multi-year period in a State with few reporting incidents could significantly impact that State's ranking. Therefore, to gain further insights into geographic influence, it would be prudent to focus on those States that are reporting a significant number of incidents. The rates of incidents may also be skewed by factors such as population densities and demographics, the variability of motorcoach or school bus travel within the region, and other regional differences (such as tourism).

3.2.3 Key Findings for Geographic Distribution

The ratio of motorcoach fires to billion highway VMT is highest in the Eastern and Southern regions compared to the Midwestern and Western regions. While some States have higher fire counts, it is important to consider the wide variability of motorcoach operations in each State. The greatest number of school bus fires occurred in the South and Midwest compared to the West and East; however, VMT counts were not available for school bus travel.

3.3 IGNITION FACTORS

In the 2009 study, the origin of a motorcoach fire was characterized by location of ignition on the vehicle and the specific source of ignition—known as the fire's ignition point. Identifying the ignition point for each fire incident was critical for assessing measures for preventing or mitigating fires that target specific components. As the most prominent example, it was necessary in order to distinguish between fires originating in the wheel area or the engine compartment.[xix]

For this study, this level of detail was generally not available, primarily because USFA could not provide the narrative remarks entered into the NFIRS records by fire responders.[xx] Instead, this study looks at the factors and values reported by NFIRS that characterize the ignition of the fire, looking for patterns approximating the previous classification by ignition point. These factors are based on the NFIRS coded fire characteristic data elements: cause of ignition, area of origin, contributing factors, heat source, item first ignited, and material first ignited. Results of tabulating the counts and distribution of fire incidents by each of these factors are presented below.

3.3.1 Cause of Ignition

The cause of each motorcoach or school bus fire was determined based on one of seven codes available in NFIRS:

- Act of nature.
- Cause under investigation.
- Cause undetermined after investigation.
- Cause, other.
- Failure of equipment or heat source.
- Intentional (i.e., caused by the deliberate misuse of a heat source).
- Unintentional (i.e., caused by careless, reckless, or accidental acts).

Three of these codes—"Cause under investigation," "Cause undetermined after investigation," and "Cause, other"—indicate fires in which the cause was not classified. Fires with any of these three values were therefore grouped into the category "Unclassified cause."

The causes of ignition for motorcoach and school bus fires are tabulated in Appendix U. Figure 2 illustrates the distribution of motorcoach fires by cause. The majority of motorcoach fires are caused by the failure of equipment or heat source, which includes mechanical problems. Very few motorcoach fires are intentional or caused by an act of nature, such as a storm or earthquake.

[xix] The insurance data from Carrier 1 provides sufficient detail to identify area of origin and ignition source/component as described in the 2009 study, as delineated in Table 24 and Table 25 in Appendix J.

[xx] The NFIRS system continues to collect and archive this information, but has not to date been added to the active database, which was the source of the queries for this study.

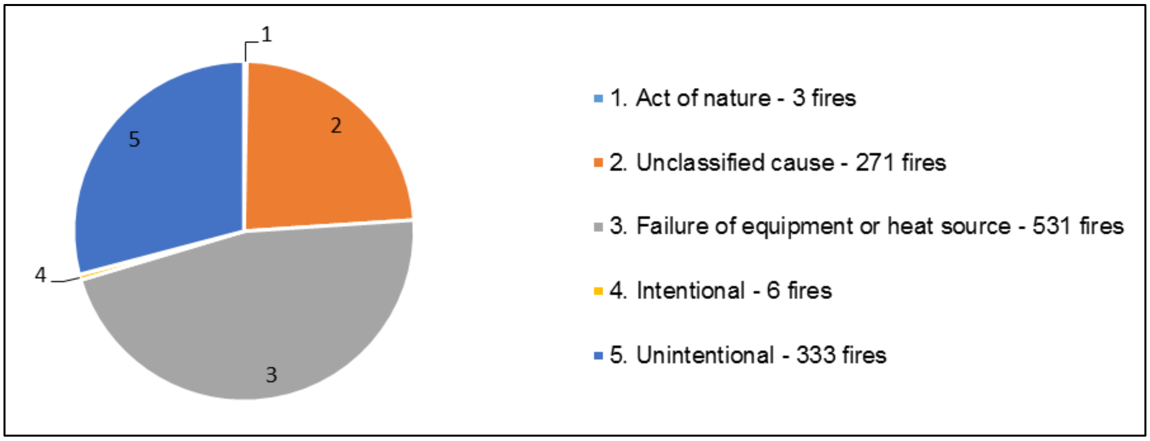

Figure 2. Pie chart. Motorcoach fires, 2004–13, by cause of ignition.

Figure 3 illustrates school bus fires by cause. Similar to motorcoach fires, the majority of school bus fires are caused by failure of equipment or heat source, including mechanical problems. However, school buses have a greater proportion of "intentional" fires. As discussed previously, when school bus fires are broken out by alarm time and cause of ignition (see Table 36 in Appendix Q), most of these intentional school bus fires are shown to have taken place between 3–4 p.m. A number of intentional school bus fires also took place between 10–11 p.m.

The study analysts explored whether this higher proportion of intentional school bus fires may have been the result of fires caused by human error, considering the average age of school bus passengers. NFIRS states that "intentional" fires include the deliberate misuse of a heat source or a fire of an incendiary nature, while "unintentional" incidents are caused by careless, reckless, or accidental acts. It is important to consider that intention may be considered a matter of perspective, and that "intentional" fires may include some fires that resulted from horseplay on school buses. As shown in Table 52 and Table 53 (see Appendix V), 21 percent of school bus fires and 25 percent of motorcoach fires that occur in the operator or passenger area are unintentional. These tables also show that 17 percent of school bus fires and 7 percent of motorcoach fires that occur in the operator or passenger area are intentional. The majority of intentional school bus fires also take place from 3–4 p.m., when student passengers would be traveling home from school. School buses are therefore more likely than motorcoaches to be targets of intentional fires in the passenger area due to inappropriate passenger activities.

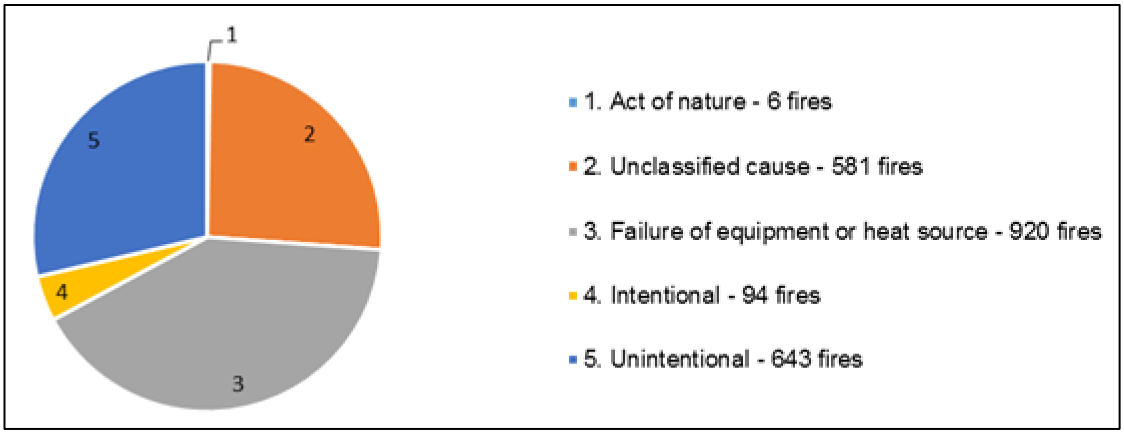

Figure 3. Pie chart. School bus fires, 2004–13, by cause of ignition.

3.3.2 Area of Origin

The area of origin refers to the primary use of the area where the fire started within the motorcoach or school bus. While the majority of fires originated in the vehicle area, some started on or near a highway, parking lot, street, or other area outside the vehicle. In these cases, the fire then spread to the motorcoach or school bus. A detailed breakdown of fires in each area of origin is illustrated in Appendix W.

Figure 4 and Figure 5 illustrate the proportions of fires that occurred in various areas. The categories "other known areas of origin" and "undetermined or unclassified areas of origin" specify fires that began outside the vehicle, but it should be noted that most fires originate within the vehicle area. A large majority of motorcoach and school bus fires originate in the engine area, running gear, or wheel area.

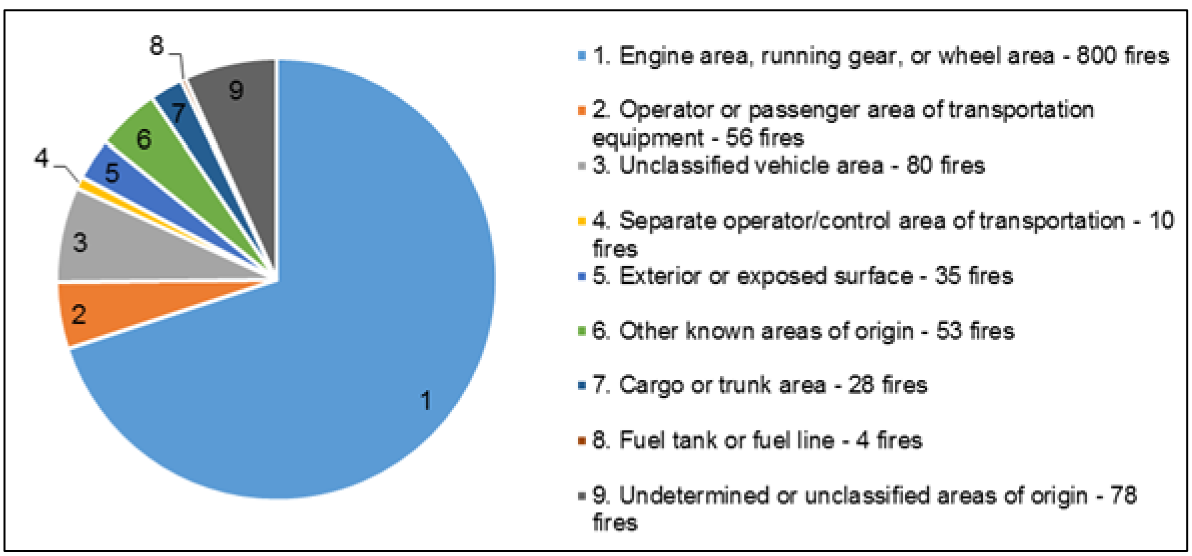

Figure 4. Pie chart. Motorcoach fires, 2004–13, by area of origin.

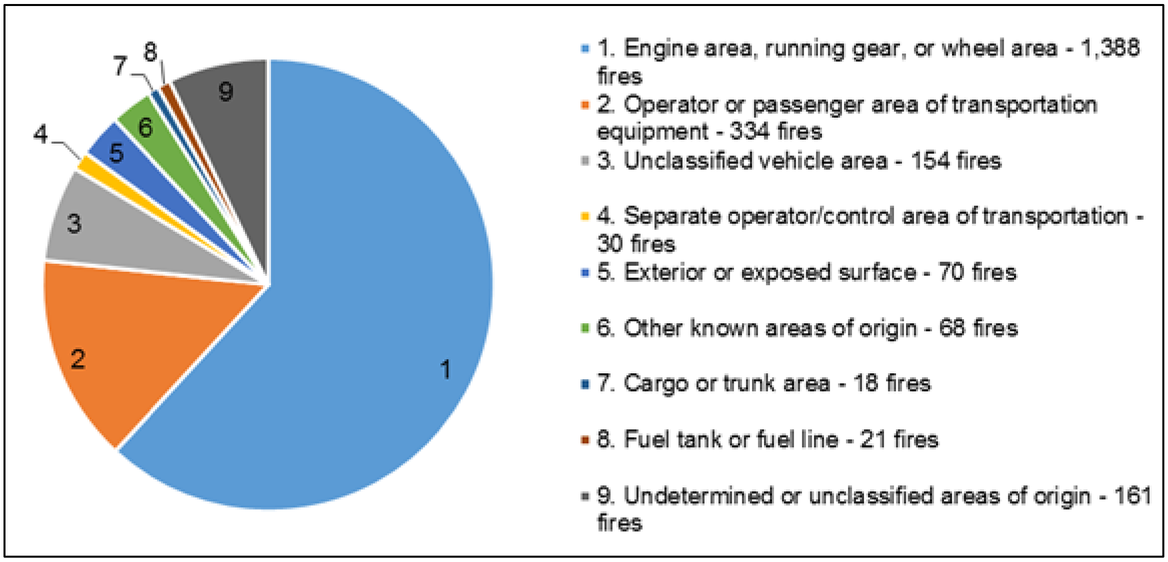

Figure 5. Pie chart. School bus fires, 2004–13, by area of origin.

The 2009 study concluded that, of the 70 percent of motorcoach fires that specified the area of origin as 'engine area, running gear or wheel area,' about half originated in the engine compartment and half in the running gear or wheel area. As discussed earlier, not having access to the textual remarks associated with the NFIRS records prevented the further breakout of this area of origin for motorcoach or school bus fires. To compensate for this deficiency, the statistical data for the remaining factors contributing to ignition were further analyzed and cross-referenced.

On the other hand, the incident data from one of the insurance companies shown in Table 23 (see Appendix J), provides an interesting, if not as statistically robust, counterpoint to the NFIRS data. Of the 189 claims for motorcoach fires in the 10-year timespan, 162 (86 percent) were determined to have originated in either the engine or wheel areas. One hundred (53 percent) were engine fires, and 62 (33 percent) were wheel area fires. While the proportion of wheel area fires is roughly the same as concluded in the 2009 study, the proportion of fires originating in the engine compartment is substantially higher.

3.3.3 Contributing Factors

Factors contributing to ignition demonstrate circumstances and components responsible for a motorcoach or school bus fire. Factors referenced in this report include:

- Mechanical failure or malfunction (including leaks, breaks, or worn out equipment).
- Electrical failure or malfunction (including short-circuit arcing)
- Operational deficiency (including failure to clean vehicle equipment).
- Other known factors (including the misuse of material or playing with the heat source).
- Undetermined or unclassified factors.

A detailed breakdown of fires with each contributing factor is illustrated in Appendix X.

Figure 6 and Figure 7 illustrate motorcoach and school bus fires by factor contributing to ignition. A mechanical failure or malfunction contributed to 48 percent of school bus fires and 65 percent of motorcoach fires where the factor contributing to ignition could be determined. While this percentage for motorcoaches is high, Appendix X shows that motorcoach fires due to mechanical failure or malfunction have been trending down since 2008. An electrical failure or malfunction contributed to 35 percent of school bus fires and 20 percent of motorcoach fires where the factor contributing to ignition could be determined.

Fire-related recalls, as listed in Appendix P, cite similar possible ignition factors. For popular school bus and motorcoach manufacturers, recalls for electrical systems, engines and engine cooling elements, mechanical equipment, and fuel systems were made due to increased fire risk.

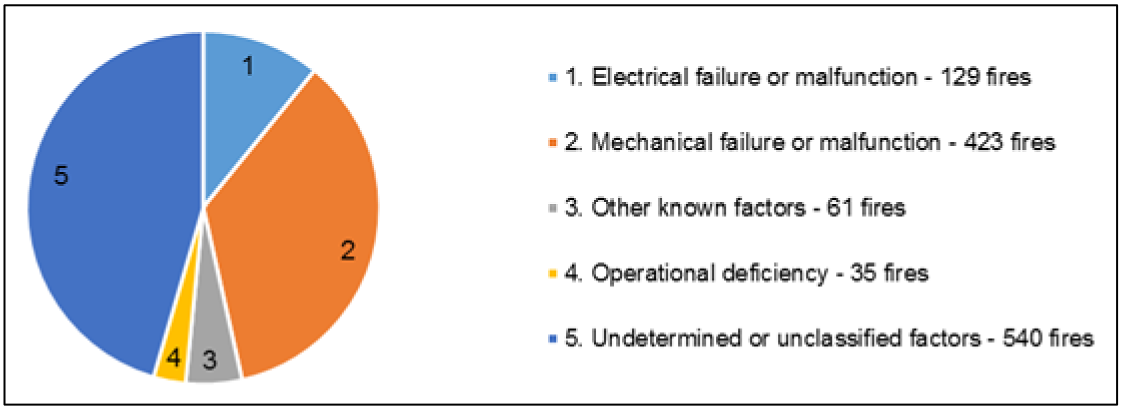

Figure 6. Pie chart. Motorcoach fires, 2004–13, by factor contributing to ignition.

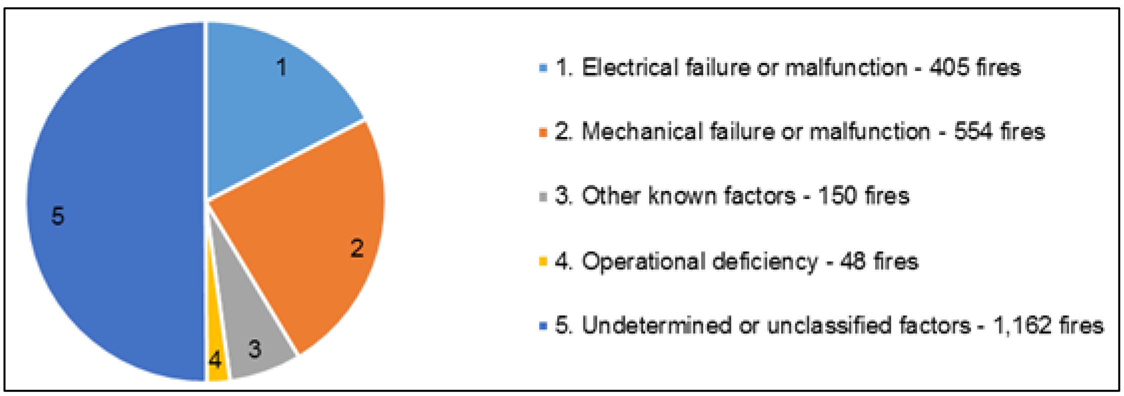

Figure 7. Pie chart. School bus fires, 2004–13, by factor contributing to ignition.

3.3.4 Heat Source and Item First Ignited

The heat source describes the thermal factor responsible for setting fire to the item first ignited. The item first ignited is defined as the first item that had sufficient volume, heat intensity, or exposure to electrical sparks to extend to uncontrolled or self-perpetuating fire.

Appendix Y displays a breakdown of the various items first ignited on motorcoaches and school buses. NFIRS also provides a field for the type of material that was first ignited by the heat source. The material may be a gas, flammable liquid, chemical, plastic, wood, paper, fabric, or any number of other materials.

Figure 8 and Figure 9 illustrate motorcoach and school bus fires by heat source. The heat source for 73 percent of school bus fires and 74 percent of motorcoach fires where the heat source was known was the vehicle's operating equipment. The most common values in the operating equipment category are: radiated or conducted heat from the operating equipment; arcing; and a spark, ember, or flame from the operating equipment. The second most common category of heat source for both types of vehicles was a hot or smoldering object, most often heat or a spark from friction. A detailed breakdown of fires by specific heat source is illustrated in Appendix Z.

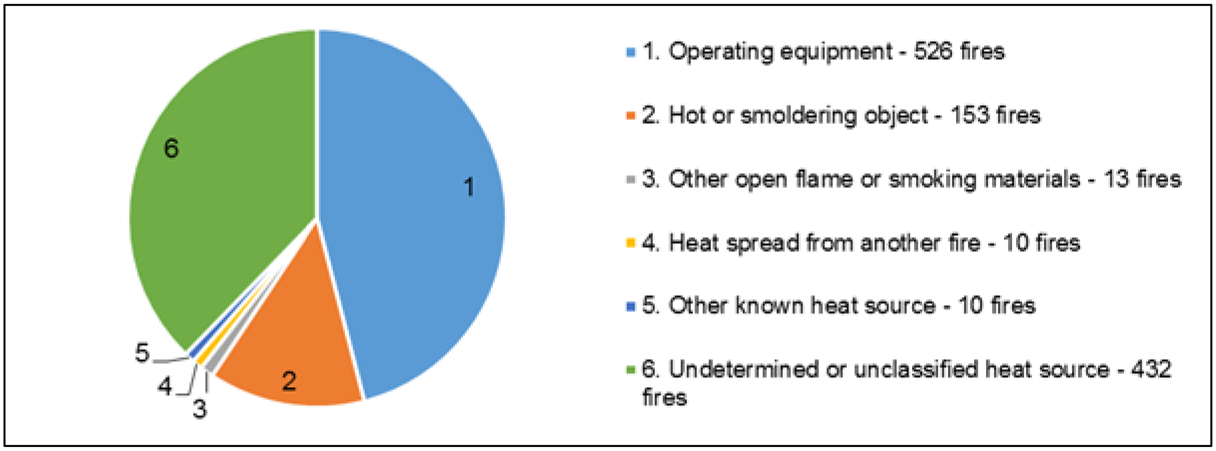

Figure 8. Pie chart. Motorcoach fires, 2004–13, by heat source.

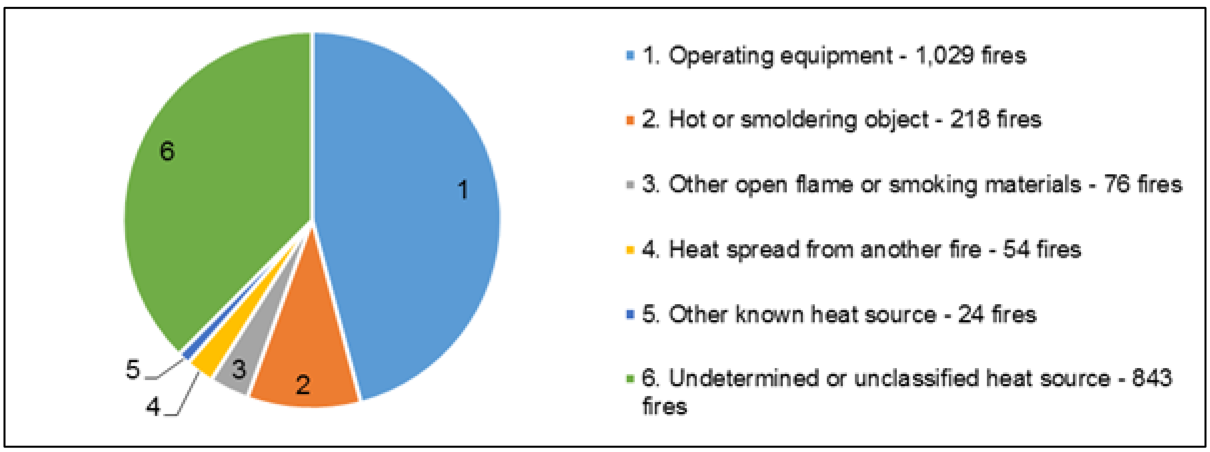

Figure 9. Pie chart. School bus fires, 2004–13, by heat source.

As demonstrated in Appendix Y, the most common items first ignited on both school buses and motorcoaches fall under the category "general materials," which includes electrical wire, cable insulation, tires, conveyor belts, drive belts, and V-belts, among other materials.

Factoring in the statistics on the material first ignited (broken out in Appendix AA) provides further insight into the distribution of ignition sources. Figure 10 and Figure 11 indicate that for motorcoach and school bus fires where the specific material first ignited is known, three categories ignite most often: flammable or combustible liquid, especially transformer or lubricating oil; plastic; and rubber, excluding synthetic rubbers, which are often used to produce tires. A large number of fires were categorized under "other material first ignited," which includes subcategories such as "other known material first ignited" and "multiple types of material." These loose definitions make it difficult to ascertain what the material first ignited may have been in these cases.

In incidents where the item first ignited was known, a tire was the first item ignited in 24 percent of motorcoach fires and 8 percent of school bus fires. In addition, Table 54 and Table 55 (see Appendix V) show that the item first ignited was a tire in 13 percent of motorcoach fires and 5 percent of school bus fires that occurred in the engine area, running gear, or wheel area of the vehicle. While NFIRS data does not directly specify which fires are wheel area fires, given the total counts of motorcoach and school bus fires, it can be inferred that at least those 101 motorcoach and 66 school bus fires per year are likely wheel area fires, and that wheel area fires are more likely to occur on motorcoaches than on school buses.

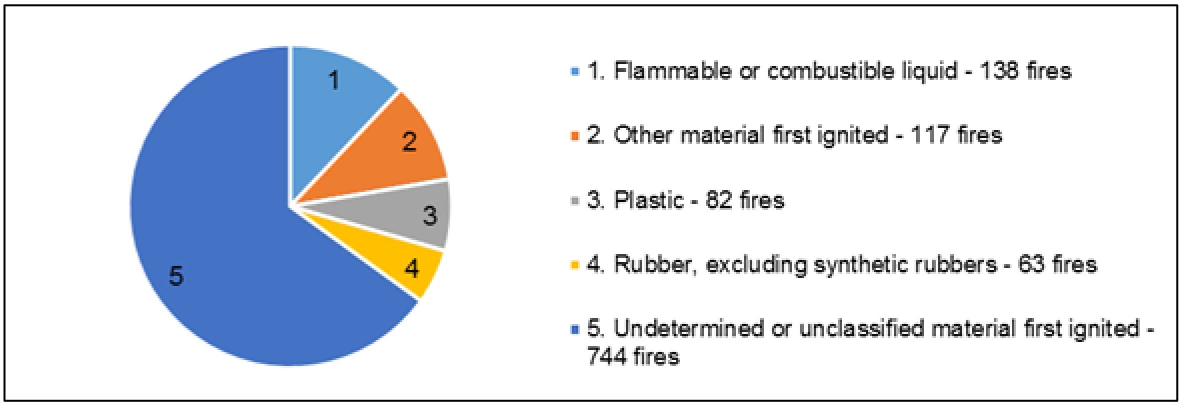

Figure 10. Pie chart. Motorcoach fires, 2004-13, by material first ignited.

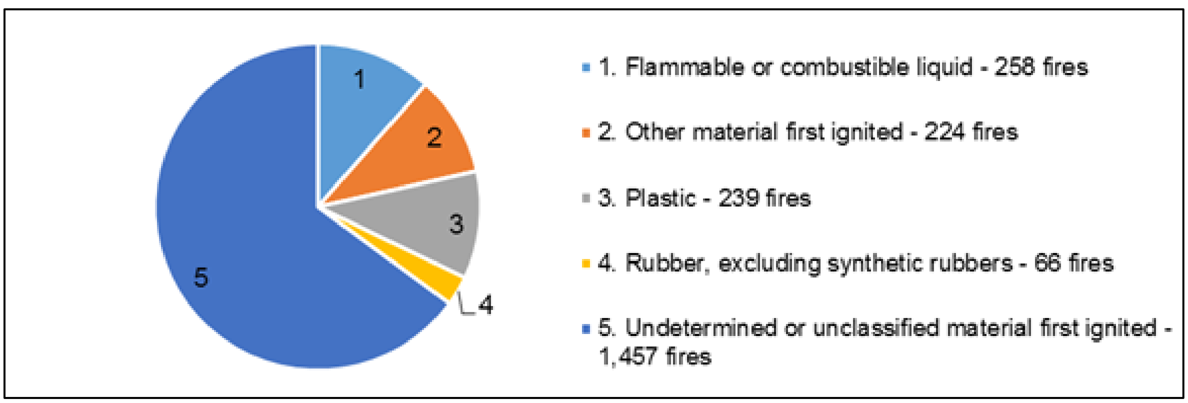

Figure 11. Pie chart. School bus fires, 2004–13, by material first ignited.

3.3.5 Key Findings for Ignition Factors

NFIRS data supplied fields for cause of ignition, area of origin, contributing factor, heat source, material first ignited, and item first ignited. Many of these fields were left undetermined or unclassified. Of the known values, the most frequent cause of ignition was failure of equipment or heat source for both motorcoaches and school buses. Unlike motorcoach fires, a significant number of school bus fires were classified as intentional.

The most frequent area of origin for motorcoach and school bus fires was the engine area, running gear, or wheel area. Seventy-seven percent of motorcoach fires and 68 percent of school bus fires with known areas of origin originated in this area. A significant number of these fires on motorcoaches cited a tire as the item first ignited, and were likely wheel area fires, while a significant number of engine area, running gear, or wheel area fires on school buses cited an electrical wire as the item first ignited and were likely electrical fires. This aligns with what was determined in the 2009 study, which cited that wheel area and engine fires were the most frequent.

The most frequent contributing factor for both motorcoaches and school buses was mechanical failure or malfunction, followed by electrical failure or malfunction. However, motorcoach fires are more likely to be mechanical than electrical, when compared to school bus fires.

3.4 INVOLVED VEHICLE CHARACTERISTICS

Considering that motorcoach and school bus fires most often occur as a direct result of the vehicle itself (as shown in Figure 2 and Figure 3), it is crucial to understand involved vehicle characteristics such as model year, vehicle age, manufacturer, model, and engine type, which may help inform industry standards relating to bus fire safety.

3.4.1 Model Year and Vehicle Age

The model years (MYs) for vehicles newer than 1980 that were involved in fires from 2004 to 2013 are listed in 1,127 motorcoach fire records (88 percent) and 2,042 school bus fire records (87 percent). These records are presented by incident year and vehicle MY in Appendix BB. Each calendar year period in Appendix CC shows few fires for brand new vehicles. Figure 12 and Figure 13 show the annual average counts of fire-involved vehicles between 2004 and 2013 by those vehicles' MYs, against the average annual population of vehicles for each MY.

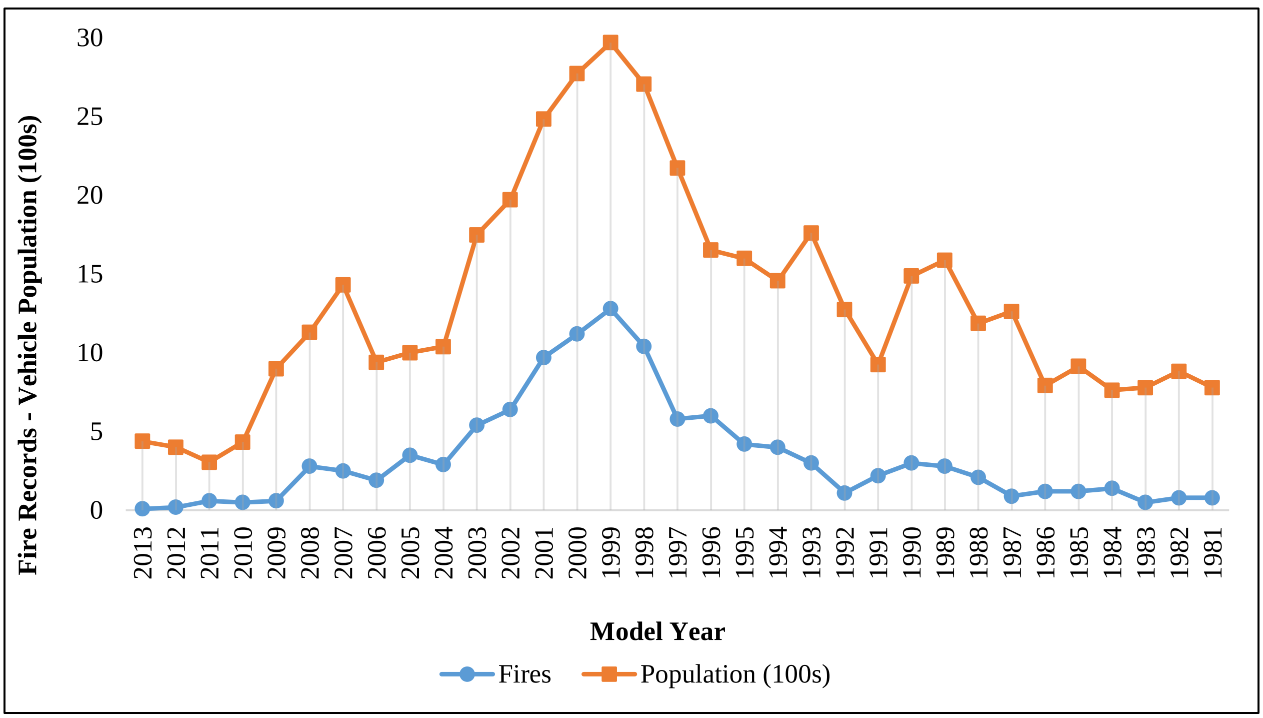

Figure 12. Line graph. Average annual motorcoach fires and average population, 2004–13, by model year.

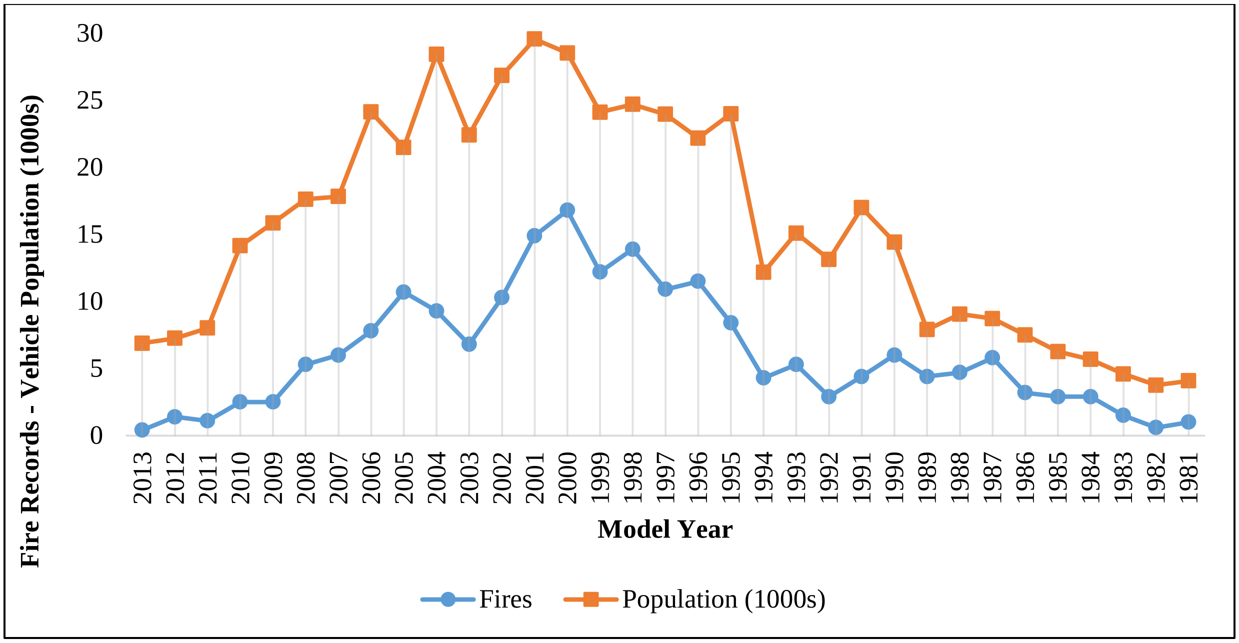

Figure 13. Line graph. Average annual school bus fires and average population, 2004–13, by model year.

The greatest number of motorcoach fires involved MY 1999 vehicles (128 fires). About 50 percent of the incident records involve motorcoaches of MYs 1998–2003. Similar to the findings in the 2009 study, these motorcoaches not only had a higher reported frequency of fires, but also a substantially higher reported incident rate relative to their population.(xxi)

The claims data for motorcoach fires for the two insurance companies shown in Table 21 (see Appendix J) reveal similar findings. Of the 329 claims, 136 (41 percent) were for fires on motorcoaches with MYs 1995–99, and 100 (30 percent) were for fires on motorcoaches with MYs 2000–04. The incident rates relative to the population of these MY ranges were substantially higher than the average for all MYs.

School bus fires, as well as the fire incident rate relative to the population, were more evenly distributed across MY vehicles than motorcoach fires. The greatest number of school bus fires involved MY 2000 vehicles (168 fires). About 39 percent of the incident records involved school buses of MYs 1996–2001. These school buses not only had a higher reported frequency of fires, but also had a higher reported incident rate relative to their population.

Figure 14 and Figure 15 plot the number of fires by age of vehicle recorded between 2004 and 2013 against a scaled-vehicle population total based on statistics from R.L. Polk for 2005, 2009, and 2013. Vehicle age was calculated using the MY and fire date from the data.

Figure 14 shows the frequency of reported motorcoach fires by age of vehicle and the extent to which they correspond with the number of motorcoaches on the road. While the motorcoach population peaks at age 6, the number of fire records is at its highest at about age 9. Both the

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(xxi) Data from Insurance Carrier1 shows a similar pattern for motorcoach fires. See Appendix J.

number of motorcoach fires and the ratio of fires to vehicle population are higher for motorcoaches between the ages of 6 and 13 than for any other multi-year age span.

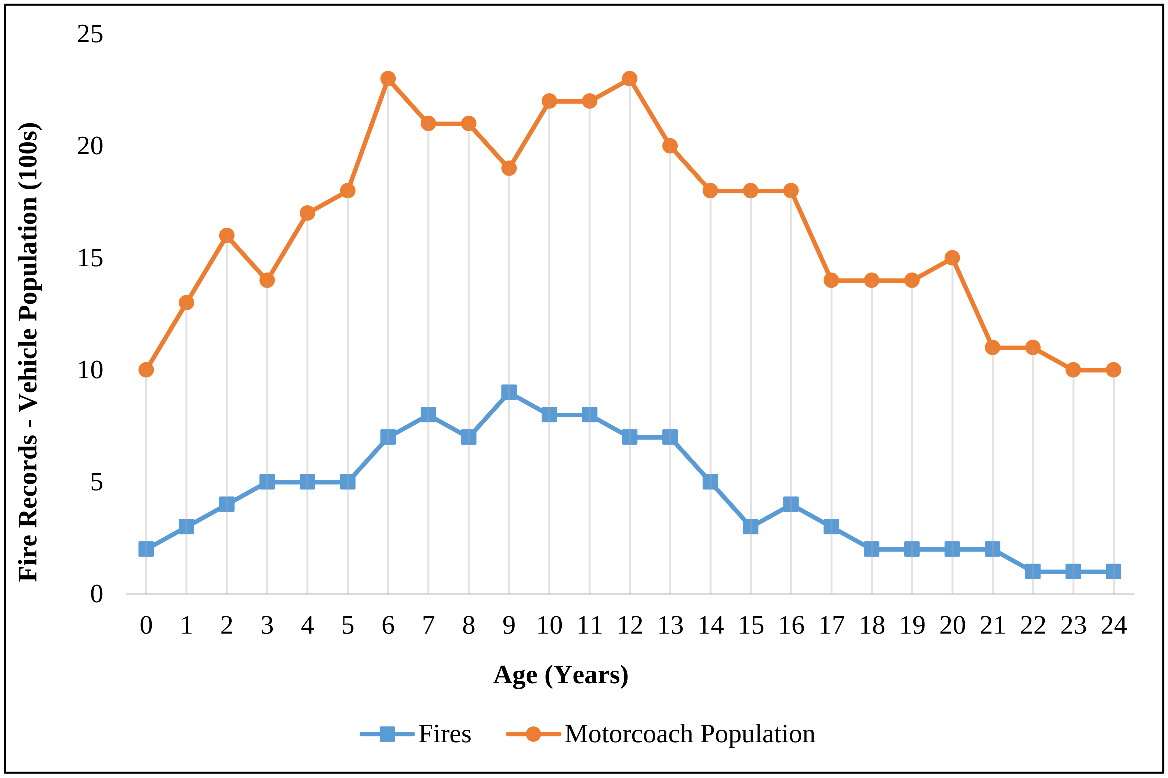

Figure 14. Line graph. Motorcoach fire records and average population, 2004–13, by vehicle age.

Figure 15 shows the frequency of school bus fires by age of vehicle and the extent to which they correspond with the number of school buses on the road. The school bus population stays relatively consistent, peaking at ages 1, 9, 10, and 12. The number of fire records begins to climb at age 4 and is at its highest at age 9. The number of school bus fires and the ratio of school bus fires to vehicle population are highest for school buses between the ages of 4 and 11.

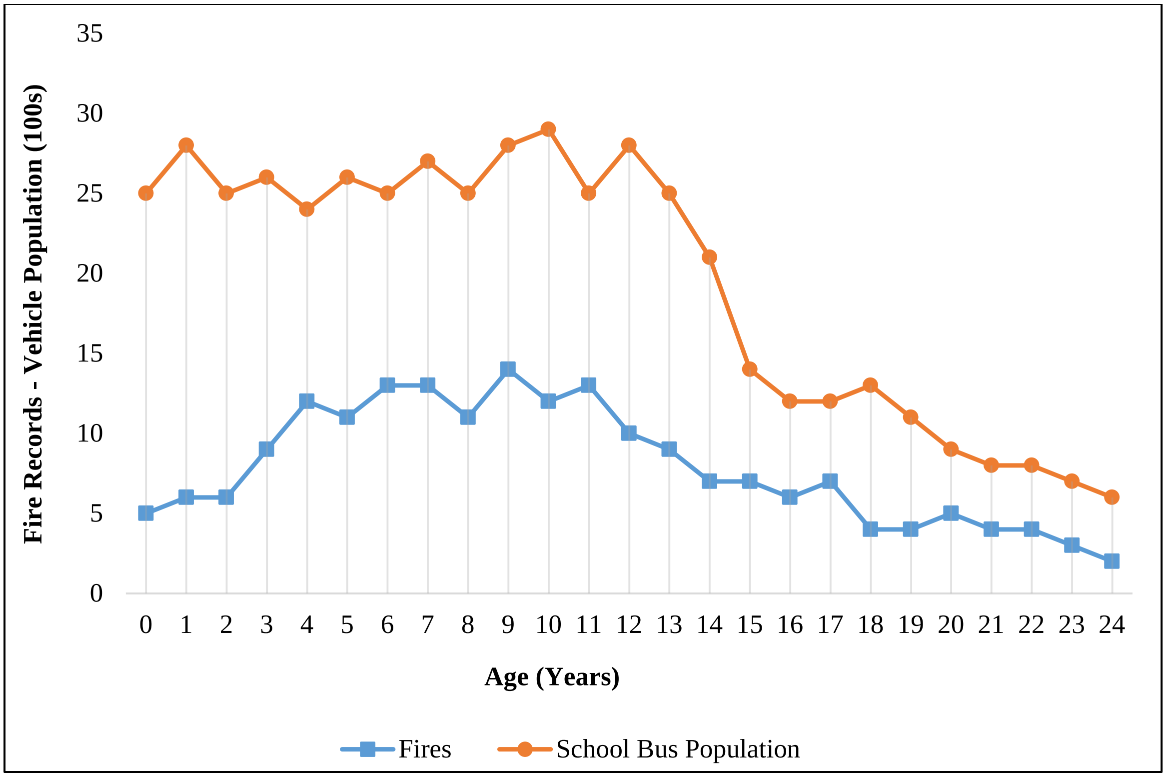

Figure 15. Line graph. School bus fire records and average population, 2004–13, by vehicle age.

3.4.2 Impact of Advanced Technology on New Motorcoaches

New technologies, such as automatic detection and suppression systems, are increasingly penetrating the motorcoach market. As stated in the 2009 study, only buses produced in MY 2004 and later were available for sale equipped with automatic fire warning and suppression systems. These systems included combinations of tire pressure monitoring and engine-compartment fire detection/suppression (but they did not include turbocharger failure detection).

To assess the impact that the increasing popularity of fire suppression systems might have on the school bus and motorcoach population, study analysts looked at fires, motorcoach ages, and populations in 2005, 2009, and 2013. Figure 16 shows that the percent of newer vehicles that caught fire in 2005 is higher than the percent of newer vehicles that caught fire in 2009 or 2013. This could indicate that the greater availability and increasing popularity of technologies such as fire warning and suppression systems is helping prevent fires.

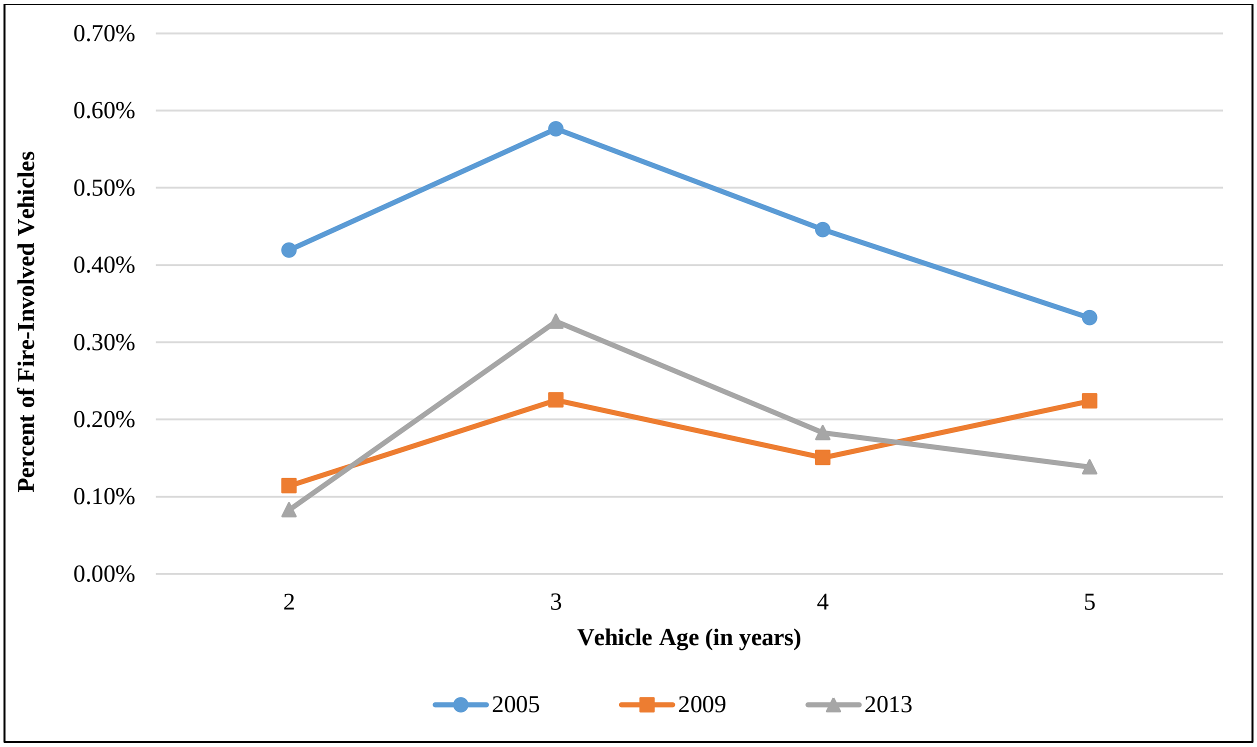

Figure 16. Line graph. Percent of fire-involved vehicles, by vehicle age, in 2005, 2009, and 2013.

3.4.3 Vehicle Make and Model

The vehicle manufacturer could be determined for 3,467 (95 percent) of the motorcoach and school bus records. This was a more complete set of manufacturer data than in the 2009 study, where vehicle manufacturer could be determined for only 80 percent of motorcoach records. Table 9 and Table 10 show the breakdown of fire records between 2004 and 2013 for vehicles made by the top motorcoach and school bus manufacturers. These records were compared to average annual populations of vehicles from major manufacturers (calculated from registration data from R.L. Polk), in order to measure fire likelihood based on manufacturer. Table 78 and Table 79 in Appendix CC provide a breakdown of fire records for the same manufacturers, by year.[(xxii)]

Table 9. Motorcoach fire records, 2004–13, by major manufacturer.

Vehicle Manufacturer	Total Fire Count 2004–13	Average Population	Percent of Vehicles Involved in Fire
MCI	556	25,096	2.2%
Van Hool	194	5,503	3.5%
Prevost	154	9,150	1.6%
Neoplan	47	3,150	1.6%

[xxii] Fire records for the two insurance companies show similar relative statistics. MCI motorcoaches have the highest number of incidents yet the lowest percentage relative to population. See Appendix J, Table 22 for details.

Table 10. School bus fire records, 2004–13, by major manufacturer.

Vehicle Manufacturer	Total Fire Count 2004–13	Average Annual Population	Percent of Vehicles Involved in Fire
International	687	259,085	0.3%
Blue Bird	569	79,221	0.7%
Thomas	357	33,292	1.1%
GM	291	48,668	0.6%
Freightliner	168	78,805	0.2%
Ford	92	26,948	0.3%

Information on fire-related recalls for major manufacturers was available via NHTSA's recall database. Appendix P lists recall data for Blue Bird (46,966 vehicles affected), MCI (8,702 vehicles affected), Prevost (583 vehicles affected), Thomas (124,238 vehicles affected), and Van Hool (3,488 vehicles affected).

The vehicle model could be determined for 1,527 (42 percent) of the motorcoach and school bus records. This was a less complete set of model data than in the 2009 study, where vehicle model could be determined for 67 percent of motorcoach records. Table 11and Table 12 show the total number fire records between 2004 and 2013 for each of the most popular motorcoach and school bus models. Table 80 and Table 81 in Appendix CC break those totals down by year.

Table 11. Motorcoach fire records, 2004–13, by selected model.

Make	Model	Total Fires
Van Hool	T2100	61
Van Hool	C2045	42
MCI	102dl3	36
Neoplan	Advanced	30
Van Hool	T800	25
MCI	D4500	17
Prevost	Le Mirage	17
MCI	J4500	15
Van Hool	T2145	12
MCI	102c3	11
MCI	G4500	10
Prevost	H3-45	10

Table 12. School bus fire records, 2004–13, by selected model.

Make	Model	Total Fires
International	3000	350
Freightliner	Chassis	151
GM	S6000	99
International	3800	85
GM	C6000	51
International	S-Series	27
GM	B-Series	26
Blue Bird	All American	24
Thomas	Saf-T-Liner	23
International	S Series	11
Blue Bird	Vision	9
GM	B7t042	9

3.4.4 Engine Make and Model

There are three major manufacturers of motorcoach engines: Detroit Diesel, Cummins, and Caterpillar. Table 13 shows the number of involved motorcoaches, with selected engine makes and models. Fire record counts for each engine make and model are similar to those determined in the 2009 study. The majority of school bus engines are manufactured by International, Cummins, Caterpillar, Detroit Diesel, Ford, General Motors, and Mercedes-Benz. Table 14 shows the number of involved school buses, with selected engine makes and models. As is the case with vehicle make and model, since most motorcoach and school bus engines are manufactured by a limited number of companies, a mechanical or electrical issue in one engine make or model is likely to affect a large number of vehicles. A comprehensive list of fire records by engine make and model can be found in Appendix DD.

Table 13. Motorcoach fire records, 2004–13, by selected engine make and model.

Engine Make	Engine Model	Fire Records
Caterpillar	3176	10
Caterpillar	C12	3
Caterpillar	C13	5
Caterpillar	C7	1
Caterpillar	C9	4
Cummins	6B SERIES	1
Cummins	6C SERIES	1
Cummins	C8.3	2
Cummins	ISC	4
Cummins	ISL	3
Cummins	ISM	11
Cummins	L10	29
Cummins	M11	46
Detroit Diesel	Jun-71	2
Detroit Diesel	6V92	42
Detroit Diesel	8.2L	5
Detroit Diesel	8V71	9
Detroit Diesel	8V92	15
Detroit Diesel	SERIES 40	1
Detroit Diesel	SERIES 50	5
Detroit Diesel	SERIES 60	388
Unknown	Unknown	30

Table 14. School bus fire records, 2004–13, by selected engine make and model.

Engine Make	Engine Model	Fire Records
Caterpillar	3116	16
Caterpillar	3126	48
Caterpillar	3126B	38
Caterpillar	C7	89
Cummins	6B SERIES	194
Cummins	6C SERIES	57
Cummins	ISB	52
Cummins	ISC	25
Detroit Diesel	8.2L	27
Ford	6.1L	24
Ford	6.6L	10
Ford	7.0L	5
General Motors	5.7L	25
General Motors	6.0L	89
General Motors	8.1L	5
International	6.9L	6
International	7.3L	17
International	9.0L	8
International	DT360	10
International	DT408	5
International	DT466	155
International	DTA360	18
International	T444E	217
International	VT365	24
Mercedes-Benz	MBE904	13
Mercedes-Benz	MBE906	59

3.4.5 Key Findings for Involved Vehicle Characteristics

About 50 percent of the motorcoach fire incident records involve vehicles of MYs 1998–2003. These motorcoaches not only had a higher reported frequency of fire occurrences but also a substantially higher reported incident rate relative to their population. School bus fire records by MY were more evenly distributed than motorcoach fire records, but also had a period of higher frequency for MYs 1996–2001. An analysis of vehicle age showed that the percent of newer vehicles that caught fire in 2005 was higher than the percent of newer vehicles that caught fire in 2009 or 2013, indicating that implementation of advanced technologies such as fire suppression systems may have a positive effect on fire prevention and mitigation for reportable fires. There are a small number of major manufacturers for motorcoaches, school buses, and motorcoach and school bus engines. As a result, a problem, deficiency, or improvement made by one motorcoach, school bus, or engine manufacturer can have a significant impact on a large number of vehicles.

3.5 COMPLIANCE DATA INDICATORS

This analysis seeks to identify indicators that reflect the likelihood that a motorcoach carrier or vehicle has been or will become fire involved. If these indicators can be shown to correlate with historical data, they can be useful in targeting carriers in order to prevent or mitigate future fires. The relationship between reported motorcoach fire incidents and roadside inspections and the resulting OOS violations, carrier safety ratings, and carrier Vehicle Maintenance BASIC percentiles were examined. Due to the limited Federal regulatory authority over school bus operations, Federal compliance data for school buses were not sufficient to be included in this analysis.

3.5.1 Roadside Inspections—Out-of-Service Violations

This study examined whether there was a correlation between motorcoach fires and the general condition of the vehicle, as determined by roadside inspections. Between 2004 and 2013, reported fires occurred in 876 motorcoaches that were identified as having had a roadside inspection between 2003 and 2013, as illustrated in Appendix EE. An important measure of the safety condition of a vehicle is its OOS rate. Vehicle OOS rate is defined as the percentage of vehicle inspections that resulted in the issuance of a vehicle OOS order.

Figure 17 illustrates the values and trends of vehicle OOS rates for involved buses, all buses, and all CMVs from 2003 to 2013. Figure 17 shows generally higher OOS rates for motorcoaches involved in a fire subsequent to an inspection compared with OOS rates for all buses inspected. This may be indicative of the relationship between the general state of repair and maintenance of motorcoaches, as identified by critical vehicle inspection criteria, and their later fire involvement. From 2005 to 2009, the OOS rate for fire-involved motorcoaches increased from the level of all buses to the level of all CMVs. Therefore, the OOS rate during those years became a more reliable indicator of fire risk. This upward trend has not continued since 2009, but the OOS rate for fire-involved motorcoaches has stayed above the OOS rate for all buses. This implies that vehicle OOS rate is not a reliable indicator of motorcoach fire risk at this time. Analysis of more current and future data is required to show that the risk of fire involvement for motorcoaches with higher OOS rates is greater than that for those with lower OOS rates.

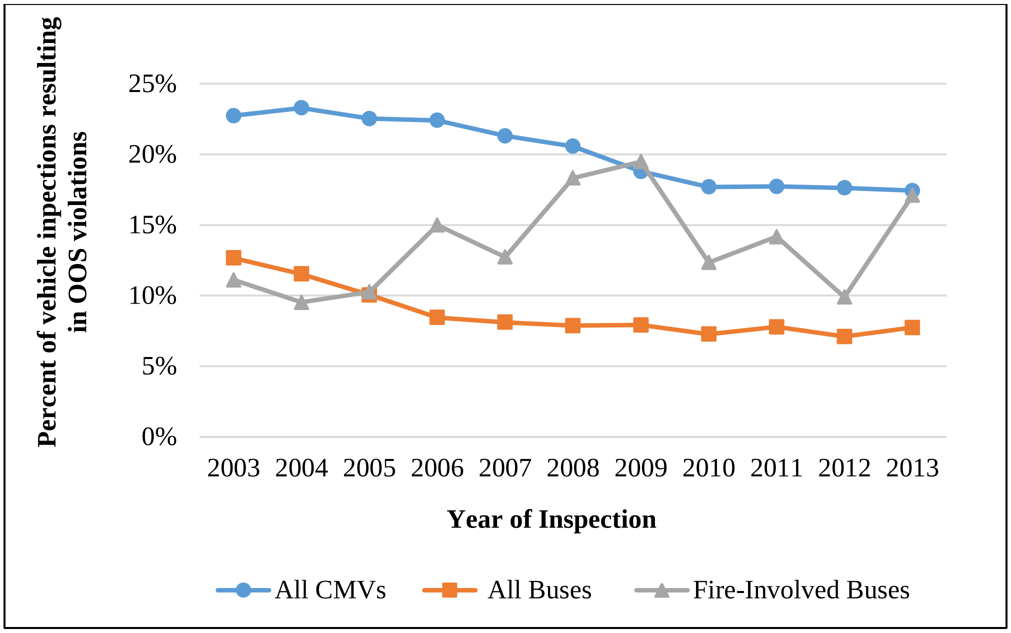

Figure 17. Line graph. Roadside inspection OOS rates for motorcoaches, all buses, and all CMVs, 2003–13.

3.5.2 Carrier Safety Ratings

Table 15 shows the ratings given to 363 motorcoach carriers during 844 compliance reviews (or other types of investigations) conducted between 2004 and 2013. The vast majority of safety ratings in all categories were satisfactory for motorcoach carriers that had experienced or were about to experience fires. Relatively few less-than-satisfactory (conditional or unsatisfactory) ratings were given in any category, but there were sizeable proportions of less-than-satisfactory ratings in the two categories representing major causal factors for motorcoach fires, namely Factor 3, Operational (12 percent), and Factor 4, Vehicle (17 percent).

The 2009 study concluded that carriers involved in fires have no higher rates of operational or vehicle-related compliance problems than do those without fire involvement. However, the 2009 data set included all passenger carriers. The current data set is more focused, including only motorcoach carriers, and thus provides a more targeted analysis. Table 15 shows that the percentages of motorcoach carriers that had been rated less than satisfactory and had experienced or were about to experience a fire incident are higher than the percentages of all motorcoach carriers that were rated less than satisfactory. Therefore, motorcoach carriers involved in fires actually have a higher rate of operational or vehicle-related compliance problems than those without fire involvement, indicating that a less-than-satisfactory rating could be an indicator for fire risk.

Table 15. Safety ratings for motorcoach carriers, 2004–13.

Safety Rating Level	Motorcoach Carriers with Fire Incident Factor 3 Rating: Operational (Number)	Motorcoach Carriers with Fire Incident Factor 3 Rating: Operational (Percent)	Motorcoach Carriers with Fire Incident Factor 4 Rating: Vehicle (Number)	Motorcoach Carriers with Fire Incident Factor 4 Rating: Vehicle (Percent)	All Motorcoach Carriers Factor 3 Rating: Operational (Number)	All Motorcoach Carriers Factor 3 Rating: Operational (Percent)	All Motorcoach Carriers Factor 4 Rating: Vehicle (Number)	All Motorcoach Carriers Factor 4 Rating: Vehicle (Percent)
Satisfactory	**635**	88%	**595**	83%	**4,561**	91%	**4,410**	88%
Conditional	**3**	0%	**112**	16%	**15**	0%	**556**	11%
Unsatisfactory	**80**	11%	**11**	2%	**451**	9%	**61**	1%
Total with rating	**718**	100%	**718**	100%	**5,027**	100%	**5,028**	100%
Rated less than satisfactory	**83**	12%	**123**	17%	**446**	9%	**617**	12%
No rating	**126**	15%	**126**	15%	**1,604**	24%	**1,604**	24%
Total	**844**	-	**844**	-	**6,631**	-	**6,631**	-

Of these investigations, 844 resulted in 1,182 inspection, repair, and maintenance violations. Most were cited for poor recordkeeping rather than for actual inspection, repair, and maintenance problems. Table 16 shows that 447 (38 percent) of these violations (denoted with an asterisk) were cited for problems not having to do primarily with poor recordkeeping. Five of these violations (1.1 percent) were acute: four were for failing to correct OOS defects reported on a DVIR, and one was for failing to repair parts not meeting inspection standards. There were 58 (13 percent) non-recordkeeping critical violations: 39 for failing to require the driver to prepare a vehicle inspection report, and 19 for using a CMV not periodically inspected. These percentages were similar to those found in the 2009 study.

Table 16. Inspection, repair, and maintenance violation counts for 363 fire-involved motorcoach carriers, 2004–13.

Section Description	Violations: Total	Violations: Acute	Violations: Critical
Failing to keep inspection form for 12 months	121	0	0
Failing to require driver to prepare vehicle inspection report*	117	0	39
Failing to certify that repairs were made or were not necessary*	110	0	0
Failing to keep a maintenance record identifying the vehicle	98	0	0
Failing to ensure inspection report is complete and accurate	87	0	0
Failing to have a means of indicating maintenance due dates	80	0	0
Failing to keep a record of tests conducted on pushout windows	77	0	0
Failing to inspect pushout windows every 90 days*	69	0	0
Failing to retain vehicle inspection report for at least 3 months	60	0	0
Using a CMV not periodically inspected*	59	0	19
Failing to keep a record of inspections and repairs	52	0	0
Failing to maintain evidence of inspector's qualifications	41	0	0
Failing to require driver to sign vehicle inspection report	40	0	0
Failing to correct out-of-service defects reported on DVIR*	33	4	0
Failing to retain evidence of brake inspector's qualifications	23	0	0
Failing to retain periodic inspection report for 14 months	18	0	0
Failing to keep minimum records of inspection and maintenance	18	0	6
Failing to inspect and maintain vehicle for safe operation*	16	0	0
Failing to prepare inspection report in correct form & manner	11	0	0
Failure to correct defects noted on inspection*	11	0	0
Operating a CMV without periodic inspection*	8	0	0
Failing to retain inspection/maintenance records for 1 year	8	0	0
Operating vehicle likely to cause accident or breakdown*	6	0	0
Failing to ensure each brake inspector is qualified*	5	0	0
Using an inspector who is not qualified*	3	0	0
Brake inspector does not meet minimum qualifications*	3	0	0
Failing to ensure that vehicle is properly lubricated*	2	0	0
Failing to ensure vehicle is free of oil and/or grease leaks*	2	0	0
Operating an out-of-service vehicle*	2	0	0
Driver vehicle inspection report	1	0	0
Failing to repair parts not meeting inspection standards*	1	1	0

*Violations marked with an asterisk were not primarily recordkeeping in nature.

3.5.3 Carrier Vehicle Maintenance Behavior Analysis and Safety Improvement Categories

FMCSA uses BASICs to identify motor carriers with safety performance problems and prioritize them for interventions (e.g., warning letters or investigations). Table 17 looks at motorcoach carriers with and without fire records in 2010–13, and the percent of those carriers that exceeded FMCSA's safety intervention threshold in the Vehicle Maintenance BASIC and were prioritized for an intervention.

Table 17. Vehicle Maintenance BASIC prioritization of motorcoach carriers, 2004–13.

Year	Number of Prioritized Motorcoach Carriers with Fire Incident	All Motorcoach Carriers with Fire Incident	Percent of Motorcoach Carriers with Fire Incident That Were Prioritized	Number of Prioritized Motorcoach Carriers (Overall)	Number of Motorcoach Carriers (Overall)	Percent of Motorcoach Carriers That Were Prioritized (Overall)
2010	27	98	27.6%	194	4276	4.5%
2011	6	55	10.9%	347	4541	7.6%
2012	6	36	16.7%	343	4607	7.4%
2013	8	47	17%	416	4751	8.8%

The percentages of motorcoach carriers that were prioritized for intervention based on vehicle maintenance and repair violations and had experienced or were about to experience a fire incident in the same year are higher than the percentages of all motorcoach carriers that were similarly prioritized for intervention. Therefore, motorcoach carriers involved in fires are more likely to have exceeded the safety intervention threshold in the Vehicle Maintenance BASIC than those without fire involvement.

3.5.4 Key Findings for Compliance Data Indicators

Much like the 2009 study, this analysis showed that vehicle OOS rates for motorcoaches involved in a fire are generally higher than OOS rates for all buses inspected, and this difference is increasing. The OOS rate for fire-involved motorcoaches from 2005 to 2009 increased each year from the level of all buses to the level of all CMVs, indicating that the OOS rate over the long term may prove to be a reliable indicator of fire risk. For carrier safety ratings, motorcoach carriers involved in fires actually have a higher rate of operational or vehicle-related compliance problems than those without fire involvement, indicating that a less-than-satisfactory rating could be an indicator for fire risk. Motorcoach carriers involved in fires are also more likely to have exceeded the safety intervention threshold in the Vehicle Maintenance BASIC than those without fire involvement, suggesting that high percentiles in the Vehicle Maintenance BASIC are associated with high fire involvement.

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4. RECOMMENDATIONS

Recommendations from this study expand on those stated in the 2009 study. Analysis of the literature and data on motorcoach and school bus fire risk suggests that FMCSA, other agencies, and the passenger-carrier industry enhance data quality and reporting, operational training and outreach, vehicle design and equipment development, and vehicle inspection and maintenance standards. At the level of data collection, standardization and collaboration with other data source organizations will be integral to developing and maintaining a robust data set of motorcoach fire incidents. Analysis of the data further suggests that current vehicle inspection standards and maintenance and investigation practices could be strengthened to provide greater focus on issues related to fire safety. While significant progress has been made in recent years, roadside inspection criteria may be further revised to include more fire precursors.

Research in the field should continue efforts to identify critical inspection items associated with fire risk. Recommended areas of exploration include the use of vehicle OOS rates as an indicator for focused fire safety investigations, the development of wheel-well fire detection/suppression systems, and methods to enhance fire-response equipment, fire safety procedures, and training requirements.

4.1 DATA QUALITY AND REPORTING

The difficulties in compiling and analyzing the data for this study, as in the 2009 study, were compounded by the quality of the available data from the available data sources for identifying and characterizing motorcoach fires. These included the lack of appropriately distinct data elements, and records that had missing, inaccurately reported, or inconsistent data. These deficiencies apply equally to school bus fire records. In addition, the completeness of the school bus fire data base is further aggravated by the fact that most of their operations are not regulated by FMCSA and therefore are not adequately recorded in MCMIS. Accordingly, the data quality and reporting recommendations[(xxiii)] from the 2009 study under the following categories continue to apply to those of this study:

- Collaboration with data-source organizations to improve their coverage, depth, and quality of reporting of key elements related to motorcoach fire incidents.
- Promotion of adherence to regulatory guidance for reporting motorcoach fires to MCMIS.
- Support of data standardization initiatives for defining common data elements and coding for crash reports.

As stated earlier, NFIRS contributed largely to the primary database, and NFIRS reporting by local fire departments is voluntary. Furthermore, it is important to note that, according to the NFPA, approximately 85 percent of all fire departments within the United States are either all or

[xxiii] See *Motorcoach Fire Safety Analysis*, 2009, pp.55-57.

mostly volunteer; therefore, time and budgetary constraints may be factors when considering the accuracy or completeness of the reporting.

In 2014, the NFPA conducted a workshop to address the quality of fire experience data. As a result, four priority strategies to improve the quality of reporting were identified.[(22)] While the workshop covered all fire events and not specifically vehicle fires, the findings pertain to the issues this study encountered with the data used, reflect recommendations on data from the 2009 study, and continue to provide relevant guidance. The four priority strategies are as follows:

- ***Improve the quality of the input of fire data.*** The amount of usable data in NFIRS and other sources would be greatly enhanced by more consistent reporting, the inclusion of complete VINs, and the identification and inclusion of fields that could identify specific ignition points of vehicle fires. Such quality improvements would aid in the identification of fire trends and patterns.
- ***Identify and address reasons for fires that are underreported and undetermined.*** Increased training and education for those reporting the data could aid in a better quality of reporting, especially if training deficiencies are first identified. Users might also benefit from knowing how reported data is used and the long-term safety implications of complete reporting.
- ***Identify and link all relevant existing data systems.*** Standardization of data filed across reporting agencies could allow the transfer of data more easily, and potentially allow for less competition between collection agencies. NFPA 950 provides a framework to help standardize the sharing of digital data among agencies with the goal of supporting all-hazards response. This type of standard could be applied elsewhere to facilitate the sharing of data.
- ***Develop a strategy for long-term maintenance and future updates for NFIRS.*** The use of a core set of data fields could aid in the collection of benchmarking data for users of the NFIRS database. While a set of core standards would be maintained, the identification and inclusion of new fields of data, especially those that can address technological and design changes, and the process to better share and integrate this data would aid in future identification of fire trends and patterns.

Study analysts also suggest an additional recommendation for enhancing vehicle fire safety research:

- ***Enhance the structure and coding for NFIRS mobile property-related reporting elements.*** NFPA, FHWA, NHTSA, and other stakeholder agencies and associations should collaborate with USFA to enhance NFIRS vehicle-specific fire reporting data elements and field code values.

4.2 OPERATIONAL TRAINING AND OUTREACH

Despite significant technological advances that aim to prevent crashes and fires or mitigate the effects of fires, the human factor in these events remains significant. As mentioned in Section 1, driver training plays an important role in fire safety, whether it is for evacuation procedures or for adequately covering a pre-trip inspection. Likewise, being able to communicate to all stakeholders the importance of the driver role is equally essential.

4.2.1 Training

The role of training in preventing and mitigating fires, which was cited in the 2009 study, cannot be understated. Increased training (and insurance that all training is up to date for motorcoach carriers, school bus operators, school districts, drivers, mechanics, maintenance, and operational personnel) is critical. Drivers cannot react appropriately to a component warning if they are not trained on a vehicle, its equipment, and the proper course of action for a fire-involved situation. Similarly, maintenance personnel cannot address or prevent issues if they are not in possession of the most current training standards. Since crashes do play a role in fires, drivers should also be properly trained in accident avoidance systems such as electronic stability control and antilock braking systems.

Given that mechanical failures were identified as one of the largest contributing factors to fires, training for identification of fire risk and fire precursors, as well as proper maintenance, may be an effective tool in reducing fire risk.

4.2.2 Stakeholder Outreach

While drivers may receive the training they need, it is important that charter companies, school districts, contractors, and the industry in general embrace the importance of fire safety, avoidance, and prevention, and prioritize those over measures such as on-time performance. Drivers need to know that the companies that employ them, and the industry in which they operate, value safety first and foremost. For example, a driver should never have to choose between meeting a schedule and taking the necessary time to address a component warning that may indicate a situation in which a fire is imminent.

4.3 VEHICLE DESIGN AND EQUIPMENT DEVELOPMENT

In recent years, there have been improvements in safety that could lead to fewer fires or mitigate the severity of those that do occur. However, more can be done. Component and design changes for motorcoaches and school buses, including the implementation of advanced technologies, could lead to fewer or less severe fires, thereby diminishing the severity, frequency, and damage of fires.

4.3.1 Design Changes

Consideration should be given to design changes that could further enhance safety or prevent fire or its spread. The majority of fires start in the engine or wheel area. A large number of school bus fires originate in the passenger area. Therefore, design changes that target any of these areas alone would have significant impact on passenger safety. The 2009 study recommended a number of design changes to common ignition points that remain relevant today, including: favoring wide single tires rather than dual tires to prevent friction and heat build-up; heat shielding turbochargers to better guard against engine fires; better protection of wiring from water and wear; and increased use of heat resistance materials in the wheel area. Given the known fire risks associated with diesel particulate filters (DPFs) and high heat generation, the use of adequate heat shielding is particularly important for vehicles that include DPF technologies. Design changes to the DPF itself to further reduce fire risk should be considered.

As alternative fuel vehicles such as compressed natural gas school buses gain acceptance and popularity, the types of fires that can result and the potential design changes within the vehicle that may prevent or mitigate fires resulting from these advances should be addressed. Some of the OOS criteria in Appendix B specifically address vehicles powered by alternative fuels. These changes are new for the 2016 criteria.

4.3.2 Inclusion of Safety Equipment as Standard on Motorcoaches

Industry adoption of fire suppression systems is gaining momentum, but much can still be done. The 2009 study recommended that this type of equipment be evaluated for its effectiveness in reducing and mitigating motorcoach fires.

The current analysis demonstrates an appreciable reduction in fire rates in newer vehicles from 2005 to 2013, likely because fire suppression systems and other anti-fire technologies have become more widely implemented. This equipment should be mandatory on all new motorcoaches and school buses. It is important to note that while these technologies can prevent fires, they can also mitigate fires, thereby lessening the associated severity and damages.

4.3.3 Adoption of Fire Suppression Equipment and Associated Standards

As mentioned in Section 1, Sweden has adopted the P-mark as the baseline standard for testing of fire suppression systems. Adoption of such a standard within the United States would ensure that fire suppression systems are held to consistent standards and would be expected to provide a minimum level of protection for the environment in which they are protecting.

4.3.4 Support of Technologies to Mitigate or Prevent Wheel Area Fires

The need to address wheel area fires, also discussed in the 2009 study, remains significant. The current study notes that while NFIRS data could not specify which fires originated in the wheel area, inferences can be made from the item first ignited (e.g., tire) in a specific area first ignited (e.g., engine area, running gear, or wheel area) that 101 of the motorcoach fires and 66 of the school bus fires originated in the wheel area, thereby supporting the recommendation for technologies that detect and suppress wheel area fires.

While some systems are currently available that can actively detect heat in the wheel area, a low-cost, reliable fire suppression system for this area has yet to be developed. However, as indicated in Section 1, component warning systems such as TPMS and antilock braking systems may be used to identify situations that can lead to a fire. While this is by no means a solution to wheel area fires, mandatory inclusion of these technologies on all vehicles, and the associated training of drivers and maintenance personnel who might use these systems, would be effective in reducing or mitigating fires.

It is important to note that the 2012 update to the Motorcoach Safety Action Plan lists a number of open NTSB recommendations. This plan, which originated in 2009, was undertaken at the direction of then-U.S. Secretary of Transportation Raymond H. LaHood in an effort to combat serious motorcoach fatalities. Various agencies examined all areas of motorcoach safety and identified actions that could address or improve safety. The result was the Motorcoach Safety Action Plan, an aggressive multi-agency approach to undertake the recommended actions.

Of the open NTSB recommendations, four pertain specifically to design changes on motorcoaches that would enhance existing fire safety if addressed, and support the recommendations from this study.[(xxiv)] These include the development of a FMVSS to provide enhanced fire protection in the fuel area; development of an FMVSS to fire-harden exterior fire-prone materials so as to prevent fire spread into the passenger area; the development of detection systems for heat and fire in the wheel area; and the evaluation of the need for an FMVSS requiring fire detection and suppression systems on motorcoaches.

4.4 INSPECTION STANDARDS

This study shows that motorcoach and school bus fire prevention and risk mitigation depend on proper vehicle inspection and maintenance by trained personnel to ensure all parts and systems are in good condition and will operate as expected. It follows that enforcement agents can further mitigate fire risk by using inspection standards and compliance procedures that target known precursors of fire risk. OOS criteria associated with these precursors are listed in Section 1.

Like the 2009 study, the current study found that OOS rates are not necessarily a reliable indicator of motorcoach fire risk. However, carriers with a rating that is less than satisfactory may be at a higher fire risk.

Key recommendations for the identification of critical inspection items from the 2009 study do not vary greatly from what is recommended below, thereby highlighting the need to continually address and define inspection criteria.

4.4.1 Expanded Collaborative Efforts to Identify Critical Inspection Items Associated with Fire Risk

Proper and effective inspections cannot take place without first having the right set of inspection criteria. Some gaps exist between the FMCSRs and NAS inspection criteria with respect to addressing fire safety in common motorcoach fire ignition points. Since States adopt standards based on the FMCSRs and NAS inspection criteria, the following is also applicable to school buses.

Gaps could be filled by specifically targeting vehicle areas and parts that are critical to fire prevention during pre-trip and post-trip inspections (including DVIRs). For those checks that cannot be accomplished daily, periodic inspection requirements could be developed.

For parts of the vehicle not visible to a driver or inspector, it is important that proper and routine maintenance be conducted that meets or exceeds the original equipment manufacturer's

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[xxiv] For example, control panels, video cassette recorders, global positioning systems (GPS) and public address (PA) systems.

specifications. Examples of this type of equipment are items such as unitized wheel hubs, turbochargers, and electrical wiring. In particular, given that electrical fires on school buses were as numerous as mechanical fires, States could look to strengthen their inspection requirements for electrical equipment on school buses.

To further the effort to expand inspection efforts and effectiveness, CVSA may consider expanding the OOS criteria to address the following potential fire precursors:

- Brakes.
- Reduction of the 20 percent threshold.
- Frozen valves.
- Leaking fluid.
- Wheel bearing failures.
- Exhaust systems.
- Melting rubber or melting plastic smell.
- Improper parts.
- Auxiliary power unit exhaust located too close to wiring, fuel system, or combustibles.
- MY 2007 and later diesel particulate malfunctions.
- Tires.
- Tire pressure monitoring device indicating improper tire pressure.
- Wheels and hubs.
- Pending bearing failure indicated by squeaking or grinding bearing sound when rotating.
- Visible lubricant or fluids on hub or wheel assembly.
- Electrical.
- Electrical devices or accessories intermittent or inoperable.
- Development of criteria for the following items:
  - Turbochargers.
  - Unitized wheel hubs.
  - Air conditioners.
  - Automatic fire suppression systems.
  - Component warning lights or systems.
- Verification that NHTSA safety recalls has been performed on each vehicle.

Since the 2009 study, as a result of continuing work by CVSA, updates to OOS criteria for brakes, wheels, exhaust, and fuel systems have been put into place. CVSA continues to look at all vehicle safety issues and is working toward defining new inspection and OOS criteria that may further address gaps in fire safety.

4.4.2 Increased Inspection Frequency

Regardless of the inclusion of new inspection items and OOS criteria, this study has shown that motorcoaches involved in a fire subsequent to an inspection have higher OOS rates than all buses inspected. While the sample of inspected vehicles was relatively small, motorcoach carriers that had exceeded the safety intervention threshold for the Vehicle Maintenance BASIC showed a higher risk of fire involvement.

FMCSA is currently redefining its investigative priorities so that passenger carriers considered to be higher risk are prioritized for investigations. Future data that results from inspections of these at-risk carriers could help to identify critical inspection items in the future that contribute to fire risk.

Increased inspection frequency could also be directed toward areas of greatest need. Data from the analysis may be used to determine which States and regions may have a higher fire risk and therefore be prioritized for increased inspections. Additionally, consideration should be given to what factors are causing the increased fire risk in certain States and regions. While motorcoach conditions vary widely between regions, fire rates in the Eastern and Southern regions have a higher incident of motorcoach fires, while the Western and Eastern regions have high incidents of school bus fires.

4.4.3 Increased Training for Inspectors

Training for the inspection of motorcoaches and school buses, both roadside and onsite, could be enhanced with the use of additional training for inspectors relative to the identification of specific fire risks. Even if the risks do not have corresponding OOS criteria, identification and subsequent attention to the risk by the driver could potentially lead to an increase in fire safety. It is important that the inspectors be trained specifically in the risks associated with passenger carriers, and with the equipment specific or unique to these vehicles, as well.

4.5 SUMMARY

The recommendations described above have been echoed throughout the motor carrier industry and various regulatory agencies. In particular, the USDOT's 2009 Motorcoach Safety Action Plan stated action items to enhance occupant protection in fire-related incidents, calling for the evaluation of the feasibility of more stringent flammability requirements for interior and exterior components and the evaluation of the need for regulations requiring the installation of fire detection and protection systems. The 2009 Motorcoach Safety Action Plan also stated that NHTSA had identified improving motorcoach fire safety requirements as a priority safety area; additionally, it advocated for follow-up research for evaluating the efficacy of fire detection and suppression systems and fire retardant and fire hardening materials.

The analysis and conclusions in this study continue to highlight a significant opportunity to measure and improve the safety of motorcoach and school bus operations throughout the United States. Furthermore, this study honors FMCSA's commitment to follow the NTSB recommendation from the 2005 Wilmer, TX fire investigation to “establish a process to continuously gather and evaluate information on the causes, frequency, and severity of bus and motorcoach fires and conduct ongoing analysis of fire data to measure the effectiveness of the fire prevention and mitigation techniques.” There should be additional follow-up to the four open NTSB recommendations related to passenger-carrier fire safety, as stated in Appendix D. Given these concerns, it is clear that passenger-carrier fire safety is an important subject that warrants continued attention and increasing cooperation.

APPENDIX A—SCHOOL BUS TYPES

TYPE A

The Type A school bus, shown in Figure 18, consists of a bus body constructed upon a cutaway front-section vehicle. Type A school buses fall under one of two classifications: Type A1, with a gross vehicle weight rating (GVWR) of 10,000 pounds or less; or Type A2, with a GVWR of more than 10,000 pounds. Additional details are as follows:

- Entrance: Driver enters from a left-side driver's door. The passenger entrance is on the right side of the vehicle behind the front wheels.
- Capacity: Designed to carry 10 or more passengers, and can typically seat around 16–30 passengers.
- Engine: Located in the front of the vehicle ahead of the windshield.

Figure 18. Photograph. Type A school bus.

TYPE B

The Type B school bus, shown in Figure 19, consists of a bus body constructed and installed on a front-section vehicle chassis, or stripped chassis, with a GVWR of more than 10,000 pounds. Additional details are as follows:

- Entrance: The entrance door is behind the front wheels.
- Capacity: Designed to carry 10 or more passengers, and can typically seat 30 to 36 passengers.
- Engine: Located in the front of the vehicle. Part of the engine is beneath and/or behind the windshield and beside the driver's seat.

Figure 19. Photograph. Type B school bus.

TYPE C

The Type C school bus (shown in Figure 20) consists of a body installed on a flat-back cowl chassis with a GVWR of more than 10,000 pounds. This type can also include a cutaway truck chassis or truck chassis with cab, with or without a left side door, and with a GVWR greater than 21,500 pounds. Additional details are as follows:

- Entrance: The entrance door is behind the front wheels.
- Capacity: Designed to carry 10 or more passengers, and can typically seat 36 to 78 passengers.
- Engine: Located in the front of the vehicle ahead of the windshield.

Figure 20. Photograph. Type C school bus.

TYPE D

Type D school buses (shown in Figure 21) have a body installed on the chassis with a GVWR of more than 10,000 pounds. This type can be up to 45 feet in length. Additional details are as follows:

- Entrance: The entrance door is ahead of the front wheels.
- Capacity: Designed to carry 10 or more passengers, and can typically seat 54 to 90 passengers.
- Engine: May be located behind the windshield beside the driver's seat; behind the rear wheels; or mid-ship between the front and rear axles.

Figure 21. Photograph. Type D school bus.

Note: References 23, 24, 25, 26, 27, and 28 provide source information for this appendix.

APPENDIX B—OUT-OF-SERVICE CRITERIA FOR BUSES AND MOTORCOACHES

Fire Ignition Point	Critical Vehicle Inspection Item	OOS Criteria	Additional Fire Precursors
Brakes	Brake Systems	• Defective brakes – 20 percent rule • Brake smoke or fire • Improper brake adjustments • Air-brake hose or tubing damaged by heat • Low air pressure warning device • Hydraulic brakes leaking or damaged • Rotor has evidence of metal-to-metal contact*	• Defective brakes • Sticking air or control valve causing excessive brake liner to rotor/drum • Wheel bearing failure • Leaking oil onto braking system
Exhaust System	Exhaust System	• Leaking or discharging under chassis* • Improper placement so as to result in acting as a heat source to electrical wiring, fuel source, or other combustible materials	• Melting rubber or melting plastic smell • Improper parts • Auxiliary power unit exhaust located too close to wiring, fuel system, or combustibles • MY 2007 and later diesel particulate malfunctions
Fluid Lines	Fuel System	• Dripping or leaking liquid fuel • Leaking gas for CNG and liquefied natural gas vehicles**	• N/A
Tires	Tires	• Damaged, worn, bulging, leaking • Leak, underinflated, overinflated • Improperly mounted or rubbing against its mate or body of vehicle • Improperly sized • Object lodged between sets of dual tires**	• Tire pressure monitoring device indicating improper tire pressure
Wheels and Hubs	Wheels, Rims, and Hubs	• Bearing cap is missing or broken • Smoke from wheel hub • Leaking from wheel seal • Lubricant leaking from hub • No visible or measurable lubricant in hub	• Pending bearing failure indicated by squeaking or grinding bearing sound when rotating • Visible lubricant or fluids on hub or wheel assembly
Electrical	Buses, Motorcoaches, Passenger Vans or Other Passenger-Carrying Vehicles—Emergency Exits/Electrical Cables and Systems in Engine and Battery Compartments/ Seating	• Chafed, frayed, damaged, burnt cable that is exposed • Missing or damaged protective grommets or mountings • Leaking lubricant	• Electrical devices/ accessories intermittent or inoperable

*Updated as of 2012.

** Updated as of 2016.

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APPENDIX C—NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION VEHICLE SAFETY STANDARDS

NHTSA has a legislative mandate under Title 49 of the United States Code, Part 571, to issue FMVSSs to which manufacturers of motor vehicle and equipment items must conform and certify compliance.

The two FMVSSs that relate most directly to motorcoach and school bus fire safety are:

- **217: Bus Emergency Exits and Window Retention Release:** This standard establishes requirements for the retention of windows in buses, including operating forces, opening dimensions, and markings for push-out bus windows and other emergency exits. Its purpose is to minimize the likelihood of occupants being thrown from the bus and to provide a means of readily accessible emergency egress. This standard also includes requirements that each school bus have an emergency door either at the rear or side of the bus, an interlock system that will prevent the engine from starting if an emergency door is locked, and an audible warning system that will sound an alarm if an emergency door release mechanism is not closed while the engine is running.
- **302: Flammability of Interior Materials:** This standard specifies burn resistance requirements for materials used in the occupant compartments of motor vehicles. Its purpose is to reduce the deaths and injuries to motor vehicle occupants caused by vehicle fires, especially those originating in the interior of the vehicle from sources such as matches or cigarettes.

Fuel system integrity also plays a role in helping reduce or prevent fires that result from fuel spillage. The following FMVSSs relate to fuel system integrity in motorcoaches and school buses:

- **301: Fuel System Integrity:** This standard specifies requirements for the integrity of motor vehicle fuel systems. Its purpose is to reduce deaths and injuries occurring from fires that result from fuel spillage during and after motor vehicle crashes. This standard applies to motorcoaches that have a GVWR of 10,000 pounds or less and to school buses that have a GVWR greater than 10,000 pounds.
- **303: Fuel System Integrity of Compressed Natural Gas Vehicles**: This standard specifies requirements for the integrity of motor vehicle fuel systems using CNG. Its purpose is to reduce deaths and injuries occurring from fires that result from fuel leakage in vehicles using CNG during and after motor vehicle crashes. This standard applies to buses that have a GVWR of 10,000 pounds or less.
- **304: Compressed Natural Gas Fuel Container Integrity:** This standard specifies requirements for the integrity of CNG motor vehicle fuel containers in order to reduce deaths and injuries occurring from fires that result from fuel leakage. This standard specifies that CNG fuel containers are subject to the bonfire test and must be equipped with a pressure relief device in case of exposure to fire.

School Buses

The school bus is the most stringently regulated vehicle on the road. Among the 33 crash-avoidance, crash-survival, and post-crash standards that school buses must meet, several were developed with direct, though not necessarily exclusive, application to school buses. Five FMVSSs were developed specifically for school bus application.

- 131: School Bus Pedestrian Safety Devices.
- 220: School Bus Rollover Protection.
- 221: School Bus Body Joint Strength.
- 222: School Bus Passenger Seating and Crash Protection.
- 301: Fuel System Integrity.

Note: References 29, 30, 31, and 32 provide source information for this appendix.

APPENDIX D—NATIONAL TRANSPORATION SAFETY BOARD RECOMMENDATIONS FOLLOWING THE WILMER, TX FIRE INVESTIGATION

NTSB conducted an investigation into the probable causes surrounding the 2005 Wilmer, TX motorcoach fire in which 23 passengers died, and consequently issued the following five safety recommendations to NHTSA. While recommendations H-07-04 through H-07-07 remain classified open, NHTSA has addressed H-07-08 and requested in August 2015 that the recommendation be classified as “Closed–Acceptable Action.”

- **H-07-04:** Develop a Federal Motor Vehicle Safety Standard to provide enhanced fire protection of the fuel system in areas of motorcoaches and buses where the system may be exposed to the effects of a fire.
- **H-07-05:** Develop a Federal Motor Vehicle Safety Standard to provide fire-hardening of exterior fire-prone materials, such as those in areas around wheel wells, to limit the potential for flame spread into a motorcoach or bus passenger compartment.
- **H-07-06:** Develop detection systems to monitor the temperature of wheel-well compartments in motorcoaches and buses to provide early warning of malfunctions that could lead to fires.
- **H-07-07:** Evaluate the need for a Federal Motor Vehicle Safety Standard that would require installation of fire detection and suppression systems on motorcoaches.
- **H-07-08:** Evaluate current emergency evacuation designs of motorcoaches and buses by conducting simulation studies and evacuation drills that take into account, at a minimum, acceptable egress times for various post-accident environments, including fire and smoke; unavailable exit situations; and the current above-ground height and design of window exits to be used in emergencies by all potential vehicle occupants.

NTSB also issued the following three safety recommendations to FMCSA, all of which have been classified as closed.

- **H-07-01:** Establish a process to continuously gather and evaluate information on the causes, frequency, and severity of bus and motorcoach fires and conduct ongoing analysis of fire data to measure the effectiveness of the fire prevention and mitigation techniques identified and instituted as a result of Volpe fire safety analysis study.
- **H-07-02:** Revise the Federal Motor Carrier Safety Regulations at 49 CFR 393.205 to prohibit a commercial vehicle from operating with wheel seal or other hub lubrication leaks. (Classified as “Closed–Acceptable Alternate Action.”)
- **H-07-03:** To protect the traveling public until completion of the Comprehensive Safety Analysis 2010 Initiative, immediately issue an Interim Rule to include all Federal Motor Carrier Safety Regulations in the current compliance review process so that all violations of regulations are reflected in the calculation of a carrier’s final rating. (Classified as “Closed–Acceptable Alternate Action.”)

NTSB issued the following recommendations to NHTSA as a result of a special investigation concerning tire-related passenger vehicle crashes:

- **H-15-027:** Seek authority to require all tire dealers to register tires at the point of sale, and then require them to do so.
- **H-15-28:** Develop voluntary standards, in consultation with tire industry leaders, for a computerized method of capturing, storing, and uploading tire registration information at the point of sale.
- **H-15-29:** Include fields on the tire registration form for the purchaser's e-mail address, telephone number, and vehicle identification number to assist manufacturers in locating and notifying owners of recalled tires.
- **H-15-30:** Require tire manufacturers to include the complete tire identification number on both the inboard and outboard sidewalls of a tire.
- **H-15-31:** Require tire manufacturers to put the safety recall information for their tires on their websites in a format that is searchable by tire identification number as well as by brand and model; if necessary, seek legislative authority to implement this recommendation.
- **H-15-32:** Modify the tire recall search feature on your website to allow users to search for recalls by tire identification number as well as by brand and model.
- **H-15-33:** Determine the level of crash risk associated with tire aging since the implementation of Federal Motor Vehicle Safety Standard Nos. 138 and 139; if, based on this determination, it appears that the aging-related risk should be mitigated, develop and implement a plan to promote the tire-aging test protocol to reduce the risk.
- **H-15-34:** Develop a consensus document with input from the automotive industry, the tire industry, and safety advocacy groups that addresses tire aging and service life and that also includes best practices for those consumers whose tires are most at risk of experiencing an aging-related failure.
- **H-15-35:** Develop, in consultation with automotive and tire industry representatives, a tire safety action plan to reduce or mitigate tire-related crashes by promoting technological innovation and adapting regulations as necessary.

NTSB issued the following recommendations to NHTSA following investigations into a crash involving a Volvo truck tractor (operated by FedEx Freight, Inc.) and a Setra motorcoach in California that became fire-involved and resulted in 10 fatalities.

- **H-15-12:** Revise Federal Motor Vehicle Safety Standard 302 to adopt the more rigorous performance standards for interior flammability and smoke emissions characteristics already in use throughout the USDOT for commercial aviation and rail passenger transportation.
- **H-15-13:** Require new motorcoach and bus designs to include a secondary door for use as an additional emergency exit.

APPENDIX E—BUS FIRE STUDIES

Motorcoach Fire Safety Final Report

NHTSA (2015)

In July 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) was enacted. MAP-21 instructed NHTSA to research the most prevalent causes of motorcoach fires and methods to prevent them. Southwest Research Institute was contracted to develop test procedures and performance criteria to assess fire detection and suppression for engine compartment fires and fire detection in wheel wells. This research was a follow-on to the NIST research program.

Fire Mitigation Advisory

Bus Industry Confederation (BIC) of Australia (2014)

BIC, in cooperation with the Queensland, New South Wales and Western Australia transportation authorities, developed this advisory to capture actions to reduce the frequency and severity of bus fires in Australia. The study presents key findings and recommendations for bus fire mitigation.

The Yellow School Bus Industry White Paper

National School Transportation Association (NSTA) (2013)

This document provides a comprehensive look at the school bus industry. The NSTA explores the industry’s history of safety innovation and development, examines the characteristics of the vehicle, and reviews ways in which the Federal government regulates school bus safety.

Motorcoach Flammability Project Final Report: Tire Fires – Passenger Compartment Penetration, Tenability, Mitigation, and Material Performance

NHTSA (2011)

The NIST conducted the research outlined in this report to support NHTSA’s effort to improve motorcoach fire safety based on the NTSB recommendations made in 2007.

U.S. Vehicle Fire Trends and Patterns

NFPA Fire Analysis and Research Division (2010)

This study by NFPA’s Marty Ahrens gathered data from the USFA’s NFIRS and the NFPA’s annual fire department experience survey to provide details about the types of vehicles involved in fires and the circumstances of highway vehicle fires.

Compressed Natural Gas Bus Safety: A Quantitative Risk Assessment

Center for Technology Risk Studies, University of Maryland (2005)

Samuel Chamberlain and Mohammad Modarres assessed the fire safety risks associated with CNG vehicle systems, comprising primarily a typical school bus and supporting fuel infrastructure. This study uses the probabilistic risk assessment (PRA) approach to model and predict fire safety risk of CNG buses.

Fire Investigations: Why Motorcoaches May Burn (A Mechanical Analysis)

Americoach Systems (2007)

Christopher W. Ferrone, president of Americoach Systems, Inc., published a paper that includes a mechanical analysis of motorcoach fires and a discussion of preventive measures.

Vehicle Fires Involving Buses and School Buses

NFPA (2006)

NFPA published a study of causes of commercial and school bus fires, based on data collected from the NFIRS database (described in Section 2 of this report). NFPA grouped causal factors into categories defined by NFIRS.

Stop Bus Fires in Their Tracks

BUSRide Magazine and Lancer Insurance (2002)

BUSRide Magazine published an interview with Bob Crescenzo and Randy O'Neill of Lancer Insurance that detailed common origin locations and ignition points of motorcoach fires. Crescenzo delivered the keynote address 10 years later at the 2012 FIVE Bus Fire Conference, where he emphasized that despite technological advancements in bus design and manufacturing, fire risk had not diminished.

Bus Fires in Finland During 2000

Finland Accident Investigation Board (2000)

Finland's Accident Investigation Board published a study of 33 fires involving city, charter, and long-distance buses that occurred in a 1-year period.

Motorcoach Census

ABA (2013)

A study of the size and activity of the motorcoach industry in the United States and Canada in 2013.

Technical Briefing: Bus Fires

CVSA Passenger Carrier Committee (2006)

A CVSA passenger-carrier subcommittee on motorcoach fire-causation issues produced a report on common fire origin locations and ignition points, based on field experience. In 2007, the CVSA Passenger Carrier Committee and Executive Committee approved this report as an addendum to CVSA Passenger Vehicle Inspector course materials.

Bus Fires in Sweden 2005–2013

SP Technical Research Institute of Sweden

The Swedish Civil Contingencies Agency's (MSB) fire database and statistics form the framework for the national statistics of all fires that occurred in Sweden during each year. The database is based on incident reports from the Fire Rescue Services (FRS). Since 2005, bus fires have a separate category in the template for the FRS incident report. The purpose of this survey was to map bus incidents related to fires in commercial traffic between 2005 and 2013. The study includes 1,255 records spread over a 9-year period.

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APPENDIX F—IGNITION SOURCES ON MOTORCOACHES AND BUSES

Location	Ignition Source	Ignition Type	Conditions
Engine compartment	Air-conditioner compressor	Spark	Improperly shielded clutch coil or wires
Engine compartment	Air-conditioner compressor or blower	Heat	Failure
Engine compartment	Alternator	Heat	Diode failure
Engine compartment	Auxiliary generator	Heat	Operating normally; especially hot when dirty
Engine compartment	Auxiliary heater/exhaust	Heat	Operating normally; especially hot when dirty
Engine compartment	Diesel particulate filter	Heat	During regeneration
Engine compartment	Electrical accessories	Heat	Overtaxed electrical system
Engine compartment	Electronic modules, control panels	Heat	Short circuits, faults, improper installation
Engine compartment	Engine block, muffler, turbocharger	Heat	Operating normally; especially hot when dirty
Engine compartment	Exhaust system	Heat	Operating normally; especially hot when dirty
Engine compartment	Wires and cables, especially high-amperage cables (alternator, starter, jumper)	Spark	Short circuit or wire arcing due to insulation breach, improperly routed or supported wires, bad connections, wear
Fuel system	Diesel fuel heater	Spark	Improperly shielded
Bus interior	Electronic equipment[xxv]	Heat	Failures, faults, improper installation
Bus interior	Electric heaters, defrosters, motors	Heat	Malfunctioning or improperly installed
Bus interior	Wires and cables	Heat	Overtaxed electrical system, improper accessory installation
Bus interior	Wires and cables	Spark	Short circuit or wire arcing due to insulation breach, improperly routed or supported wires, bad connections, wear
Bus interior	Electric heaters, defrosters, motors	Spark	Malfunctioning or improperly shielded
Wheel wells	Brakes	Heat	Overused or malfunctioning (seized, frozen, incompletely released, dragging)
Wheel wells	Tires	Heat	When underinflated, especially in dual configuration
Wheel wells	Wheel bearings/hubs	Heat	Malfunctioning due to insufficient lubrication or wear

[xxv] For example, control panels, video control recorders, global positioning systems, and public address systems.

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APPENDIX G—COMBUSTIBLE MATERIAL SOURCES ON MOTORCOACHES AND SCHOOL BUSES

Location	Component	Material	Conditions
Engine compartment	Alternator	Cooling oil	Failing oil-cooled alternator
Engine compartment	Lines running from coolant reservoir to engine, auxiliary heater, generator	Coolant	Leaking hoses, housings, couplings, fittings, filters, sensors
Engine compartment	Lines running from fluid reservoir to power-steering pump	Power-steering fluid	Leaking hoses, housings, couplings, fittings, filters, sensors
Engine compartment	Lines running from fluid reservoir to transmission	Transmission fluid	Leaking hoses, housings, couplings, fittings, filters, sensors
Engine compartment	Lines running from oil reservoir to engine, turbocharger, generator, alternator (if oil-cooled)	Lubricating/ cooling oil	Leaking hoses, housings, couplings, fittings, filters, sensors
Engine compartment	Lines running to engine, auxiliary heater, generator	Diesel fuel	Leaking hoses, housings, couplings, fittings, filters, sensors
Engine compartment	Turbocharger	Lubricating oil	Failing turbocharger
Fuel system	Lines running from fuel tank to engine compartment	Diesel fuel	Leaking hoses, housings, couplings, fittings, filters, sensors
Bus interior	Floors, seats, etc.	Wood, carpeting, upholstery, padding	Combustible when exposed to high heat or flame
Bus interior	Floors, window frames, etc.	Rubber	Combustible when exposed to high heat or flame
Bus interior	Seats, dashboard, panels, etc.	Plastic	Combustible when exposed to high heat or flame
Wheel well	Brake pads and shoes	Laminate and other materials	Brake dragging, wheel bearing failure
Wheel well	Tires	Rubber	Low tire pressure, overheating, flat
Wheel well	Wheel bearings	Lubricating oil or grease	Loss of lubricant, bearing failure

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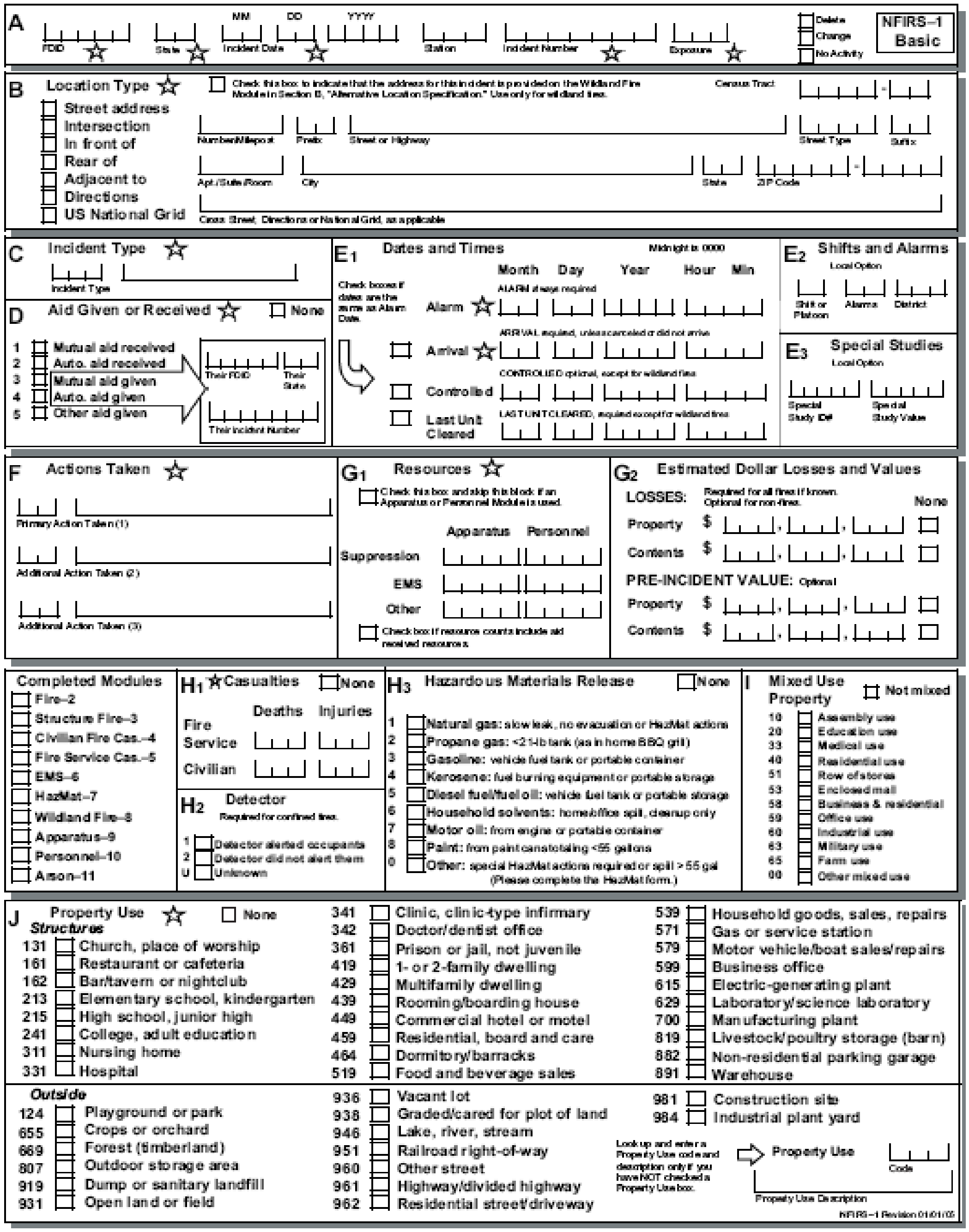
APPENDIX H—NATIONAL FIRE INCIDENT REPORTING SYSTEM DATA COLLECTION SHEETS FOR VEHICLE FIRES



A
FDID ☆ State ☆ MM DD YYYY Incident Date ☆ Station Incident Number ☆ Exposure ☆
Delete / Change / No Activity
NFIRS–1 Basic

B Location Type ☆
Check this box to indicate that the address for this incident is provided on the Wildland Fire Module in Section B, "Alternative Location Specification." Use only for wildland fires.
Census Tract
Street address
Intersection
In front of
Rear of
Adjacent to
Directions
US National Grid
Number/Milepost · Prefix · Street or Highway · Street Type · Suffix
Apt./Suite/Room · City · State · ZIP Code
Cross Street, Directions or National Grid, as applicable

C Incident Type ☆
Incident Type

D Aid Given or Received ☆ None
1 Mutual aid received
2 Auto. aid received
3 Mutual aid given
4 Auto. aid given
5 Other aid given
Their FDID · Their State · Their Incident Number

E1 Dates and Times
Midnight is 0000
Month Day Year Hour Min
Check boxes if dates are the same as Alarm Date.
ALARM always required
Alarm ☆
ARRIVAL required, unless canceled or did not arrive
Arrival ☆
CONTROLLED optional, except for wildland fires
Controlled
LAST UNIT CLEARED, required except for wildland fires
Last Unit Cleared

E2 Shifts and Alarms
Local Option
Shift or Platoon · Alarms · District

E3 Special Studies
Local Option
Special Study ID# · Special Study Value

F Actions Taken ☆
Primary Action Taken (1)
Additional Action Taken (2)
Additional Action Taken (3)

G1 Resources ☆
Check this box and skip this block if an Apparatus or Personnel Module is used.
Apparatus · Personnel
Suppression
EMS
Other
Check box if resource counts include aid received resources.

G2 Estimated Dollar Losses and Values
LOSSES: Required for all fires if known. Optional for non-fires. None
Property $
Contents $
PRE-INCIDENT VALUE: Optional
Property $
Contents $

Completed Modules
Fire–2
Structure Fire–3
Civilian Fire Cas.–4
Fire Service Cas.–5
EMS–6
HazMat–7
Wildland Fire–8
Apparatus–9
Personnel–10
Arson–11

H1 ☆ Casualties None
Deaths · Injuries
Fire Service
Civilian

H2 Detector
Required for confined fires.
1 Detector alerted occupants
2 Detector did not alert them
U Unknown

H3 Hazardous Materials Release None
1 Natural gas: slow leak, no evacuation or HazMat actions
2 Propane gas: <21-lb tank (as in home BBQ grill)
3 Gasoline: vehicle fuel tank or portable container
4 Kerosene: fuel burning equipment or portable storage
5 Diesel fuel/fuel oil: vehicle fuel tank or portable storage
6 Household solvents: home/office spill, cleanup only
7 Motor oil: from engine or portable container
8 Paint: from paint cans totaling <55 gallons
0 Other: special HazMat actions required or spill > 55 gal (Please complete the HazMat form.)

I Mixed Use Property · Not mixed
10 Assembly use
20 Education use
33 Medical use
40 Residential use
51 Row of stores
53 Enclosed mall
58 Business & residential
59 Office use
60 Industrial use
63 Military use
65 Farm use
00 Other mixed use

J Property Use ☆ None
Structures
131 Church, place of worship
161 Restaurant or cafeteria
162 Bar/tavern or nightclub
213 Elementary school, kindergarten
215 High school, junior high
241 College, adult education
311 Nursing home
331 Hospital
341 Clinic, clinic-type infirmary
342 Doctor/dentist office
361 Prison or jail, not juvenile
419 1- or 2-family dwelling
429 Multifamily dwelling
439 Rooming/boarding house
449 Commercial hotel or motel
459 Residential, board and care
464 Dormitory/barracks
519 Food and beverage sales
539 Household goods, sales, repairs
571 Gas or service station
579 Motor vehicle/boat sales/repairs
599 Business office
615 Electric-generating plant
629 Laboratory/science laboratory
700 Manufacturing plant
819 Livestock/poultry storage (barn)
882 Non-residential parking garage
891 Warehouse

Outside
124 Playground or park
655 Crops or orchard
669 Forest (timberland)
807 Outdoor storage area
919 Dump or sanitary landfill
931 Open land or field
936 Vacant lot
938 Graded/cared for plot of land
946 Lake, river, stream
951 Railroad right-of-way
960 Other street
961 Highway/divided highway
962 Residential street/driveway
981 Construction site
984 Industrial plant yard
Look up and enter a Property Use code and description only if you have NOT checked a Property Use box: Property Use
Code
Property Use Description
NFIRS–1 Revision 01/01/05

K1 **Person/Entity Involved**
Local Option

Business Name (if applicable) | Area Code | Phone Number

☐ Check this box if same address as incident Location (Section B). Then skip the three duplicate address lines.

Mr., Ms., Mrs. | First Name | MI | Last Name | Suffix

Number | Prefix | Street or Highway | Street Type | Suffix

Post Office Box | Apt./Suite/Room | City

State | ZIP Code

☐ **More people involved? Check this box and attach Supplemental Forms (NFIRS–1S) as necessary.**

K2 **Owner**
Local Option

☐ Same as person involved? Then check this box and skip the rest of this block.

Business Name (if applicable) | Area Code | Phone Number

☐ Check this box if same address as incident Location (Section B). Then skip the three duplicate address lines.

Mr., Ms., Mrs. | First Name | MI | Last Name | Suffix

Number | Prefix | Street or Highway | Street Type | Suffix

Post Office Box | Apt./Suite/Room | City

State | ZIP Code

L **Remarks:**
Local Option

Fire Module Required?

Check the box that applies and then complete the Fire Module based on Incident Type, as follows:

☐ Buildings 111	Complete Fire & Structure Modules
☐ Special structure 112	Complete Fire Module & Section I, Structure Module
☐ Confined 113–118	Basic Module Only
☐ Mobile property 120–123	Complete Fire & Structure Modules
☐ Vehicle 130–138	Complete Fire Module
☐ Vegetation 140–143	Complete Fire or Wildland Module
☐ Outside rubbish fire 150–155	Basic Module Only
☐ Special outside fire 160	Complete Fire or Wildland Module
☐ Special outside fire 161–163	Complete Fire Module
☐ Crop fire 170–173	Complete Fire or Wildland Module

ITEMS WITH A ☆ MUST ALWAYS BE COMPLETED!

☐ **More remarks? Check this box and attach Supplemental Forms (NFIRS–1S) as necessary.**

M **Authorization**

Officer in charge ID | Signature | Position or rank | Assignment | Month | Day | Year

Check box if same as Officer in charge. ⇨ ☐ Member making report ID | Signature | Position or rank | Assignment | Month | Day | Year

A FDID ☆ | State ☆ | Incident Date (MM DD YYYY) ☆ | Station | Incident Number ☆ | Exposure ☆

☐ Delete
☐ Change

NFIRS–2 Fire

B Property Details

B1 Estimated number of residential living units in building of origin *whether or not all units became involved* ☐ Not Residential

B2 Number of buildings involved ☐ Buildings not involved

B3 Acres burned (outside fires) ☐ None ☐ Less than one acre

C On-Site Materials or Products ☐ None

Complete if there were any significant amounts of commercial, industrial, energy, or agricultural products or materials on the property, *whether or not they became involved*

Enter up to three codes. Check one box for each code entered.

On-site material (1)

On-site material (2)

On-site material (3)

On-Site Materials Storage Use (for each material)

1 ☐ Bulk storage or warehousing
2 ☐ Processing or manufacturing
3 ☐ Packaged goods for sale
4 ☐ Repair or service
U ☐ Undetermined

D Ignition

D1 Area of fire origin ☆

D2 Heat source ☆

D3 Item first ignited ☆ 1 ☐ Check box if fire spread was confined to object of origin.

D4 Type of material first ignited — Required only if item first ignited code is 00 or <70

E1 Cause of Ignition ☆

☐ Check box if this is an exposure report. ⇨ Skip to Section G

1 ☐ Intentional
2 ☐ Unintentional
3 ☐ Failure of equipment or heat source
4 ☐ Act of nature
5 ☐ Cause under investigation
U ☐ Cause undetermined after investigation

E2 Factors Contributing to Ignition ☆ ☐ None

Factor contributing to ignition (1)

Factor contributing to ignition (2)

E3 Human Factors Contributing to Ignition ☆

Check all applicable boxes ☐ None

1 ☐ Asleep
2 ☐ Possibly impaired by alcohol or drugs
3 ☐ Unattended person
4 ☐ Possibly mentally disabled
5 ☐ Physically disabled
6 ☐ Multiple persons involved
7 ☐ Age was a factor

Estimated age of person involved

1 ☐ Male 2 ☐ Female

F1 Equipment Involved in Ignition

☐ None ⇨ If equipment was not involved, skip to Section G

Equipment involved

Brand

Model

Serial #

Year

F2 Equipment Power Source

Equipment Power Source

F3 Equipment Portability

1 ☐ Portable
2 ☐ Stationary

Portable equipment normally can be moved by one or two persons, is designed to be used in multiple locations, and requires no tools to install.

G Fire Suppression Factors ☐ None

Enter up to three codes.

Fire suppression factor (1)

Fire suppression factor (2)

Fire suppression factor (3)

H1 Mobile Property Involved ☐ None

1 ☐ Not involved in ignition, but burned
2 ☐ Involved in ignition, but did not burn
3 ☐ Involved in ignition and burned

H2 Mobile Property Type and Make

Mobile property type

Mobile property make

Mobile property model | Year

License Plate Number | State | VIN

Structure fire? Please be sure to complete the Structure Fire form (NFIRS–3).

Local Use

☐ Pre-Fire Plan Available

Some of the information presented in this report may be based upon reports from other agencies:

☐ Arson report attached
☐ Police report attached
☐ Coroner report attached
☐ Other reports attached

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APPENDIX I—MOTORCOACH AND SCHOOL BUS FIRE FREQUENCY TABLES

Table 18. Frequency of motorcoach fires, 2004–13.

Year	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total
2004	114	187	10	197
2005	146	239	14	253
2006	105	172	14	186
2007	130	213	17	230
2008	118	194	17	211
2009	129	212	7	219
2010	111	182	18	200
2011	118	194	13	207
2012	93	153	9	162
2013	80	131	13	144
Total	**1,144**	**1,877**	**132**	**2,009**
Average	**114.4**	**187.7**	**13.2**	**200.9**

Table 19. Frequency of school bus fires, 2004–13.

Year	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total
2004	189	310	10	320
2005	268	440	12	452
2006	231	379	8	387
2007	257	421	11	432
2008	246	403	14	417
2009	217	356	10	366
2010	222	364	11	375
2011	241	395	10	405
2012	191	313	16	329
2013	182	298	13	311
Total	**2,244**	**3,679**	**115**	**3,794**
Average	**224.4**	**367.9**	**11.5**	**379.4**

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APPENDIX J—INSURANCE CARRIER MOTORCOACH FIRE STATISTICS

Table 20. Motorcoach fires by insurance carrier, by year of fire.

Year of Fire	Insurance 1—Coach Fires	Insurance 2—Coach Fires	Total Insurance Fires
2004	8	16	2028
2005	14	4	18
2006	17	18	35
2007	21	17	38
2008	20	18	38
2009	17	11	28
2010	18	16	34
2011	25	19	44
2012	25	10	35
2013	24	11	35
Total	**189**	**140**	**2333**

Table 21. Motorcoach fires by insurance company and estimated fires per vehicle, by model year range.

Model Year	Insurance 1—Coach Fires	Insurance 2—Coach Fires	Total Insurance Fires	Est. Avg. Population	Fires/ 1,000 Vehicles
1980–84	3	1	4	3,000	1.3
1985–89	9	9	18	5,500	3.3
1990–94	18	10	28	6,800	4.2
1995–99	76	60	136	10,000	13.7
2000–04	62	38	100	9,700	10.3
2005–09	16	19	35	5,300	6.6
2010–14	1	0	1	1,700	0.6
Unknown	4	3	7	500	14.0
All Model Years	**189**	**140**	**329**	**42,500**	**7.8**

Table 22. Motorcoach fires and estimated fires per vehicle, by motorcoach manufacturer.

Make	Insurance 1—Coach Fires	Insurance 2—Coach Fires	Total Insurance Fires	Est. Avg. Population	Fires/ 1,000 Vehicles
MCI	94	63	157	25,000	6.3
Van Hool	49	37	86	5,500	15.6
Prevost	26	34	60	9,000	6.6
Others	20	6	26	4,000	6.5
Total	**189**	**140**	**329**	**43,500**	**7.8**

Table 23. Insurance Carrier 1: Motorcoach fires by area of origin, by year of fire.

Year of Fire	Insurance 1 Coach Fires	Origin Location Code 1 Engine	Origin Location Code 2 Wheel	Origin Location Code 3 Interior	Origin Location Code 4 Fuel	Origin Location Code 5 Unspecified	Origin Location Code 6 Other	Most Frequent Origin Components
2004	8	7	0	1	0	0	0	Turbocharger (4)
2005	14	4	9	0	0	0	1	Wheel bearing, brake, tire (6)
2006	17	6	7	0	1	1	2	Wheel bearing, brake, tire (7)
2007	21	12	9	0	0	0	0	Wheel bearing, brake, tire (7) electrical (6)
2008	20	9	7	1	0	1	2	Wheel bearing, brake, tire (5) electrical (5)
2009	17	6	8	0	1	0	2	Electrical (5)
2010	18	11	5	0	0	0	2	Wheel bearing, brake, tire (5) turbo (3)
2011	25	15	6	2	0	0	2	Electrical (9)
2012	25	15	5	1	0	3	0	Turbo (6)
2013	24	15	6	1	0	3	0	Electrical (6)
Total	**189**	**100**	**62**	**6**	**2**	**8**	**11**	**N/A**

Table 24. Insurance Carrier 1: Motorcoach fires by area of origin, by model year.

Model Year	Insurance 1 Coach Fires	Origin Location Code 1 Engine	Origin Location Code 2 Wheel	Origin Location Code 3 Interior	Origin Location Code 4 Fuel	Origin Location Code 5 Unspecified	Origin Location Code 6 Other	Fires/1,000 Vehicles
1980–84	3	0	2	0	0	0	1	3,000
1985–89	9	5	1	0	0	1	2	5,500
1990–94	18	12	3	1	1	0	1	6,800
1995–99	76	40	27	1	1	2	5	10,000
2000–04	62	34	22	3	0	1	2	9,700
2005–09	16	9	6	1	0	0	0	5,300
2010–14	1	0	1	0	0	0	0	1,700
Unknown	4	0	0	0	0	4	0	500
All Model Years	**189**	**100**	**62**	**6**	**2**	**8**	**11**	**42,500**

Table 25. Insurance Carrier 1: Motorcoach fires, counts of most frequently cited ignition location.

Most Frequently Cited Cause/Components	Number
Electrical, Miscellaneous	31
Turbocharger	22
Tire	20
Wheel bearing	17
Electrical, Short Circuit	16
Brake	14
Fuel line	8
Electrical, Wiring	4
Arson	4

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APPENDIX K—MAPPING BETWEEN MOTORCOACH FIRE KEY ANALYSIS FIELDS AND MMUCC STANDARD DATA ELEMENTS

This appendix shows a preliminary mapping between a number of key analysis fields and data elements defined in the MMUCC standard. This mapping may be useful in expanding and ensuring data quality for future data reporting.

Table 26. Preliminary mapping between motorcoach fire key analysis fields and MMUCC standard data elements.

Key Analysis Field	Closest Matching Existing MMUCC Data Element Identifier–Name	Closest Matching Existing MMUCC Data Element Definition	Proposed New MMUCC Data Element or Additional Attributes and Values for Existing Data Element Name	Proposed New MMUCC Data Element or Additional Attributes and Values for Existing Data Element Definition
Fire date	**C1 Crash Date and Time**	The date (year, month, and day) and time (00:00–23:59) at which the crash occurred	N/A	N/A
State where fire occurred	**C3 Crash County**	The county or equivalent entity in which the crash occurred *(may include full State/county/city General Services Administration [GSA] locator code)*	**Crash State**	The Federal Information Processing Standard (FIPS) identifier or GSA locator code of the State where the incident occurred
Fire origin location	**C6 First Harmful Event**	The first injury or damage-producing event that characterizes the crash type; *attribute for non-collision/fire or explosion*	***Attribute*: Suspected Fire Origin Location**	The area of the vehicle where reporting official estimated that fire originated; values include engine compartment, wheel well
Fire ignition point	**C6 First Harmful Event**	Same as above	***Attribute*: Fire Ignition Point**	The specific vehicle system or component where ignition occurred
Number of direct injuries	**CD5 Number of Non-Fatally Injured Persons**	The total number of persons injured, excluding fatalities within 30 days of the crash	***Attribute* (for non-collision/ fire or explosion): Number of Non-Fatally Injured Directly from the Fire**	Same as CD5, excluding injuries due to response activities

Key Analysis Field	Closest Matching Existing MMUCC Data Element Identifier–Name	Closest Matching Existing MMUCC Data Element Definition	Proposed New MMUCC Data Element or Additional Attributes and Values for Existing Data Element Name	Proposed New MMUCC Data Element or Additional Attributes and Values for Existing Data Element Definition
Number of direct fatalities	**CD6 Number of Fatalities**	The total number of fatalities within 30 days of the crash (motorists and non-motorists) that resulted from injuries sustained as a result of the crash	***Attribute* (for Non-Collision/ Fire or Explosion): Number of Fatally Injured Directly from the Fire**	Same as CD5, excluding fatalities due to response activities
Value of damaged property	**None**	N/A	**Property Damage**	Value of property loss in crash, excluding property outside the vehicle(s) involved
Vehicle model year/age	**V6 Motor Vehicle Model Year**	Year assigned to a motor vehicle by the manufacturer	N/A	N/A
Vehicle Identification Number	**V1 Motor Vehicle Identification Number (VIN)**	A unique combination of alphanumerical or numerical characters assigned to a specific motor vehicle that is designated by the manufacturer	N/A	N/A
Vehicle make/manufacturer	**V5 Motor Vehicle Make**	The distinctive (coded) name applied to a group of motor vehicles by a manufacturer. *Attribute: Name Assigned by Motor Vehicle Manufacturer Using National Crime Information Center (NCIC) Standard*	**V5 Motor Vehicle Make**	Include additional values for bus manufacturers not in NCIC standard
Vehicle model name	**V7 Motor Vehicle Model**	Manufacturer-assigned code denoting a family of motor vehicles (within a make) that have a degree of similarity in construction, such as body, chassis, etc.	N/A	N/A

Key Analysis Field	Closest Matching Existing MMUCC Data Element Identifier–Name	Closest Matching Existing MMUCC Data Element Definition	Proposed New MMUCC Data Element or Additional Attributes and Values for Existing Data Element Name	Proposed New MMUCC Data Element or Additional Attributes and Values for Existing Data Element Definition
Engine manufacturer	**None**	N/A	**Engine Manufacturer**	Name or Data Universal Numbering System (DUNS) code for engine manufacturer
Vehicles with identifiable failure detection and/or fire detection and suppression systems	**None**	N/A	**Equipped with Failure or Fire Detection and Suppression Systems**	*Values: Yes/No*
No. of pre-fire roadside inspection(s) performed on motorcoach(es) in 2003 and later	**N/A**	N/A	N/A	N/A
No. of pre-fire roadside inspections(s) performed on same-carrier motorcoach(es) in 2003 and later	**N/A**	N/A	N/A	N/A
No. of pre-fire compliance review(s) conducted on carrier up to 2 years before fire	**N/A**	N/A	N/A	N/A

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APPENDIX L—STATE DATA SYSTEM INCIDENT COUNTS

Table 27. SDS fire incident counts and comparable counts from primary sources.

State	Year Range Provided	SDS Total Motorcoach and School Bus	SDS Motorcoach	Primary Data Motorcoach	School Bus	Primary Data School Bus	Matched to MCMIS Not Selected for Primary Data	Matched to Primary Data
FL	2004–11	12	3	222	9	238	2	5
IL	2004–11	35	0	66	35	202	4	1
KY	2004–12	5	2	31	3	35	2	0
MI	2004–12	37	1	58	36	183	0	0
MO	2004–13	1	0	25	1	81	1	0
NJ	2004–12	6	2	107	4	84	0	0
NY	2004–12	13	13	131	N/A	181	8	1
OH	2004–12	18	5	85	13	211	5	5
PA	2004–12	11	4	50	7	36	10	1
—	**Total**	**138**	**30**	**775**	**108**	**1,251**	**32**	**13**

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APPENDIX M—VEHICLE AND CRASH DESCRIPTORS USED TO QUERY STATE DATA SYSTEM

Table 28. Vehicle and crash descriptors used to query NHTSA SDS, 2001–06.

State	Date	VIN	Make/Model	Vehicle Descriptors	Crash Descriptors
Arkansas	Yes	No	Yes	Bus, school bus, cross country	Fire/explosion
California	Yes	No	Yes	Bus/van, bus, school bus, private transport, commercial passenger bus	Uses “other” for fire - not clear distinction
Florida	Yes	Yes	Yes	Bus/van, private transport school bus, commercial passenger bus	Fire/explosion
Illinois	Yes	Yes	Yes (2008-2012)	Bus over 15 passengers, school bus, mass transit, other transit	Fire occurred, fire/explosion
Kansas	N/A	N/A	N/A	N/A	Files corrupted
Kentucky	Yes	Yes	Yes	Bus, coach, school bus	Fire/explosion
Michigan	Yes	Yes	Yes	Bus, school bus, CDL truck/bus	Fire/explosion
Missouri	Yes	No	Yes	Bus (driver + seats for over 15), Bus(driver + seats under 15), School bus	Fire
New Jersey	Yes	Yes	Yes	School bus, other bus, vehicle used as a school bus, bus > 9 seats	Fire/explosion
New York	Yes	N/A	Yes	Bus (Omnibus), over-the-road coach	Fire/explosion
Ohio	Yes	No	Yes	School bus, other, bus greater than 15 seats	Fire/explosion
Pennsylvania	Yes	No	Yes	Bus, commercial passenger carrier, cross-country/intercity bus	Fire

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APPENDIX N—MEDIA RECORD DATA

Table 29. Total number of fire incidents and total number of buses involved in fires.

Category	Number	Percent
Total Number of Fire Incidents	**99**	—
• Incidents that noted involved vehicle characteristics	51	52%
• Incidents that involve more than one vehicle	6	6%
• Incidents in which the fire started in the engine	27	27%
• Total number of fatalities	1	—
• Total number of injuries	25	—
Total Number of Buses Involved in Fires	**134**	—
• School buses	90	67%
• Motorcoaches	44	33%
• Buses involved in fires that were not in NFIRS	104	78%
• Buses involved in fires that were in NFIRS	30	22%

RELEVANT CONCLUSIONS:

- Fifty-two percent of records found for bus fires in 2013 mentioned some kind of involved vehicle characteristic, such as school bus type, model year, make, or model.
- Six percent of motorcoach and school bus fire incidents in 2013 involved more than one vehicle. The most vehicles involved in one incident was 22.
- Twenty-seven percent of motorcoach and school bus fire records in 2013 mentioned that the fire began in the engine compartment. Some of these records noted that this was not a definitive conclusion, and that the incident would undergo investigation.
- One person died in 2013 due to a school bus fire. The victim left a camp stove burning in the school bus while he slept, which was likely the source of ignition. There were no fatalities due to motorcoach fires in 2013.
- Twenty-five people were injured in 2013 due to school bus and motorcoach fires, mostly due to smoke inhalation. The most injuries occurred during a school bus fire in Humble, TX. Eighteen students onboard were taken to the hospital for elevated levels of carbon monoxide.
- Thirty-four percent more school buses than motorcoaches caught fire in 2013.
- Seventy-eight percent of the fires found in the media search were not reported in NFIRS.

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APPENDIX O—SCHOOL BUS AND MOTORCOACH POPULATION DATA

Table 30. Derivation of study population counts from R.L. Polk's bus classification scheme.

Year	Original Bus Classifications and Counts from Polk Registration Data Bus type	Original Bus Classifications and Counts from Polk Registration Data Make-Model Counts	Original Bus Classifications and Counts from Polk Registration Data Total Buses	New Bus Classifications and Counts Based on Internet Make-Model Research New Bus Classification	New Bus Classifications and Counts Based on Internet Make-Model Research New Make-Model Counts	New Bus Classifications and Counts Based on Internet Make-Model Research Percent New / Polk Make-Model Counts	New Bus Classifications and Counts Based on Internet Make-Model Research New Total Buses	New Bus Classifications and Counts Based on Internet Make-Model Research Percent New / Polk Total Buses
2005	BUS SCHOOL	155	513,894	OTHER	3	2%	13	0%
2005	BUS SCHOOL	155	513,894	SCHOOL	152	98%	513,881	100%
2005	BUS NON SCHOOL	227	113,966	COACH	39	17%	41,283	36%
2005	BUS NON SCHOOL	227	113,966	OTHER	50	22%	8,012	7%
2005	BUS NON SCHOOL	227	113,966	SCHOOL	55	24%	14,112	12%
2005	BUS NON SCHOOL	227	113,966	TRANSIT	83	37%	50,559	44%
2005	All	382	627,860	Total SCHOOL	207	54%	527,993	84%
2005	All	382	627,860	Total COACH	39	10%	41,266	7%
2009	BUS SCHOOL	166	568,510	OTHER	5	3%	290	0%
2009	BUS SCHOOL	166	568,510	SCHOOL	161	97%	568,220	100%
2009	BUS NON SCHOOL	241	124,104	COACH	47	20%	47,803	39%
2009	BUS NON SCHOOL	241	124,104	OTHER	50	21%	10,893	9%
2009	BUS NON SCHOOL	241	124,104	SCHOOL	58	24%	8,518	7%
2009	BUS NON SCHOOL	241	124,104	TRANSIT	86	36%	5,6890	46%
2009	All	407	692,614	Total SCHOOL	219	54%	576,738	83%
2009	All	407	692,614	Total COACH	47	12%	47,803	7%
2013	BUS SCHOOL	115	514,393	SCHOOL	111	97%	477,122	93%
2013	BUS SCHOOL	115	514,393	TRANSIT	4	3%	37,271	7%

Year	Original Bus Classifications and Counts from Polk Registration Data Bus type	Original Bus Classifications and Counts from Polk Registration Data Make-Model Counts	Original Bus Classifications and Counts from Polk Registration Data Total Buses	New Bus Classifications and Counts Based on Internet Make-Model Research New Bus Classification	New Bus Classifications and Counts Based on Internet Make-Model Research New Make-Model Counts	New Bus Classifications and Counts Based on Internet Make-Model Research Percent New / Polk Make-Model Counts	New Bus Classifications and Counts Based on Internet Make-Model Research New Total Buses	New Bus Classifications and Counts Based on Internet Make-Model Research Percent New / Polk Total Buses
2013	BUS NON SCHOOL	221	114,246	COACH	46	21%	43,268	38%
2013	BUS NON SCHOOL	221	114,246	OTHER	27	12%	9,926	9%
2013	BUS NON SCHOOL	221	114,246	SCHOOL	61	28%	8,664	8%
2013	BUS NON SCHOOL	221	114,246	TRANSIT	87	39%	52,388	46%
2013	All	336	628,639	Total SCHOOL	172	51%	485,786	77%
2013	All	336	628,639	Total COACH	46	14%	43,268	7%

Table 31. Motorcoach population, by manufacturer.

Top Motorcoach Manufacturers	2005 Count	2009 Count	2013 Count	Average Population Count
Motor Coach Industries (MCI)	17,784	20,143	19,468	19,132
Prevost	7,901	9,720	9,830	9,150
Transportation Manufacturing Corporation (TMC)	7,450	6,919	3,525	5,965
Van Hool	4,251	5,849	6,408	5,503
Neoplan	3,833	3,435	2,183	3,150
Evobus	0	1,241	1,452	898
Freightliner	47	399	0	149
Bus & Coach Intl (BCI)	0	76	84	53
Volvo	0	0	318	106
Total	**41,266**	**47,782**	**43,268**	**44,106**

Table 32. School bus population, by manufacturer.

Top School Bus Manufacturers	2005 Count	2009 Count	2013 Count	Average Population Count
International	232,234	194,765	120,683	182,561
Blue Bird	64,116	81,963	91,583	79,221
Freightliner	52,323	80,896	103,196	78,805
IC Corporation	41,688	94,302	93,582	76,524
Ford	37,102	29,857	13,885	26,948
Chevrolet	33,479	29,665	14,046	25,730
Thomas	29,516	35,514	34,845	33,292
GMC	29,002	26,277	13,536	22,938
Genesis Transit Buses	5,661	3,254	1,651	3,522
Spartan Motors	836	705	336	626
Crown Coach	805	875	418	699
Oshkosh Motor Truck Co.	692	495	332	506
Crane Carrier	276	120	69	155
Dodge	179	135	0	105
Gillig	84	106	30	73
Total	**527,993**	**578,929**	**488,192**	**531,705**

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APPENDIX P—FIRE-RISK-RELATED RECALLS

Table 33. Fire-risk-related motorcoach and school bus recalls, 2004–13.

Make	Component Category	Vehicles Affected	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Models Recalled
Blue Bird	Electrical system	29,510	0	0	0	0	7	2	13	6	0	0	28
Blue Bird	Engine and engine cooling	13,975	0	8	4	0	17	0	22	8	0	0	59
Blue Bird	Equipment	2,555	0	0	0	0	0	1	3	1	0	0	5
Blue Bird	Fuel system	757	0	0	0	0	0	0	0	4	6	0	10
Blue Bird	Brakes	156	5	0	0	0	0	0	0	0	0	0	5
Blue Bird	Structure: body	13	0	0	1	0	0	0	0	0	0	0	1
MCI	Engine and engine cooling	4,775	0	0	71	0	0	0	0	2	0	0	73
MCI	Visibility: defroster/ mirror devices	1,768	0	0	31	0	0	0	0	0	0	0	31
MCI	Electrical system	1,119	0	0	0	0	0	14	0	2	0	0	16
MCI	Interior lighting	1,013	0	0	0	0	0	14	0	0	7	0	21
MCI	Equipment	27	0	0	0	0	0	0	0	1	0	0	1
Prevost	Electrical system	428	0	0	0	0	0	0	0	0	3	0	3
Prevost	Equipment	107	0	0	0	0	0	0	0	5	6	0	11
Prevost	Fuel system	48	0	0	0	0	0	0	0	4	0	0	4
Thomas	Electrical system	56,104	0	0	9	2	40	0	18	3	0	0	72
Thomas	Fuel system	31,842	0	0	0	3	0	6	0	0	0	0	9
Thomas	Engine and engine cooling	26,257	0	4	0	0	0	7	8	33	3	0	55
Thomas	Equipment	6,895	0	0	0	0	0	0	0	48	0	0	48
Thomas	Suspension	3,140	0	0	1	0	1	0	0	0	0	0	2
Van Hool	Visibility: defroster/ mirror devices	1,673	0	0	0	0	0	0	0	38	0	0	38
Van Hool	Engine and engine cooling	1,596	0	0	15	0	3	4	0	0	6	0	28
Van Hool	Fuel system	203	0	0	0	0	0	0	0	0	6	0	6
Van Hool	Interior lighting	16	0	0	0	0	0	2	0	0	0	0	2

Table 34. Motorcoach and school bus recalls, by manufacturer.

Make	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Models Recalled	Vehicles Affected
Blue Bird	5	8	5	0	24	3	38	19	6	0	108	46966
MCI	0	0	102	0	0	28	0	5	7	0	142	8702
Prevost	0	0	0	0	0	0	0	9	9	0	18	583
Thomas	0	4	10	5	41	13	26	84	3	0	186	124238
Van Hool	0	0	15	0	3	6	0	38	12	0	74	3285

APPENDIX Q—ALARM TIME

It is important to note that "Alarm Time" is when the incident was first reported, not necessarily when it began. Bus barn fires may have taken longer to report, as people were not immediately aware of or affected by the fire.

Table 35. Motorcoach fires, 2004–13, by alarm time and selected cause of ignition.

Alarm Time	Mechanical or Electrical Failure Number (Percent)	Operational Deficiency Number (Percent)	Intentional Number (Percent)
12–12:59 a.m.	**20** (1%)	**0** (0%)	**4** (4%)
1–1:59 a.m.	**14** (1%)	**1** (1%)	**2** (2%)
2–2:59 a.m.	**13** (1%)	**1** (1%)	**6** (6%)
3–3:59 a.m.	**9** (1%)	**1** (1%)	**3** (3%)
4–4:59 a.m.	**30** (2%)	**0** (0%)	**2** (2%)
5–5:59 a.m.	**17** (1%)	**0** (0%)	**5** (5%)
6–6:59 a.m.	**58** (4%)	**5** (6%)	**5** (5%)
7–7:59 a.m.	**115** (8%)	**12** (15%)	**3** (3%)
8–8:59 a.m.	**119** (8%)	**5** (6%)	**5** (5%)
9–9:59 a.m.	**76** (5%)	**6** (8%)	**2** (2%)
10–10:59 a.m.	**55** (4%)	**1** (1%)	**4** (4%)
11–11:59 a.m.	**64** (5%)	**2** (3%)	**6** (6%)
12–12:59 p.m.	**61** (4%)	**2** (3%)	**4** (4%)
1–1:59 p.m.	**76** (5%)	**5** (6%)	**3** (3%)
2–2:59 p.m.	**110** (8%)	**4** (5%)	**1** (1%)
3–3:59 p.m.	**133** (9%)	**10** (13%)	**13** (13%)
4–4:59 p.m.	**127** (9%)	**9** (11%)	**7** (7%)
5–5:59 p.m.	**62** (4%)	**0** (0%)	**0** (0%)
6–6:59 p.m.	**58** (4%)	**3** (4%)	**7** (7%)
7–7:59 p.m.	**50** (4%)	**4** (5%)	**4** (4%)
8–8:59 p.m.	**41** (3%)	**3** (4%)	**4** (4%)
9–9:59 p.m.	**38** (3%)	**3** (4%)	**2** (2%)
10–10:59 p.m.	**31** (2%)	**1** (1%)	**7** (7%)
11–11:59 p.m.	**35** (2%)	**1** (1%)	**1** (1%)
Total	**1416 (100%)**	**79 (100%)**	**100 (100%)**

Table 36. School bus fires, 2004–13, by alarm time and selected cause of ignition.

Alarm Time	Mechanical or Electrical Failure Number (Percent)	Operational Deficiency Number (Percent)	Intentional Number (Percent)
12–12:59 a.m.	**14** (2%)	**0** (0%)	**4** (4%)
1–1:59 a.m.	**10** (1%)	**1** (2%)	**2** (2%)
2–2:59 a.m.	**6** (1%)	**0** (0%)	**5** (5%)
3–3:59 a.m.	**1** (0%)	**0** (0%)	**2** (2%)
4–4:59 a.m.	**15** (2%)	**0** (0%)	**2** (2%)
5–5:59 a.m.	**11** (1%)	**0** (0%)	**4** (4%)
6–6:59 a.m.	**42** (5%)	**3** (7%)	**5** (5%)
7–7:59 a.m.	**85** (9%)	**8** (17%)	**3** (3%)
8–8:59 a.m.	**83** (9%)	**4** (9%)	**5** (5%)
9–9:59 a.m.	**42** (5%)	**3** (7%)	**1** (1%)
10–10:59 a.m.	**32** (4%)	**1** (2%)	**4** (4%)
11–11:59 a.m.	**39** (4%)	**1** (2%)	**6** (6%)
12–12:59 p.m.	**37** (4%)	**2** (4%)	**4** (4%)
1–1:59 p.m.	**53** (6%)	**3** (7%)	**3** (3%)
2–2:59 p.m.	**75** (8%)	**3** (7%)	**1** (1%)
3–3:59 p.m.	**101** (11%)	**5** (11%)	**13** (14%)
4–4:59 p.m.	**90** (10%)	**3** (7%)	**7** (7%)
5–5:59 p.m.	**32** (4%)	**0** (0%)	**0** (0%)
6–6:59 p.m.	**28** (3%)	**1** (2%)	**7** (7%)
7–7:59 p.m.	**28** (3%)	**2** (4%)	**4** (4%)
8–8:59 p.m.	**23** (3%)	**3** (7%)	**3** (3%)
9–9:59 p.m.	**18** (2%)	**2** (4%)	**2** (2%)
10–10:59 p.m.	**15** (2%)	**0** (0%)	**6** (6%)
11–11:59 p.m.	**16** (2%)	**1** (2%)	**1** (1%)
Total	**899 (100%)**	**46 (100%)**	**94 (100%)**

APPENDIX R—FATALITIES AND INJURIES

Table 37. Motorcoach fatal fires and total fatalities, 2004–13.

Year	NFIRS Fatal Fires	NFIRS Fatal Fires-Expanded	NFIRS Fatalities	NFIRS Fatalities-Expanded	MCMIS Fatal Fires	MCMIS Fatalities	Total NFIRS Fatal Fires Expanded plus MCMIS Fatal Fires	Total NFIRS Fatalities Expanded plus MCMIS Fatalities
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	1	23	1	23
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	1	1	1	1
2008	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0
2011	0	0	0	0	1	1	1	1
2012	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**3**	**25**	**3**	**25**
Average	**0**	**0**	**0**	**0**	**0.3**	**2.5**	**0.3**	**2.5**

Table 38. School bus fatal fires and total fatalities, 2004–13.

Year	NFIRS Fatal Fires	NFIRS Fatal Fires-Expanded	NFIRS Fatalities	NFIRS Fatalities-Expanded	MCMIS Fatal Fires	MCMIS Fatalities	Total NFIRS Fatal Fires Expanded plus MCMIS Fatal Fires	Total NFIRS Fatalities Expanded plus MCMIS Fatalities
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	2	5	2	5
2006	0	0	0	0	1	1	1	1
2007	0	0	0	0	0	0	0	0
2008	0	0	0	0	1	1	1	1
2009	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0
2011	0	0	0	0	1	2	1	2
2012	0	0	0	0	1	1	1	1
2013	1	2	1	2	0	0	2	2
Total	**1**	**2**	**1**	**2**	**6**	**10**	**8**	**12**
Average	**0.1**	**0.2**	**0.1**	**0.2**	**0.6**	**1**	**0.8**	**1.2**

Table 39. Motorcoach injury fires and total injuries, 2004–13.

Year	NFIRS Injuries Fires	NFIRS Injuries Fires-Expanded	NFIRS Injuries	NFIRS Injuries-Expanded	MCMIS Injuries Fires	MCMIS Injuries	Total NFIRS Injuries Fires Expanded plus MCMIS Injuries Fires	Total NFIRS Injuries Expanded plus MCMIS Injuries
2004	3	5	5	8	2	16	7	24
2005	4	7	4	7	3	19	10	26
2006	4	7	7	11	1	1	8	12
2007	0	0	0	0	1	1	1	1
2008	0	0	0	0	2	55	2	55
2009	0	0	0	0	2	6	2	6
2010	0	0	0	0	1	7	1	7
2011	2	3	2	3	1	42	4	45
2012	1	2	2	3	1	2	3	5
2013	1	2	1	2	2	3	4	5
Total	**15**	**26**	**21**	**34**	**16**	**152**	**42**	**186**
Average	**1.5**	**2.6**	**2.1**	**3.4**	**1.6**	**15.2**	**4.2**	**18.6**

Table 40. School bus injury fires and total injuries, 2004–13.

Year	NFIRS Injury Fires	NFIRS Injuries Fires-Expanded	NFIRS Injuries	NFIRS Injuries-Expanded	MCMIS Injury Fires	MCMIS Injuries	Total NFIRS Injury Fires Expanded plus MCMIS Injuries Fires	Total NFIRS Injuries Expanded plus MCMIS Injuries
2004	2	3	3	5	0	0	3	5
2005	2	3	2	3	7	13	10	16
2006	2	3	3	5	4	7	7	12
2007	3	5	8	13	2	3	7	16
2008	4	7	11	18	6	28	13	46
2009	4	7	4	7	1	1	8	8
2010	1	2	2	3	3	4	5	7
2011	0	0	0	0	3	8	3	8
2012	1	2	1	2	4	10	6	12
2013	1	2	1	2	5	28	7	30
Total	**20**	**34**	**35**	**58**	**35**	**102**	**69**	**160**
Average	**2**	**3.4**	**3.5**	**5.8**	**3.5**	**10.2**	**6.9**	**16**

APPENDIX S—MOTORCOACH FIRE RECORDS AND ALL VEHICLE HIGHWAY/MAJOR ARTERIAL TRAVEL FROM 2004 TO 2013, BY REGION AND STATE

Table 41. Motorcoach fire records and all vehicle highway/major arterial travel, Eastern region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded	Highway VMT (millions)
Connecticut	21	34	0	34	307,697
Delaware	2	3	3	6	83,536
Dist. of Columbia	2	3	0	3	31,767
Maine	0	0	1	1	131,714
Maryland	24	39	2	41	550,499
Massachusetts	56	92	0	92	514,011
New Hampshire	3	5	0	5	125,557
New Jersey	64	105	2	107	688,153
New York	66	108	23	131	1,160,590
Pennsylvania	22	36	14	50	967,526
Rhode Island	0	0	0	0	86,395
Vermont	0	0	0	0	63,614
Virginia	52	85	1	86	786,440
West Virginia	5	8	0	8	196,602
Total	**317**	**518**	**46**	**564**	**5,694,102**

Table 42. Motorcoach fire records and all vehicle highway/major arterial travel, Southern region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded	Highway VMT (millions)
Alabama	16	26	11	37	502,508
Arkansas	8	13	1	14	316,388
Florida	134	220	2	222	1,663,289
Georgia	44	72	0	72	936,774
Kentucky	18	30	1	31	434,033
Louisiana	18	30	1	31	438,744
Mississippi	9	15	0	15	332,757
New Mexico	4	7	0	7	217,214
North Carolina	37	61	5	66	841,011
Oklahoma	5	8	2	10	433,027
South Carolina	18	30	0	30	489,566
Tennessee	25	41	0	41	641,983
Total	**336**	**553**	**23**	**576**	**7,247,294**

Table 43. Motorcoach fire records and all vehicle highway/major arterial travel, Midwest region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded	Highway VMT (millions)
Illinois	39	64	2	66	1,012,993
Indiana	11	18	0	18	633,524
Iowa	2	3	0	3	296,583
Kansas	6	10	2	12	282,560
Michigan	34	56	2	58	982,772
Minnesota	11	18	1	19	532,416
Missouri	13	21	4	25	614,112
Nebraska	1	2	0	2	185,370
Ohio	50	82	3	85	992,377
Wisconsin	7	11	12	23	553,675
Total	**174**	**285**	**26**	**311**	**6,086,383**

Table 44. Motorcoach fire records and all vehicle highway/major arterial travel, Western region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded	Highway VMT (millions)
Alaska	3	5	0	5	44,247
Arizona	8	13	9	22	562,721
California	98	161	8	169	3,334,332
Colorado	16	26	1	27	456,152
Hawaii	8	13	0	13	81,761
Idaho	4	7	0	7	132,666
Montana	1	2	0	2	101,597
Nevada	22	36	3	39	197,647
North Dakota	5	8	0	8	76,975
Oregon	13	21	0	21	328,824
South Dakota	5	8	3	11	88,147
Texas	97	159	5	164	2,389,422
Utah	12	20	3	23	230,044
Washington	24	39	2	41	546,897
Wyoming	1	2	3	5	80,765
Total	**317**	**520**	**37**	**557**	**8,652,197**

APPENDIX T—SCHOOL BUS FIRE RECORDS FROM 2004 TO 2013, BY REGION AND STATE

Table 45. School bus fire records, Eastern region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded
Connecticut	38	62	0	62
Delaware	4	7	0	7
Dist. of Columbia	2	3	0	3
Maine	12	20	2	22
Maryland	46	75	9	84
Massachusetts	100	164	1	165
New Hampshire	9	15	0	15
New Jersey	50	82	2	84
New York	108	177	4	181
Pennsylvania	17	28	8	36
Rhode Island	2	3	0	3
Vermont	9	15	0	15
Virginia	102	167	6	173
West Virginia	10	16	1	17
Total	**509**	**834**	**33**	**867**

Table 46. School bus fire records, Southern region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded
Alabama	10	16	2	18
Arkansas	28	46	0	46
Florida	145	238	0	238
Georgia	114	187	1	188
Kentucky	21	34	1	35
Louisiana	62	102	1	103
Mississippi	35	57	0	57
New Mexico	4	7	0	7
North Carolina	88	144	10	154
Oklahoma	23	38	10	48
South Carolina	112	184	0	184
Tennessee	74	121	1	122
Total	**716**	**1,174**	**26**	**1,200**

Table 47. School bus fire records, Midwestern region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded
Illinois	122	200	2	202
Indiana	32	52	0	52
Iowa	19	31	0	31
Kansas	26	43	5	48
Michigan	110	180	3	183
Minnesota	27	44	2	46
Missouri	43	71	10	81
Nebraska	13	21	1	22
Ohio	126	207	4	211
Wisconsin	30	49	10	59
Total	**548**	**898**	**37**	**935**

Table 48. School bus fire records, Western region, 2004–13.

State	NFIRS Fires	NFIRS Fires Expanded	MCMIS Fires	Total MCMIS and Expanded
Alaska	11	18	0	18
Arizona	21	34	5	39
California	88	144	7	151
Colorado	12	20	0	20
Hawaii	6	10	0	10
Idaho	9	15	0	15
Montana	7	11	1	12
Nevada	28	46	2	48
North Dakota	6	10	1	11
Oregon	46	75	0	75
South Dakota	6	10	0	10
Texas	181	297	3	300
Utah	12	20	0	20
Washington	34	56	0	56
Wyoming	4	7	0	7
Total	**471**	**773**	**19**	**792**

APPENDIX U—CAUSE OF IGNITION

Table 49. Motorcoach and school bus fires, 2004–13, by cause of ignition.

Cause	Count
Act of nature	9
Unclassified cause	852
Failure of equipment or heat source	1,451
Intentional	100
Unintentional	976
Total	**3,388**

Table 50. Motorcoach fires, 2004–13, by cause of ignition.

Cause	Count
Act of nature	6
Unclassified cause	581
Failure of equipment or heat source	920
Intentional	94
Unintentional	643
Total	**2,244**

Table 51. School bus fire causes, 2004–13, by cause of ignition.

Cause	Count
Act of nature	3
Unclassified cause	271
Failure of equipment or heat source	531
Intentional	6
Unintentional	333
Total	**1,144**

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APPENDIX V—IGNITION FACTOR COMBINATION TABLES

Table 52. Motorcoach fires, 2004–13, area of origin by cause of ignition.

Area of Origin	Failure of Equipment Number (Percent)	Unintentional Number (Percent)	Intentional Number (Percent)	Act of Nature Number (Percent)	Unclassified Number (Percent)	Total Fires
Engine area, running gear, or wheel area	**418** (52%)	**228** (29%)	**2** (0%)	**2** (0%)	**150** (19%)	**800**
Unclassified vehicle area	**32** (40%)	**30** (38%)	**0** (0%)	**0** (0%)	**18** (23%)	**80**
Operator or passenger area of transportation equipment	**21** (38%)	**14** (25%)	**4** (7%)	**0** (0%)	**17** (30%)	**56**
Exterior or exposed surface	**15** (43%)	**10** (29%)	**0** (0%)	**0** (0%)	**10** (29%)	**35**
Cargo/trunk area	**7** (25%)	**14** (50%)	**0** (0%)	**0** (0%)	**7** (25%)	**28**
Separate operator/control area of transportation	**5** (50%)	**4** (40%)	**0** (0%)	**0** (0%)	**1** (10%)	**10**
Fuel tank or fuel line	**1** (25%)	**3** (75%)	**0** (0%)	**0** (0%)	**0** (0%)	**4**
Other known area	**17** (32%)	**15** (28%)	**0** (0%)	**1** (2%)	**20** (38%)	**53**
Undetermined or unclassified	**15** (19%)	**15** (19%)	**0** (0%)	**0** (0%)	**48** (62%)	**78**

Table 53. School bus fires, 2004–13, area of origin by cause of ignition.

Area of Origin	Failure of Equipment Number (Percent)	Unintentional Number (Percent)	Intentional Number (Percent)	Act of Nature Number (Percent)	Unclassified Number (Percent)	Total Fires
Engine area, running gear, or wheel area	**658** (47%)	**434** (31%)	**18** (1%)	**4** (0%)	**274** (20%)	**1,388**
Operator or passenger area of transportation equipment	**112** (34%)	**71** (21%)	**56** (17%)	**1** (0%)	**94** (28%)	**334**
Unclassified vehicle area	**56** (36%)	**48** (31%)	**5** (3%)	**0** (0%)	**45** (29%)	**154**
Exterior or exposed surface	**19** (27%)	**17** (24%)	**4** (6%)	**0** (0%)	**30** (43%)	**70**
Separate operator/control area of transportation	**15** (50%)	**9** (30%)	**0** (0%)	**0** (0%)	**6** (20%)	**30**
Fuel tank or fuel line	**9** (43%)	**7** (33%)	**1** (5%)	**0** (0%)	**4** (19%)	**21**
Cargo or trunk area	**3** (17%)	**8** (44%)	**1** (6%)	**0** (0%)	**6** (33%)	**18**
Other known area	**21** (31%)	**20** (29%)	**3** (4%)	**1** (1%)	**23** (34%)	**68**
Undetermined or unclassified	**27** (17%)	**29** (18%)	**6** (4%)	**0** (0%)	**99** (61%)	**161**

Table 54. Motorcoach fires, 2004–13, area of origin by item first ignited.

Area of Origin	Electrical Wire Number (Percent)	Conveyor Belt Number (Percent)	Tire Number (Percent)	Flammable or Combustible Liquid or Gas or Associated Part Number (Percent)	Undetermined, Unclassified Item First Ignited Number (Percent)	Other Known Item First Ignited Number (Percent)	Total Fires
Engine area, running gear or wheel area	**92** (12%)	**12** (2%)	**101** (13%)	**143** (18%)	**414** (52%)	**38** (5%)	**800**
Operator or passenger area of transportation equipment	**16** (29%)	**0** (0%)	**0** (0%)	**3** (5%)	**30** (54%)	**7** (13%)	**56**
Vehicle area, other	**10** (13%)	**0** (0%)	**11** (14%)	**5** (6%)	**49** (61%)	**5** (6%)	**80**
Cargo or trunk area	**9** (32%)	**1** (4%)	**0** (0%)	**1** (4%)	**10** (36%)	**7** (25%)	**28**
Separate operator/control area of transportation	**9** (90%)	**0** (0%)	**0** (0%)	**0** (0%)	**1** (10%)	**0** (0%)	**10**
Exterior or exposed surface	**2** (6%)	**0** (0%)	**11** (31%)	**0** (0%)	**18** (51%)	**4** (11%)	**35**
Fuel tank or fuel line	**0** (0%)	**0** (0%)	**0** (0%)	**4** (100%)	**0** (0%)	**0** (0%)	**4**
Other known area	**5** (9%)	**1** (2%)	**1** (2%)	**5** (9%)	**28** (53%)	**13** (25%)	**53**
Undetermined	**2** (3%)	**0** (0%)	**1** (1%)	**1** (1%)	**71** (91%)	**3** (4%)	**78**

Table 55. School bus fires, 2004–13, area of origin by item first ignited.

Area of Origin	Electrical Wire Number (Percent)	Conveyor Belt Number (Percent)	Tire Number (Percent)	Flammable or Combustible Liquid or Gas or Associated Part Number (Percent)	Undetermined, Unclassified Item First Ignited Number (Percent)	Other Known Item First Ignited Number (Percent)	Total Fires
Engine area, running gear, or wheel area	**286** (21%)	**14** (1%)	**66** (5%)	**259** (19%)	**704** (51%)	**59** (4%)	**1,388**
Operator or passenger area of transportation equipment	**108** (32%)	**0** (0%)	**0** (0%)	**7** (2%)	**150** (45%)	**69** (21%)	**334**
Vehicle area, other	**36** (23%)	**0** (0%)	**9** (6%)	**5** (3%)	**91** (59%)	**13** (8%)	**154**
Separate operator/control area of transportation	**20** (67%)	**0** (0%)	**0** (0%)	**0** (0%)	**9** (30%)	**1** (3%)	**30**
Exterior or exposed surface	**5** (7%)	**0** (0%)	**5** (7%)	**9** (13%)	**29** (41%)	**22** (31%)	**70**
Cargo or trunk area	**3** (17%)	**0** (0%)	**3** (17%)	**2** (11%)	**3** (17%)	**7** (39%)	**18**
Fuel tank or fuel line	**2** (10%)	**0** (0%)	**0** (0%)	**15** (71%)	**3** (14%)	**1** (5%)	**21**
Other known area	**10** (15%)	**0** (0%)	**2** (3%)	**8** (12%)	**31** (46%)	**17** (25%)	**68**
Undetermined	**5** (3%)	**0** (0%)	**2** (1%)	**2** (1%)	**146** (91%)	**6** (4%)	**161**

APPENDIX W—AREA OF ORIGIN

Table 56. Motorcoach fires, 2004–13.

Area of Origin	Fires (Number)	Fires (Percent)
Vehicle areas	**1,013**	**98%**
• Engine area, running gear, or wheel area	800	77%
• Unclassified vehicle area	80	8%
• Operator or passenger area of transportation equipment	56	5%
• Exterior or exposed surface	35	3%
• Cargo or trunk area	28	3%
• Separate operator/control area of transportation	10	1%
Other areas of origin	**22**	**2%**
• Highway, parking lot, street: on or near	11	1%
• Unclassified outside area	6	1%
Total	**1,035**	**100%**
Other known areas of origin	31	N/A
Undetermined	78	N/A
Total fires	**1,144**	**N/A**

Table 57. School bus fires, 2004–13.

Area of Origin	Fires (Number)	Fires (Percent)
Vehicle areas	**2,015**	**98%**
• Engine area, running gear, or wheel area	1,388	68%
• Operator or passenger area of transportation equipment	334	16%
• Vehicle area, other	154	8%
• Exterior or exposed surface	70	3%
• Separate operator/control area of transportation	30	1%
• Fuel tank or fuel line	21	1%
• Cargo or trunk area	18	1%
Other areas of origin	**33**	**2%**
• Outside area, other	12	1%
• Highway, parking lot, street: on or near	14	1%
Total	**2,048**	**100%**
Means of Egress	35	N/A
Undetermined	161	N/A
Total fires	**2,244**	**N/A**

Table 58. Motorcoach fires, by area of origin.

Area of Origin	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Engine area, running gear, or wheel area	79	104	66	94	85	96	75	85	66	50	**800**
Operator or passenger area of transportation equipment	8	2	8	5	6	7	10	5	2	3	**56**
Exterior or exposed surface	8	7	4	5	1	0	2	4	2	2	**35**
Unclassified vehicle area	5	7	8	9	10	8	9	7	9	8	**80**
Other known areas of origin	3	7	4	4	7	6	6	5	6	5	**53**
Fuel tank or fuel line	1	1	0	0	0	0	0	1	1	0	**4**
Cargo or trunk area	0	3	5	1	4	3	3	3	3	3	**28**
Separate operator/control area of transportation	0	2	0	2	0	1	0	2	2	1	**10**
Undetermined or unclassified area of origin	10	13	10	10	5	8	6	6	2	8	**78**
Total Fires	**114**	**146**	**105**	**130**	**118**	**129**	**111**	**118**	**93**	**80**	**1,144**

Table 59. School bus fires, by area of origin.

Area of Origin	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Engine area, running gear, or wheel area	106	170	147	150	153	138	143	148	125	108	**1,388**
Operator or passenger area of transportation equipment	39	44	32	42	38	31	30	30	22	26	**334**
Unclassified vehicle area	15	12	15	27	18	15	12	14	17	9	**154**
Separate operator/control area of transportation	5	2	2	5	3	5	2	2	2	2	**30**
Exterior or exposed surface	4	6	15	6	4	5	7	5	8	10	**70**
Other known areas of origin	4	8	4	2	10	5	7	11	6	11	**68**
Cargo or trunk area	2	3	2	7	1	1	0	1	1	0	**18**
Fuel tank or fuel line	2	5	1	2	3	2	2	1	1	2	**21**
Undetermined or unclassified area of origin	12	18	13	16	16	15	19	29	9	14	**161**
Total Fires	**189**	**268**	**231**	**257**	**246**	**217**	**222**	**241**	**191**	**182**	**2,244**

APPENDIX X—FACTOR CONTRIBUTING TO IGNITION

Only NFIRS records were used in these calculations. NFIRS has four fields for "Factor Contributing to Ignition;" only the first two were used. Factors 3 and 4 were not significantly populated. These tables show only those entries where the percent was more than 0 percent. "Undetermined," "Null," and "Other" values were grouped together in the "Undetermined" category.

Table 60. School bus fires, 2004–13.

Factor Contributing to Ignition	Fires (Number)	Fires (Percent)
Mechanical failure or malfunction	**554**	**48%**
• Unclassified mechanical failure, malfunction	353	31%
• Leak or break	131	11%
• Worn out	46	4%
• Backfire	14	1%
• Automatic control failure	8	1%
Electrical failure or malfunction	**405**	**35%**
• Unclassified Electrical failure, malfunction	168	15%
• Unspecified short-circuit arc	130	11%
• Short circuit arc from defective, worn insulation	54	5%
• Arc, spark from operating equipment	23	2%
• Short circuit arc from mechanical damage	14	1%
• Arc from faulty contact, broken conductor	12	1%
Operational deficiency	**48**	**4%**
• Unclassified Operational deficiency	18	2%
• Equipment not being operated properly	8	1%
• Failure to clean	7	1%
Other factors	**150**	**13%**
• Exposure fire	54	5%
• Other known factors	30	3%
• Heat source too close to combustibles	18	2%
• Playing with heat source	14	1%
• Misuse of material or product, other	11	1%
• Cutting, welding too close to combustible	9	1%
• Abandoned or discarded materials or products	7	1%
• Flammable liquid or gas spilled	7	1%
Known factors	**1,157**	**50%**
Undetermined or unclassified factors	**1,162**	**50%**
Total entries	**2,319**	**N/A**
Total fires	**2,244**	**N/A**

Table 61. Motorcoach fires, 2004–13.

Factor Contributing to Ignition	Fires (Number)	Fires (Percent)
Mechanical failure or malfunction	**423**	**65%**
• Unclassified mechanical failure, malfunction	304	47%
• Leak or break	70	11%
• Worn out	37	6%
• Backfire	5	1%
• Automatic control failure	4	1%
Electrical failure or malfunction	**129**	**20%**
• Unclassified Electrical failure, malfunction	52	8%
• Unspecified short-circuit arc	41	6%
• Short circuit arc from defective, worn insulation	13	2%
• Short circuit arc from mechanical damage	12	2%
• Arc, spark from operating equipment	7	1%
Operational deficiency	**35**	**5%**
• Unclassified Operational deficiency	13	2%
• Equipment not being operated properly	8	1%
• Equipment overloaded	6	1%
• Failure to clean	4	1%
Other factors	**61**	**9%**
• Exposure fire	16	2%
• Heat source too close to combustibles	12	2%
• Other known factors	11	2%
• Flammable liquid or gas spilled	7	1%
• Abandoned or discarded materials or products	6	1%
• Cutting, welding too close to combustible	5	1%
• Misuse of material or product, other	4	1%
Known factors	**648**	**55%**
Undetermined or unclassified factors	**540**	**45%**
Total entries	**1,188**	**N/A**
Total fires	**1,144**	**N/A**

Table 62. Motorcoach fires, by factor contributing to ignition.

Factor Contributing to Ignition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Entries
Mechanical failure or malfunction	42	68	42	37	54	48	44	40	25	23	**423**
Electrical failure or malfunction	16	14	16	13	7	13	17	11	10	12	**129**
Other known factors	12	7	10	4	8	6	4	4	4	2	**61**
Operational deficiency	3	1	6	5	3	4	1	8	3	1	**35**
Undetermined or unclassified factors	47	60	41	72	49	61	52	59	54	45	**540**
Total Entries	**120**	**150**	**115**	**131**	**121**	**132**	**118**	**122**	**96**	**83**	**1,188**

Table 63. School bus fires, by factor contributing to ignition.

Factor Contributing to Ignition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Entries
Electrical failure or malfunction	51	53	37	40	49	36	34	39	40	26	**405**
Mechanical failure or malfunction	46	67	63	74	53	53	49	66	34	49	**554**
Other known factors	13	21	30	16	17	8	13	13	10	9	**150**
Operational deficiency	5	2	6	7	1	6	7	6	7	1	**48**
Undetermined or unclassified factors	90	140	108	126	130	118	121	127	103	99	**1,162**
Total Entries	**205**	**283**	**244**	**263**	**250**	**221**	**224**	**251**	**194**	**184**	**2,319**

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APPENDIX Y—ITEM FIRST IGNITED

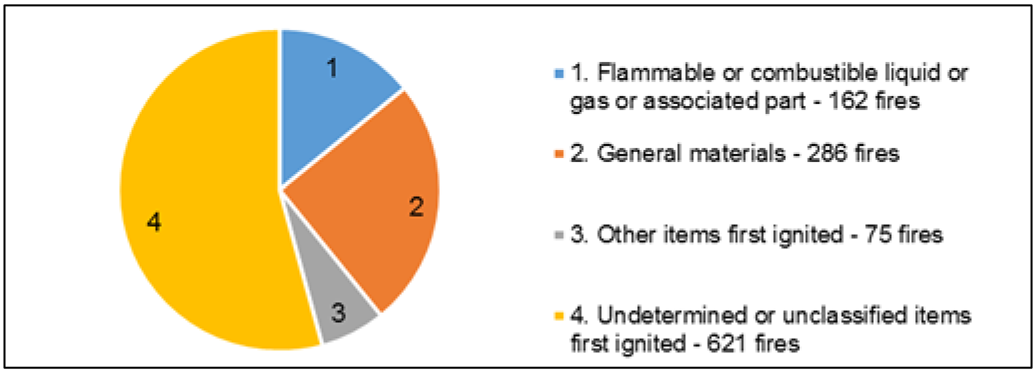

Figure 22. Pie chart. Motorcoach fires, 2004–13, by item first ignited.

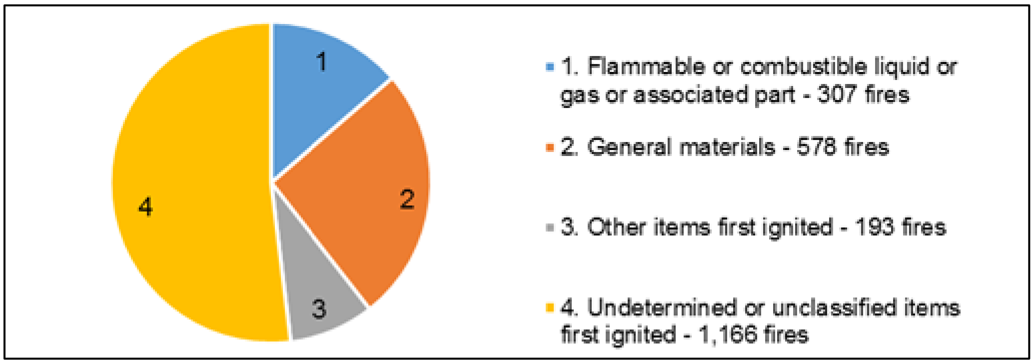

Figure 23. Pie chart. School bus fires, 2004–13, by item first ignited.

Table 64. Motorcoach fires, 2004–13, by item first ignited.

Item First Ignited	Fires (Number)	Fires (Percent)
General materials	**286**	**55%**
• Electrical wire, cable insulation	145	28%
• Tire	125	24%
• Conveyor belt, drive belt, V-belt	14	3%
Flammable or combustible liquid or gas or associated part	**162**	**31%**
• Flammable liquid/gas - in/from engine or burner	103	20%
• Liquids, piping, filters, other	20	4%
• Flammable liquid/gas - uncontained	9	2%
• Flammable liquid/gas - in/from final container	8	2%
• Pipe, duct, conduit, hose covering	7	1%
• Pipe, duct, conduit or hose	7	1%
• Flammable liquid/gas in container or pipe	5	1%
• Atomized liquid, vaporized liquid, aerosol	3	1%
Other items first ignited	**75**	**14%**
• Other known items first ignited	36	7%
• Multiple items first ignited	39	7%
Known items first ignited	**523**	**100%**
Undetermined or unclassified items first ignited	**621**	**N/A**
Total Fires	**1,144**	**N/A**

Table 65. School bus fires, 2004–13, by item first ignited.

Item First Ignited	Fires (Number)	Fires (Percent)
General materials	**578**	**54%**
• Electrical wire, cable insulation	475	44%
• Tire	87	8%
• Conveyor belt, drive belt, V-belt	14	1%
• General Materials Other (conversion only)	1	0%
• Fence, pole	1	0%
Flammable or combustible liquid or gas or associated part	**307**	**28%**
• Flammable liquid/gas - in/from engine or burner	158	15%
• Liquids, piping, filters, other	39	4%
• Pipe, duct, conduit or hose	24	2%
• Flammable liquid/gas in container or pipe	23	2%
• Flammable liquid/gas - uncontained	19	2%
• Flammable liquid/gas - in/from final container	17	2%
• Pipe, duct, conduit, hose covering	14	1%
• Atomized liquid, vaporized liquid, aerosol.	10	1%
• Filter, including evaporative cooler pads	3	0%
Other items first ignited	**193**	**18%**
• Other known items first ignited	130	12%
• Multiple items first ignited	63	6%
Known items first ignited	**1,078**	**100%**
Undetermined or unclassified items first ignited	**1,166**	**N/A**
Total Fires	**2,244**	**N/A**

Table 66. Motorcoach fires, 2004–13, by item first ignited.

Item First Ignited	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Flammable or combustible liquid or gas or associated part	20	27	19	13	22	19	12	11	12	7	**162**
General materials	31	32	32	30	24	38	29	35	17	18	**286**
Other items first ignited	7	7	8	11	14	5	8	8	2	5	**75**
Undetermined or unclassified items first ignited	56	80	46	76	58	67	62	64	62	50	**621**
Total Fires	**114**	**146**	**105**	**130**	**118**	**129**	**111**	**118**	**93**	**80**	**1,144**

Table 67. School bus fires, 2004–13, by item first ignited.

Item First Ignited	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Flammable or combustible liquid or gas or associated part	26	37	28	49	31	29	27	29	25	26	**307**
General materials	56	78	60	50	82	54	53	66	48	31	**578**
Other items first ignited	20	20	31	33	12	19	16	19	15	8	**193**
Undetermined or unclassified items first ignited	87	133	112	125	121	115	126	127	103	117	**1,166**
Total Fires	**189**	**268**	**231**	**257**	**246**	**217**	**222**	**241**	**191**	**182**	**2,244**

APPENDIX Z—HEAT SOURCE

Table 68. Motorcoach fires 2004–13, by heat source.

Heat Source	Fires (Number)	Fires (Percent)
Operating equipment	**526**	**74%**
• Radiated, conducted heat from operating equipment	217	30%
• Unclassified heat from powered equipment	179	25%
• Arcing	100	14%
• Spark, ember or flame from operating equipment	30	4%
Hot or smoldering object	**153**	**21%**
• Heat, spark from friction	90	13%
• Unclassified hot or smoldering object	46	6%
• Molten, hot material	12	2%
• Hot ember or ash	5	1%
Other Open Flame or Smoking Materials	**13**	**2%**
Heat Spread from Another Fire	**10**	**1%**
• Heat from direct flame, convection currents	4	1%
Other known heat source	**10**	**1%**
Known heat source	**712**	**100%**
Undetermined or unclassified heat source	**432**	**N/A**
Total Fires	**1,144**	**N/A**

Table 69. School bus fires 2004–13, by heat source.

Heat Source	Fires (Number)	Fires (Percent)
Operating equipment	**1,029**	**73%**
• Arcing	367	26%
• Unclassified heat from powered equipment	298	21%
• Radiated, conducted heat from operating equipment	285	20%
• Spark, ember or flame from operating equipment	79	6%
Hot or smoldering object	**218**	**16%**
• Heat, spark from friction	98	7%
• Unclassified hot or smoldering object	96	7%
• Molten, hot material	18	1%
Other Open Flame or Smoking Materials	**76**	**5%**
• Backfire from internal combustion engine	19	1%
• Cigarette lighter	18	1%
• Unclassified heat from open flame or smoking materials	13	1%
Heat Spread from Another Fire	**54**	**4%**
• Unclassified heat spread from another fire	21	1%
• Heat from direct flame, convection currents	15	1%
• Radiated heat from another fire	15	1%
Other known heat source	**24**	**2%**
Known heat source	**1,401**	**100%**
Undetermined or unclassified heat source	**843**	**N/A**
Total Fires	**2,244**	**N/A**

Table 70. Motorcoach fires, by heat source.

Heat Source	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Operating equipment	56	67	46	58	60	62	49	54	43	31	**526**
Hot or smoldering object	17	23	18	12	18	20	18	14	6	7	**153**
Other open flame or smoking materials	4	2	3	0	0	0	0	3	0	1	**13**
Heat spread from another fire	0	1	2	1	0	1	2	1	2	0	**10**
Other known heat source	0	1	1	1	3	1	0	0	0	3	**10**
Undetermined or unclassified heat source	37	52	35	58	37	45	42	46	42	38	**432**
Total Fires	**114**	**146**	**105**	**130**	**118**	**129**	**111**	**118**	**93**	**80**	**1,144**

Table 71. School bus fires, by heat source.

Heat Source	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Operating equipment	87	127	112	126	110	109	97	107	78	76	**1,029**
Hot or smoldering object	22	26	26	27	26	19	23	19	17	13	**218**
Other open flame or smoking materials	10	12	6	10	12	7	6	8	4	1	**76**
Heat spread from another fire	5	6	13	4	5	2	6	6	2	5	**54**
Other known heat source	2	3	4	2	2	4	2	4	1	0	**24**
Undetermined or unclassified heat source	63	94	70	88	91	76	88	97	89	87	**843**
Total Fires	**189**	**268**	**231**	**257**	**246**	**217**	**222**	**241**	**191**	**182**	**2,244**

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APPENDIX AA—MATERIAL FIRST IGNITED

Table 72. Motorcoach fires, 2004–13, by material first ignited.

Material first ignited	Fires (Number)	Fires (Percent)
Flammable or combustible liquid	**138**	**35%**
• Unclassified flammable or combustible liquid	55	14%
• Cooking oil, transformer or lubricating oil	36	9%
• Gasoline	23	6%
• Kerosene, No.1 and 2 fuel oil, diesel type	21	5%
• Cottonseed oil, creosote oil type combustible	2	1%
Other material first ignited	**117**	**29%**
• Other known material first ignited	51	13%
• Multiple types of material	49	12%
• Fabric, fiber, cotton, blends, rayon, wool	11	3%
• Paper, including cellulose, waxed paper	5	1%
Plastic	**82**	**21%**
Rubber, excluding synthetic rubbers	**63**	**16%**
Known materials first ignited	**400**	**100%**
Undetermined or unclassified materials first ignited	**744**	**N/A**
Total Fires	**1,144**	**N/A**

Table 73. School bus fires, 2004–13, by material first ignited.

Material first ignited	Fires (Number)	Fires (Percent)
Flammable or combustible liquid	**258**	**33%**
• Unclassified flammable or combustible liquid	102	13%
• Cooking oil, transformer or lubricating oil	55	7%
• Gasoline	51	6%
• Kerosene, No.1 and 2 fuel oil, diesel type	45	6%
• Ether, pentane type flammable liquid	2	0%
• Cottonseed oil, creosote oil type combustible	2	0%
• Turpentine, butyl alcohol type flammable liquid	1	0%
Plastic	**239**	**30%**
Other material first ignited	**224**	**28%**
• Other known material first ignited	91	12%
• Multiple types of material	82	10%
• Fabric, fiber, cotton, blends, rayon, wool	21	3%
• Plastic coated fabric	18	2%
• Paper, including cellulose, waxed paper	12	2%
Rubber, excluding synthetic rubbers	**66**	**8%**
Known materials first ignited	**787**	**100%**
Undetermined or unclassified materials first ignited	**1,457**	**N/A**
Total Fires	**2,244**	**N/A**

Table 74. Motorcoach fires, 2004–13, by material first ignited.

Material First Ignited	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Flammable or combustible liquid	15	26	15	10	17	16	11	10	12	6	**138**
Other material first ignited	14	15	16	13	15	10	9	11	8	6	**117**
Plastic	7	10	10	9	6	9	13	10	3	5	**82**
Rubber, excluding synthetic rubbers	7	6	9	4	5	8	9	10	2	3	**63**
Undetermined or unclassified material first ignited	71	89	55	94	75	86	69	77	68	60	**744**
Total Fires	**114**	**146**	**105**	**130**	**118**	**129**	**111**	**118**	**93**	**80**	**1,144**

Table 75. School bus fires, 2004–13, by material first ignited.

Material First Ignited	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total Fires
Flammable or combustible liquid	22	31	29	46	26	22	14	28	20	20	**258**
Other material first ignited	16	37	31	30	19	22	19	22	19	9	**224**
Plastic	30	42	31	20	32	12	25	16	17	14	**239**
Rubber, excluding synthetic rubbers	9	9	11	4	9	8	7	2	3	4	**66**
Undetermined or unclassified material first ignited	112	149	129	157	160	153	157	173	132	135	**1,457**
Total Fires	**189**	**268**	**231**	**257**	**246**	**217**	**222**	**241**	**191**	**182**	**2,244**

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APPENDIX BB—INCIDENTS BY YEAR AND MODEL YEAR

Table 76. Motorcoach fire records by model year, by year of incident.

Model Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Count
2013	0	0	0	0	0	0	0	0	0	1	1
2012	0	0	0	0	0	0	0	0	1	1	2
2011	0	0	0	0	0	0	0	0	3	3	6
2010	0	0	0	0	0	0	0	1	2	2	5
2009	0	0	0	0	0	0	0	3	1	2	6
2008	0	0	0	1	1	2	4	9	7	4	28
2007	0	0	0	3	3	5	4	3	1	6	25
2006	0	0	1	6	0	2	4	1	1	4	19
2005	1	7	1	6	5	3	1	4	4	3	35
2004	1	4	6	2	2	6	4	2	2	0	29
2003	5	10	7	4	6	5	4	7	3	3	54
2002	3	8	6	4	9	5	8	11	6	4	64
2001	10	8	9	9	12	9	16	11	8	5	97
2000	11	10	10	17	9	13	7	10	12	13	112
1999	12	16	12	18	16	13	17	10	4	10	128
1998	6	13	9	11	16	10	12	13	10	4	104
1997	5	5	9	5	7	9	6	4	4	4	58
1996	3	6	9	7	7	10	7	2	5	4	60
1995	9	4	3	7	6	6	2	2	2	1	42
1994	4	7	5	4	4	3	5	3	2	3	40
1993	6	5	2	3	1	2	2	3	1	5	30
1992	2	3	1	2	1	1	0	1	0	0	11
1991	4	4	0	3	4	1	1	2	3	0	22
1990	3	8	5	4	2	4	0	3	1	0	30
1989	5	6	6	3	4	2	1	1	0	0	28
1988	5	2	2	2	2	2	2	0	3	1	21
1987	3	2	0	0	1	1	1	0	1	0	9
1986	2	3	0	1	2	1	0	1	2	0	12
1985	1	3	1	2	0	0	1	3	1	0	12
1984	3	2	0	1	0	3	0	1	1	3	14
1983	2	1	0	1	1	0	0	0	0	0	5
1982	2	2	1	1	0	2	0	0	0	0	8
1981	1	2	0	2	1	1	0	1	0	0	8
1980	1	0	1	0	0	0	0	0	0	0	2

Table 77. School bus fire records by model year, by year of incident.

Model Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Count
2016	0	1	0	0	1	0	0	0	0	0	2
2015	2	1	0	0	0	0	0	1	0	0	4
2014	1	1	0	0	0	0	0	0	0	0	2
2013	0	0	0	0	0	0	2	0	0	2	4
2012	0	0	0	0	0	0	0	2	6	6	14
2011	0	0	1	2	0	0	0	2	2	4	11
2010	0	0	0	0	2	0	5	4	6	8	25
2009	0	1	0	1	4	3	3	2	4	7	25
2008	1	1	0	1	6	6	4	15	10	9	53
2007	0	1	5	6	4	5	8	12	8	11	60
2006	1	5	4	7	8	7	15	13	8	10	78
2005	6	12	13	10	16	16	9	11	7	7	107
2004	1	12	10	5	12	10	9	15	9	10	93
2003	2	8	8	4	5	11	9	10	8	3	68
2002	6	8	13	12	12	6	11	11	8	16	103
2001	6	22	16	18	15	7	13	20	16	16	149
2000	10	17	19	22	24	22	11	15	20	8	168
1999	6	8	13	5	15	27	12	14	12	10	122
1998	18	20	11	28	10	20	9	11	9	3	139
1997	14	14	7	18	13	7	16	6	10	4	109
1996	13	14	12	16	10	8	9	14	6	13	115
1995	10	10	11	12	9	6	9	6	6	5	84
1994	3	3	4	12	7	4	3	1	5	1	43
1993	4	7	9	5	2	7	7	5	3	4	53
1992	4	3	4	4	1	2	2	1	5	3	29
1991	6	8	6	5	3	3	4	2	4	3	44
1990	9	11	9	5	7	3	6	7	3	0	60
1989	5	8	6	6	5	1	4	5	4	0	44
1988	6	9	3	7	3	3	4	5	2	5	47
1987	14	6	5	8	5	5	3	4	5	3	58
1986	2	7	3	2	8	3	1	3	1	2	32
1985	4	6	4	4	3	2	3	3	0	0	29
1984	10	7	1	4	2	0	4	0	0	1	29
1983	3	2	4	1	0	3	0	2	0	0	15
1982	1	0	0	2	0	1	1	0	0	1	6
1981	0	2	0	3	3	2	0	0	0	0	10
1980	1	2	1	1	0	1	1	1	0	0	8

APPENDIX CC—VEHICLE MAKE AND MODEL

Table 78. Motorcoach fire records, by major manufacturer, by year.

Make	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Count
MCI	51	78	48	58	66	65	63	54	34	39	556
Van Hool	16	12	19	26	19	16	19	28	21	18	194
Prevost	13	18	14	16	18	8	14	16	15	22	154
Neoplan	8	9	3	3	4	9	1	7	2	1	47
Other make	36	43	35	44	28	38	32	26	30	13	325
Total	**124**	**160**	**119**	**147**	**135**	**136**	**129**	**131**	**102**	**93**	**1,276**

Table 79. School bus fire records, by major manufacturer, by year.

Make	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Count
International	57	86	55	83	73	81	65	72	52	63	687
Blue Bird	40	63	64	67	53	58	58	58	63	45	569
Thomas	16	40	40	36	45	29	41	40	40	30	357
GM	38	49	36	36	36	22	27	19	15	13	291
Freightliner	5	7	13	13	17	13	15	34	18	33	168
Ford	19	10	9	12	13	7	7	7	5	3	92
Other Makes	24	25	22	21	23	17	20	21	14	8	195
Total	**199**	**280**	**239**	**268**	**260**	**227**	**233**	**251**	**207**	**195**	**2,359**

Table 80. Motorcoach fire records, by model, by year.

Make	Model	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Count
Van Hool	T2100	5	3	1	4	9	7	7	11	7	7	61
Van Hool	C2045	3	2	4	5	3	4	4	4	7	6	42
MCI	102dl3	4	5	2	5	5	2	6	3	3	1	36
Neoplan	Advanced	7	4	3	3	3	4	1	3	2	0	30
Van Hool	T800	4	1	3	7	3	1	2	2	1	1	25
MCI	D4500	0	1	0	1	2	4	4	2	1	2	17
Prevost	Le Mirage	1	2	1	3	0	1	1	2	5	1	17
MCI	J4500	0	1	1	4	1	4	0	2	0	2	15
Van Hool	T2145	1	0	2	3	0	0	0	4	2	0	12
MCI	102c3	0	2	5	0	2	0	1	0	0	1	11
MCI	G4500	0	0	3	1	1	1	1	1	2	0	10
Prevost	H3-45	1	0	3	1	1	0	3	1	0	0	10

Table 81. School bus fire records, by model, by year.

Make	Model	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Count
International	3000	27	44	27	45	43	46	41	37	32	37	379
Freightliner	Chassis	5	5	11	10	16	11	14	31	16	32	151
GM	S6000	16	20	9	12	16	7	9	5	4	1	99
International	3800	9	13	6	8	5	8	8	14	8	6	85
GM	C6000	6	12	8	6	9	1	4	4	0	1	51
International	S-Series	5	5	2	1	1	1	2	4	1	5	27
GM	B-Series	3	2	1	2	3	4	2	3	3	3	26
Blue Bird	All American	2	0	10	2	1	0	2	3	1	3	24
Thomas	Saf-T-Liner	1	0	6	1	2	1	4	1	4	3	23
International	S Series	2	3	0	2	1	1	1	0	0	1	11
Blue Bird	Vision	0	0	0	2	0	3	2	0	0	2	9
GM	B7t042	0	1	1	1	0	0	2	0	3	1	9

APPENDIX DD—ENGINE MAKE AND MODEL

Table 82. School bus fire records, by selected engine make and model.

Engine Make	Engine Model	Fire Records
Caterpillar	3116	16
Caterpillar	3126	48
Caterpillar	3126B	38
Caterpillar	3208	3
Caterpillar	C12	1
Caterpillar	C7	89
Cummins	6B SERIES	194
Cummins	6C SERIES	57
Cummins	B5.9 CNG	1
Cummins	ISB	52
Cummins	ISC	25
Cummins	ISL-G	1
Cummins	ISM	1
Cummins	M11	2
Cummins	N 14	1
Detroit Diesel	Jun-71	1
Detroit Diesel	6V92	2
Detroit Diesel	8.2L	27
Detroit Diesel	SERIES 50	3
Detroit Diesel	SERIES 60	4
Ford	5.8L	1
Ford	6.1L	24
Ford	6.6L	10
Ford	6.8L	1
Ford	7.0L	5
Ford	7.5L	1
Ford	7.8L	1
General Motors	5.7L	25
General Motors	6.0L	89
General Motors	6.2L	3
General Motors	6.5L	4
General Motors	6.6L	1
General Motors	7.0L	3
General Motors	7.4L	2
General Motors	8.1L	5
International	5.7L	2
International	530	3

Engine Make	Engine Model	Fire Records
International	6.0L	2
International	6.4L	1
International	6.9L	6
International	7.3L	17
International	7.3L TURBO	3
International	9.0L	8
International	DT360	10
International	DT408	5
International	DT466	155
International	DT466C	1
International	DTA360	18
International	DTI466C(CA)	1
International	MAXXFORCE 7	2
International	T444E	217
International	VT365	24
Isuzu	DURAMAX 6.6L	1
John Deere	8.1L	7
Mercedes-Benz	MBE904	13
Mercedes-Benz	MBE906	59
Mercedes-Benz	OM906	3
Mercedes-Benz	MBE904	13

Table 83. Motorcoach fire records, by selected engine make and model.

Engine Make/Model	Fire Records
Caterpillar 3176	10
Caterpillar C12	3
Caterpillar C13	5
Caterpillar C7	1
Caterpillar C9	4
Cummins 6B SERIES	1
Cummins 6C SERIES	1
Cummins C8.3	2
Cummins ISC	4
Cummins ISL	3
Cummins ISM	11
Cummins L10	29
Cummins M11	46
Detroit Diesel Jun-71	2
Detroit Diesel 6V92	42
Detroit Diesel 8.2L	5
Detroit Diesel 8V71	9
Detroit Diesel 8V92	15
Detroit Diesel SERIES 40	1
Detroit Diesel SERIES 50	5
Detroit Diesel SERIES 60	388
Detroit Diesel Unknown	30
International DTA360	1
International T444E	1
Mercedes-Benz MBE906	1

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APPENDIX EE—INSPECTIONS ON COMMERCIAL MOTOR VEHICLES, ALL BUSES, AND FIRE-INVOLVED MOTORCOACHES

Table 84. CMV inspections, 2004–13.

Inspection Year	All CMVs Inspected	All CMVs Inspected that Received OOS Violations	Percent of Inspected CMVs that Received an OOS Violation
2003	3,008,044	683,876	23%
2004	3,019,475	703,187	23%
2005	3,028,443	682,275	23%
2006	3,334,974	747,502	22%
2007	3,419,403	728,582	21%
2008	3,489,530	717,872	21%
2009	3,553,337	667,944	19%
2010	3,603,291	637,680	18%
2011	3,591,789	636,607	18%
2012	3,541,566	624,475	18%
2013	3,507,831	611,458	17%

Table 85. Bus inspections, 2004–13.

Inspection Year	All Buses Inspected	All Buses Inspected that Received OOS Violations	Percent of Inspected Buses that Received an OOS Violation
2003	43,993	5,573	13%
2004	44,596	5,140	12%
2005	47,926	4,814	10%
2006	129,515	10,936	8%
2007	134,050	10,870	8%
2008	138,417	10,901	8%
2009	88,954	7,041	8%
2010	92,030	6,695	7%
2011	113,746	8,854	8%
2012	116,105	8,241	7%
2013	121,245	9,375	8%

Table 86. Inspections for fire-involved buses, 2004–13.

Inspection Year	All Buses Involved in a Fire Incident that Were Inspected	All Buses Involved in a Fire Incident that Were Inspected and Received an OOS Violation	Percent of Buses Involved in a Fire Incident that Were Inspected and Received an OOS Violation
2003	9	1	11%
2004	63	6	10%
2005	39	4	10%
2006	80	12	15%
2007	110	14	13%
2008	120	22	18%
2009	77	15	19%
2010	81	10	12%
2011	120	17	14%
2012	101	10	10%
2013	76	13	17%

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