VEHICLE FIRES INVOLVING BUSES AND SCHOOL BUSES

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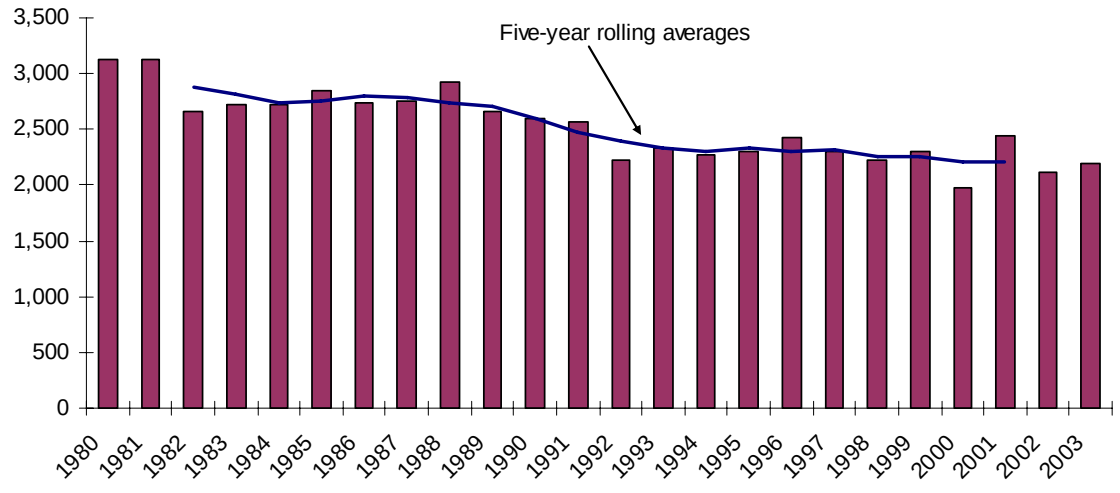
Vehicle Fires Involving Buses and School Buses

This analysis was prepared for the National Transportation Safety Board's (NTSB's) Public Hearing on Motorcoach Fires on August 8th and 9th, 2006 that was called in response to the September 2005 Texas motorcoach fire that claimed 23 lives. The analysis is based on data collected by the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and NFPA's annual fire department experience survey. More information is provided on the data sources at the end of this analysis; a detailed description of the methodology may be found in the Appendix. Vehicle fires were identified by NFIRS incident types 130-139 and buses or school buses were identified by mobile property type code 12. This code also includes trackless trolley buses; statistics for this code cannot be broken down further to separate trackless trolleys or school buses from other buses. A proportional share of vehicle fires in which the mobile property type was unknown or not reported are also included in this analysis. For most causal factors, unknown data is allocated proportionally across the known. Additional information on NFIRS may be found at http://www.usfa.dhs.gov/nfirs/.

2,210 bus or school bus fires, on average, were reported annually in 1999-2003. During the five-year period of 1999-2003, U.S. fire departments responded to an estimated average of 2,210 bus or school bus fires per year. These fires caused an estimated annual average of three civilian deaths, 30 civilian injuries, and $24.2 million in direct property damage per year. In 1999-2003, bus or school bus fires accounted for 1% of the total reported vehicle fires, 1% of the vehicle fire deaths, 2% of the vehicle fire injuries, and 2% of the vehicle fire property damage. On average, six bus or school bus fires were reported every day.

Figure 1.
Bus and School Bus Fires Reported to Local Fire Departments by Year: 1980-2003



Reported bus fires rose 4% from 2002 to 2003 but the overall trend in recent years has been flat.
Table 1 and Figure 1 show the trend in reported bus and school bus fires by year. Reported bus and school bus fires were at their peak in 1980 and 1981. The trend line, shown as five-year rolling averages, has been nearly flat in recent years.

Bus and school bus fires are less common on weekends.
The peak month for these fires was May; August and September tied for second highest. December had the smallest number of these fires. Overall, the difference between months was fairly small. Table 3 shows that bus and school bus fires were much less frequent on the weekend than the rest of the week, with just 8% on Sunday and 11% on Saturday.

73% of these fires are reported between 6:00 a.m. and 6:00 p.m.
Table 4 shows that roughly one-quarter of all bus and school bus fires are reported between 3:00 and 6:00 p.m. The period between 6:00 and 9:00 a.m. ranked second highest among the three-hour segments.

Many bus and school bus fires occur on non-road properties.
This is important because such properties generally do not fall under the jurisdiction of the National Highway Traffic Safety Administration (NHTSA), the body that regulates highway vehicles. Table 5 shows that 45% of these incidents occurred on streets, roads or driveways; 15% were on highways or divided highways. Although driveways are grouped with residential streets and roads in the NFIRS codes, they are generally not considered part of the public road system. Twelve percent occurred in vehicle parking areas, another property outside of NHTSA's domain.

Equipment or other heat source failures caused three-fifths of the bus and school bus fires.
Table 6 shows that 60% of the bus and school bus fires reported originally in Version 5.0 of NFIRS during 1999-2003 resulted from an equipment failure or failure of heat source. Thirty percent were unintentional. There may be some overlap between unintentional and equipment failure. Only 4% of bus and school bus fires were intentional.

Mechanical failures and malfunctions were leading contributing factors.
Tables 7A and 7B show the leading factors contributing to ignition, based again on data collected originally in Version 5.0 of NFIRS. In Table 7A, the factors are sorted by frequency; in 7B, by grouping. Multiple entries are allowed in this field, resulting in a total number of entries that exceeds 100%. An unclassified mechanical failure or malfunction was a factor in more than one-third (36%) of these fires; leaks or breaks factors in 14%; and an unclassified electrical failure or malfunction contributed to 10% of these incidents.

Overall, some type of mechanical failure or malfunction contributed to 59% of these fires; some type of electrical failure or malfunction contributed to 25%. Collisions or overturns are listed under operational deficiencies in Table 7B. Factors in only 10 bus or

school bus fires per year (less than 1%), these are only included because they are of special interest and the only fires likely to be captured by NHTSA's incident databases. NHTSA estimates that in 2004, only one of 275 fatal bus crashes resulted in a fire, and that less than .05% of all reported bus crashes resulted in fire.[1]

Design, manufacturing or installation deficiencies were factors in only 1% of the reported bus or school bus fires.

Table 8 shows that the heat source in one-fifth of the bus and school bus fires was radiated or conducted heat from operating equipment; arcing was the heat source in another 20%.

1999 model year was the most common in bus and school bus fires in 2003.
In 92% of the bus and school bus fires reported during 2003 for which the model year was known, the model year was 2000 or earlier. Figure 2 shows the percent of each model year since 1975. Three percent of these fires involved vehicles made before the 1975 model year.

Figure 2.
Model Year of Buses in Bus and School Bus Fires Reported to U.S. Fire Departments in 2003

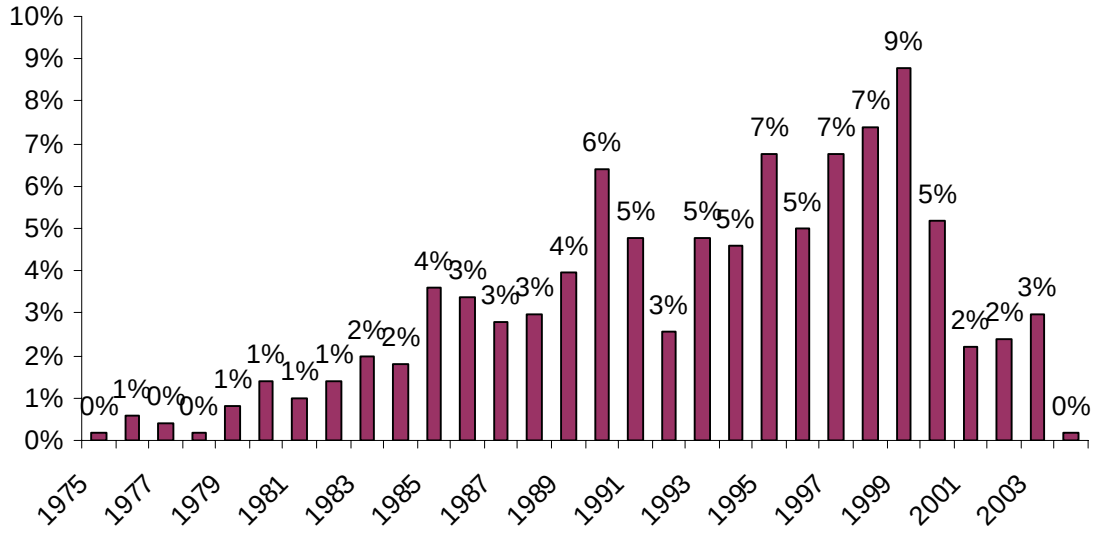


Table 9 shows that two-thirds (69%) of the bus and school bus fires began in the engine, running gear or wheel area. Twelve percent began in the operator passenger area.

[1] The National Highway Traffic Safety Administration, National Center for Statistics and Analysis, U.S. Department of Transportation, *Traffic Safety Facts 2004: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System,* p. 66, online at http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSFAnn/TSF2004.pdf.

Electrical wire or cable insulation was the item first ignited in 29% of the bus and school bus fires. Twenty-seven percent of the bus and school bus fires began with the ignition of flammable or combustible liquids or gases, piping, or filters. (See Table 10.)

The Context of these Statistics

The statistics in this analysis are projections, not counts.
Incidents that are not reported to the fire department are not included in these projections. Each year, the National Fire Protection Association (NFPA) conducts a sample-based survey of local fire departments to develop estimates of the numbers of fire department responses to fires and other incidents as well as injuries, deaths and property damage associated with reported fires. These estimates are based on summary details and lack detail. Follow-up calls are made to fire departments protecting populations under 100,000 that report vehicle fire deaths to ensure that these deaths resulted from fire, not trauma. Estimates on the numbers of fires, fire deaths, injuries and associated property damage are based on completed surveys received from roughly 10% of the nation's local fire departments.

NFIRS participation is voluntary at the federal level.
NFPA develops estimates of specific fire problems by using the detailed incident data collected by the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS). Although NFIRS is administered by the USFA, state participation in NFIRS is voluntary. While almost all states participate, different states have different reporting requirements, ranging from mandatory for all incidents, to mandatory for all fires, to mandatory for fires causing a certain amount of damage to voluntary reporting. Typically, between one-third and one-half of the fires reported to local fire departments are captured by NFIRS. Departments seeking funds under the Assistance to Firefighters Federal Grant Program must participate in NFIRS.[2] This has resulted in an increase in participation.

NFIRS data is multiplied by scaling ratios to obtain estimates of specific fire problems.
Scaling ratios are developed by dividing the projected totals from NFPA's survey by the totals in NFIRS. These ratios are then applied to the NFIRS data to develop estimates of specific fire problems. This approach was developed by analysts at the USFA, Consumer Product Safety Commission, and NFPA.[3] More details may be found in the Appendix. Unfortunately, when a particularly serious fire is included, the casualty and loss projections can be artificially inflated. Because bus fire fatalities are rare events, the

[2] Office of Grants and Training and the U.S. Fire Administration, *2006 Program Guidance for the Assistance to Firefighters Grant Program*, February 2006, p. 42, accessed at http://www.firegrantsupport.com/docs/2006AFGguidance.pdf on August 1, 2006
[3] Hall, J. R., Jr., and Harwood, B., "The National Estimates Approach to U.S. Fire Statistics," *Fire Technology*, Vol. 25, No. 2, 1989, pp. 99–113.

reporting of serious incidents may not average out over one year. Multi-year averages help to minimize this problem.

Data collection rules and definitions changed with Version 5.0 of NFIRS.
Version 5.0 of NFIRS was first introduced in 1999. The percentage of data originally collected in Version 5.0 has been steadily increasing since that time. Data collected in older versions of NFIRS are converted to Version 5.0. Because the coding structure and many of the definitions are significantly different in Version 5.0, the conversion is not exact. In some cases, it is advisable to use only Version 5.0 data. However, this reduces the number of incidents available for analysis.

NHTSA's FARS and NASS focus on traffic crashes and fatalities.
Because NFIRS was designed to document fires, it captures different data than the National Highway Traffic Safety Administration's (NHTSA's) incident databases, the Fatality Analysis Reporting System (FARS), and the National Automotive Sampling System's (NASS's) General Estimates System (GES) uses a probability sample of roadway crashes with police accident reports that resulted in damage, injury or death.[4]

FARS collects information on vehicle crashes on roadways that result in the death of an occupant or non-motorist within 30 days of the crash. State analysts collect data for the 100+ FARS data elements from a variety of existing documents, including police and EMS reports, vital statistics, coroners' reports, etc.

NASS GES data collectors obtain copies of a random sample of roughly 57,000 police accident reports from 410 police jurisdictions per year. Roughly 90 data elements are extracted from these reports.

FARS and GES both collect data on first harmful event, most harmful event, and fire occurrence. Both systems count fatalities associated with a crash and do not distinguish based on actual cause of death.

Different goals and sources result in the capture of different data.
The existing traffic databases focus chiefly on roadway crashes. According to *Traffic Facts 2004*, fires are seen in only 0.1% of vehicle crashes and an even smaller percentage of the bus crashes.

Fire department data show that under 1% of the bus fires result from collisions or rollovers. Many occur in parking lots or other non-traffic settings such as bus terminals, service stations, or schools.

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[4] The National Highway Traffic Safety Administration, National Center for Statistics and Analysis, U.S. Department of Transportation, *Traffic Safety Facts 2004: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System*, pp. 3-5, online at http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSFAnn/TSF2004.pdf.

The NHTSA databases extract information from widely used state and local reports. NFIRS is widely used by fire departments around the country. Although many have never had bus fires, filling out a report on a bus fire would be no different than filling out a report on any other type of vehicle fire for a fire department. A bus fire resulting from a crash would generate the same paperwork for police agencies as any other type of crash.

A specialized data system focusing exclusively on bus fires would face several problems. Because these occur far less often than fires or crashes, a specialized reporting system is unlikely to become routine. All personnel who are likely to be in positions with reporting responsibility need to be aware of that responsibility. With new businesses and agencies opening, closing and reorganizing, and staff coming and going, the training and communication needed are daunting.

Who can provide the best information about bus fires?

The question also arises about who should report these fires. Fire departments use NFIRS to capture all types of fires, and are accustomed to doing so. The NFIRS codes apply most directly to home fires and are designed primarily around issues for structure fires but the codes are generally useful for other fires. The use of NFIRS in combination with the stratified random-sample NFPA survey, both derived from local fire department reports, produces national estimates with the highest degree of statistical soundness available. Other databases, such as compilations of fully investigated incidents can provide more of the technical detail that decision-makers and engineers request. The lack of representativeness in such databases needs to be addressed in the analysis and can make these databases inappropriate for some purposes. Detailed investigations are rarely done for minor incidents making it difficult to identify what worked well to keep a fire minor. Because full investigations can be time consuming and expensive, they will never be an option for routine fires

The FARS and NASS GES are designed primarily to capture crash data and fires on roadways. Consequently, they miss the vast majority of bus fires.

The bus companies will probably be aware of the largest share of fires, including those that are never reported to fire departments, but it is unlikely that their records on these fires are designed to support a statistically valid database or to provide technical detail of the kind that engineers or regulators would find useful. It is also likely that companies with poor safety records will also be less likely to report or document their incidents.

What exactly is a bus?

Webster's Collegiate Dictionary (10^{th} edition, 1997) defines a "bus" as "a large motor vehicle designed to carry passengers, usually along a fixed route according to a schedule." This defines the use of the vehicle but not the design or construction of the vehicle. "Jitneys" are defied as small buses on a flexible schedule (but with a regular route). (Disabled adults and special needs students are often served by jitneys that allow them to use mass transit options suited to their special requirements.) Travel agencies, conferences, and other organizations with customized needs to transport large numbers of

people will hire vehicles that are the same as those used on the fixed routes and schedules that define a bus. Meanwhile, vans are grouped with automobiles in NFIRS codes, but vans are used as jitneys or for any bus tasks where a full-sized bus is not needed. Some transportation companies provide both van and bus transportation with vans the same size as those used by private individuals. The point of this overview of variety in serving customer needs is to note that the scope of the definition of "bus" used in fire incident databases, vehicle crash databases, vehicle inventory and trip volume databases, and regulatory requirements, all may be different. Such differences need to be reviewed and addressed in analysis.

NFPA has a report of a 1995 Georgia fatality resulting from a fire started when someone started a kerosene heater in an abandoned school bus. Such a fire would not normally be under the purview of transportation policy. However, a vehicle that looks like a bus is likely to be coded as a bus, no matter what its status and use may be at the time of a fire.

Selected Incidents from NFPA's Files

Several of the incidents below have been previously published in *NFPA Journal* or its predecessor, *Fire Journal*. These incidents are intended to illustrate the type of situations that can occur. The fires in NFPA's files tend to be more serious than usual and should not be considered representative of the typical bus fire. Routine incidents rarely attract much attention.

"Tour Bus Fire Injures Two Passengers" **West Virginia, 2003**

Two passengers, one of whom fell from an exit window, were hurt trying to escape from a burning tour bus. The bus was carrying 47 passengers, many of them older adults, when the fire occurred. The fire started after a dragging brake caused a rear tire to ignite. The fire spread into the bus's passenger compartment and is believed to have burned for nearly seven minutes before a passerby detected it.

The fire department received a 911 call reporting the fire at 5:55 p.m. and two engine companies responded. By the time firefighters arrived, the rear of the bus was heavily involved, and several passengers were injured. The company officer sounded an additional alarm and requested several emergency medical units as fire crews used two hose lines to attack the blaze. With the help of several other agencies, a HAZMAT team contained oil and fuel runoff. Three passengers were taken to the hospital, including an 87-year-old woman suffering from smoke inhalation and the 70-year-old woman who had fallen while exiting from the window. The bus, valued at $250,000, and its contents, valued at $50,000, were destroyed.

Tremblay, Kenneth J. *NFPA Journal*, v. 98 (4) July/August 2004, p.16.

Unpublished incident **Wisconsin, 1998**

Four men and two women were burned in an incendiary fire on a passenger bus that occurred after an individual carrying a bucket of gasoline boarded a bus, doused the

passengers, and lit the gasoline. The first arriving engine company was able to put out the fire quickly using extinguishers and tank water. A suspect was arrested.

From "Catastrophic Fires of 1988" **Kentucky, 1988***

At 10:55 p.m. on a May 1988 night, a Kentucky fire department was notified of a fire that occurred when a head-on collision between a school bus and a pickup truck punctured the fuel tank of the school bus. The fire blocked the main side door of the bus. Forty-two passengers were able to escape through the rear emergency door. Twenty-seven people died.

Fahy, Rita F. and Barry, John J., III, *NFPA Journal* , v. 83 (4) July/August, 1989. p. 70.
* NTSB Highway Accident Report HAR-89/01 provides more information about this fire. A synopsis is available online at http://www.ntsb.gov/publictn/1989/HAR8901.htm.

"Fire, Electrical Hazard Trap Passengers on Bus" **Illinois, 1991**

When a bus became entangled in a high-voltage power line and caught fire, one passenger died and six others were trapped and had to be rescued by fire fighters. How the bus got caught in the live transmission line is still unclear, but the line was draped over the bus and was entangled under the front tire on the driver's side. Severe arcing ignited the vehicle. Smoke and fire filled the front of the bus, blocking the front exit. Passengers rushed to the back exit. A 36-yearold woman who was the first to try to evacuate the bus was electrocuted when she touched the ground and the electrically charged vehicle simultaneously. A passerby saw the fire and called the fire department. On arrival at 6:39 p.m., fire fighters encountered fire in the front of the bus and dense smoke filling the vehicle. Bystanders reported several people were trapped inside. Assuming the bus was energized, fire fighters broke a rear window with a pike pole and instructed passengers to jump from the bus without touching the vehicle and the ground at the same time. After the passengers were evacuated and the power was turned off, fire fighters used a handline with a fog stream to extinguish the fire. Six passengers suffered smoke inhalation. The incident was extremely stressful for fire fighters because of the significant electrical hazard and because by standers were exhorting fire fighters to "do something."

Tremblay, Kenneth J. *NFPA Journal*®, v. 86 (4), July/August 1992, p. 26.

Unpublished incident **Michigan, 1991**

Faulty wiring at floor level near the driver's seat started a fire in a metropolitan bus in a garage. A bus mechanic saw smoke and immediately called 911. The fire spread out the from the front windshield of the bus, damaging the paneling on an adjacent bus. Four sprinklers operated and contained the fire. The structure suffered light smoke damage.

"Municipal Bus: Plastic Wheel Helps Fire Spread" **Massachusetts, 1977**

While driving an empty bus on a limited-access highway, the driver heard a loud noise at approximately 7:30 am, and pulled over to the side of the road. At that time, he noticed smoke coming out of the left rear wheel well. Since the radio had been removed from this

bus, eliminating the possibility of the driver calling the dispatcher for help, he decided to wait for the next bus to come by. When it arrived, at 7:41 am, the smoldering fire had developed to the flaming mode, and the incident was reported by way of the radio on the second bus to the transit authority's operations center. The fire was spreading into the interior of the bus through the fiberglass-reinforced plastic cover of the wheel well. The fire department responded to a 7:46 am alarm and found the interior of the bus well involved with fire. The blaze was quickly extinguished, but not before it had extensively damaged the bus's interior. Investigating authorities believe that an overheated brake resulted in the eventual ignition of the fiberglass-reinforced plastic wheel-well liner.

Fire Journal®, v. 71 (6) November 1977, p. 11.

Discussion

Mechanical and electrical failures are the leading factors in highway vehicle fires of all types, but these problems are factors in larger shares of bus fires. Less than 1% of the bus fires resulted from collisions or overturns compared to 3% of highway vehicle fires overall. Both buses and passenger cars have death rates of 1.2 deaths per 100 reported fires. The injury rate per 1,000 fires is almost four times as high as that seen in car fires, perhaps due to the larger number of people exposed per incident.

In most private vehicles, any passengers are generally well known to the driver. This may not be true for buses. The 1998 Wisconsin incident in which a bus passenger poured gasoline on people on the bus is unusual, but vandalism is not. Many bus riders have encountered seats that have been slit, exposing the seat’s filling. Buses tend to have fewer exits than cars.

Normally, people who ride buses are able to get on and off the bus with no or minimal assistance. Evacuations are unusual circumstances, forcing people to travel who would normally not do so, particularly via this means of transportation.

Table 1.
U.S. Bus and School Bus Fires, by Year: 1980-2003

Year	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)	Loss in 2003 Dollars (in Millions)
1980	3,120	5	7	$4.2	$9.4
1981	3,130	0	19	$5.6	$11.2
1982	2,660	0	21	$4.7	$9.0
1983	2,730	4	43	$5.1	$9.4
1984	2,720	0	24	$8.9	$15.6
1985	2,840	2	26	$4.2	$7.1
1986	2,740	0	20	$8.5	$14.2
1987	2,750	0	46	$11.2	$18.1
1988	2,930	4	25	$18.5	$28.7
1989	2,660	0	141	$9.8	$14.6
1990	2,600	0	15	$10.9	$15.3
1991	2,560	5	68	$18.0	$24.2
1992	2,230	17	118	$16.7	$21.8
1993	2,330	0	7	$14.8	$18.8
1994	2,270	3	35	$13.2	$16.4
1995	2,300	2	35	$11.8	$14.3
1996	2,420	0	49	$17.2	$20.2
1997	2,310	0	147	$22.5	$25.7
1998	2,230	0	16	$31.2	$35.3
1999*	2,310	4	47	$19.8	$21.8
2000	1,980	0	4	$19.5	$20.9
2001	2,440	5	8	$22.3	$23.1
2002	2,110	2	29	$30.0	$30.7
2003	2,200	2	56	$27.8	$27.8
1980-2003 Annual average	2,520	2	42	$14.8	
1999-2003 Annual average	2,210	3	30	$24.2	

* NFIRS data for 1999 and later was received in the Version 5.0 format. Due to the many coding changes, the 1999-2003 data can better be analyzed separately from data from previous years.

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable.

Source: NFIRS and NFPA survey; Table 705, "Purchasing Power of the Dollar" from U.S. Census Bureau's *Statistical Abstract of the United Sates: 2006 (125th Edition).*

Table 2.
U.S. Bus and School Bus Fires, by Month
1999-2003 Annual Averages

Month	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
January	180	(8%)	0	(0%)	3	(12%)	$2.4	(10%)
February	160	(7%)	1	(28%)	2	(7%)	$2.3	(10%)
March	180	(8%)	0	(17%)	2	(6%)	$1.3	(5%)
April	190	(9%)	0	(0%)	3	(8%)	$2.8	(11%)
May	220	(10%)	1	(20%)	11	(37%)	$1.6	(7%)
June	180	(8%)	1	(20%)	1	(5%)	$2.5	(11%)
July	180	(8%)	0	(0%)	4	(12%)	$3.6	(15%)
August	210	(9%)	0	(0%)	1	(2%)	$1.3	(5%)
September	210	(9%)	0	(15%)	0	(0%)	$1.4	(6%)
October	200	(9%)	0	(0%)	1	(4%)	$1.6	(6%)
November	160	(7%)	0	(0%)	1	(4%)	$2.0	(8%)
December	150	(7%)	0	(0%)	1	(3%)	$1.5	(6%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)
Monthly average	180	(8%)	0	(8%)	2	(8%)	$2.0	(8%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable.

Source: NFIRS and NFPA survey.

Table 3.
U.S. Bus and School Bus Fires, by Day of Week
1999-2003 Annual Averages

Day of Week	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Sunday	180	(8%)	0	(0%)	1	(3%)	$4.0	(17%)
Monday	350	(16%)	1	(20%)	10	(35%)	$3.0	(12%)
Tuesday	340	(15%)	0	(0%)	3	(10%)	$3.6	(15%)
Wednesday	380	(17%)	0	(0%)	5	(16%)	$3.5	(15%)
Thursday	350	(16%)	1	(20%)	3	(9%)	$2.6	(11%)
Friday	390	(18%)	1	(47%)	5	(16%)	$3.3	(14%)
Saturday	230	(11%)	0	(13%)	3	(11%)	$4.2	(17%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)
Daily average	320	(14%)	0	(14%)	4	(14%)	$3.5	(14%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable.

Source: NFIRS and NFPA survey.

Table 4.
U.S. Bus and School Bus Vehicle Fires, by Time of Day
1999-2002 Annual Averages

Time of Day	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Midnight - 2:59 a.m.	100	(4%)	1	(20%)	2	(7%)	$2.8	(12%)
3:00- 5:59 a.m.	90	(4%)	0	(0%)	0	(0%)	$2.6	(11%)
6:00 - 8:59 a.m.	420	(19%)	1	(20%)	8	(26%)	$3.3	(14%)
9:00 - 11:59 a.m.	310	(14%)	0	(17%)	1	(4%)	$3.4	(14%)
Noon - 2:59 p.m.	350	(16%)	0	(13%)	11	(39%)	$2.2	(9%)
3:00 - 5:59 p.m.	540	(24%)	1	(30%)	5	(16%)	$4.2	(17%)
6:00 - 8:59 p.m.	250	(11%)	0	(0%)	1	(4%)	$3.8	(16%)
9:00 - 11:59 p.m.	160	(7%)	0	(0%)	1	(4%)	$2.0	(8%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)
Average	280	(13%)	0	(13%)	4	(13%)	$3.0	(13%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable.

Source: NFIRS and NFPA survey.

Table 5.
U.S. Bus and School Bus Fires, by Property Use
1999-2003 Annual Averages

Fixed Property Use	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Street, road or driveway	1,000	(45%)	1	(35%)	16	(52%)	$7.8	(32%)
Highway or divided highway	340	(15%)	1	(37%)	3	(11%)	$5.2	(21%)
Vehicle parking area	270	(12%)	0	(15%)	3	(9%)	$3.4	(14%)
Unclassified vehicle storage	40	(2%)	0	(0%)	0	(0%)	$0.6	(2%)
Unclassified outside or special property	30	(1%)	0	(0%)	0	(0%)	$0.2	(1%)
One- or two-family dwelling	30	(1%)	0	(0%)	1	(2%)	$0.1	(1%)
Motor vehicle or boat sales, services or repair	30	(1%)	0	(0%)	2	(5%)	$0.2	(1%)
Bus station	20	(1%)	0	(0%)	1	(2%)	$0.2	(1%)
High school, junior high or middle school	20	(1%)	0	(0%)	0	(0%)	$0.1	(1%)
Open land or field	20	(1%)	0	(13%)	1	(2%)	$0.1	(0%)
Vacant lot	10	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Service or gas station	10	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Elementary school	10	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Manufacturing or processing facility	10	(1%)	0	(0%)	0	(0%)	$0.2	(1%)
Other known property use	180	(8%)	0	(0%)	4	(13%)	$2.2	(9%)
Unclassified or unknown property use	190	(9%)	0	(0%)	1	(2%)	$3.7	(15%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable.

Source: NFIRS and NFPA survey.

Table 6.
U.S. Bus and School Bus Fires, by Cause
Based on Version 5.0 Data Percents
1999-2003 Annual Averages

Cause	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Failure of equipment or heat source	1,320	(60%)	1	(39%)	22	(74%)	$14.0	(58%)
Unintentional	660	(30%)	1	(34%)	6	(19%)	$7.8	(32%)
Unclassified cause	130	(6%)	1	(27%)	0	(0%)	$1.3	(5%)
Intentional	100	(4%)	0	(0%)	0	(0%)	$1.1	(5%)
Act of nature	10	(0%)	0	(0%)	2	(7%)	$0.0	(0%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable. The percentages are based on the data collected originally in Version 5.0. The estimates were developed by applying these percentages to the combined total of bus fires collected in all versions of NFIRS. Fires in which the cause was under investigation, undetermined or not reported were allocated proportionally among fires with known cause.

Source: NFIRS and NFPA survey.

Table 7A.
U.S. Bus and School Bus Fires, by Factor Contributing to Ignition
Based on Version 5.0 Data Percents
1999-2003 Annual Averages

Factor Contributing to Ignition	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Unclassified mechanical failure or malfunction	800	(36%)	3	(100%)	10	(35%)	$8.5	(35%)
Leak or break	300	(14%)	0	(0%)	2	(6%)	$3.7	(15%)
Unclassified electrical failure or malfunction	220	(10%)	0	(0%)	7	(22%)	$3.2	(13%)
Unspecified short circuit arc	140	(7%)	0	(0%)	3	(9%)	$0.8	(3%)
Worn out	110	(5%)	0	(0%)	0	(0%)	$0.2	(1%)
Short circuit arc from defective or worn insulation	110	(5%)	0	(0%)	0	(0%)	$0.5	(2%)
Exposure fire	90	(4%)	0	(0%)	0	(0%)	$1.7	(7%)
Unclassified factor	80	(4%)	0	(0%)	3	(9%)	$3.2	(13%)
Backfire	60	(3%)	0	(0%)	0	(0%)	$0.2	(1%)
Unclassified misuse of material or product	40	(2%)	0	(0%)	0	(0%)	$0.3	(1%)
Flammable liquid or gas spilled	30	(2%)	0	(0%)	0	(0%)	$0.7	(3%)
Cutting or welding too close to combustible	30	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Arc or spark from operating equipment	30	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Heat source too close to combustibles.	30	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Unclassified operational deficiency	30	(1%)	0	(0%)	0	(0%)	$0.6	(3%)
Short circuit arc from mechanical damage	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Manual control failure	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Rekindle	20	(1%)	0	(0%)	0	(0%)	$0.3	(1%)
Arc from faulty contact or broken conductor	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Other known factors	120	(5%)	0	(0%)	5	(18%)	$0.6	(2%)
Total factor-contributing entries	2,290	(104%)	3	(100%)	30	(100%)	$24.6	(102%)
Total fires	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable. The percentages are based on the data collected originally in Version 5.0. The estimates were developed by applying these percentages to the combined total of bus fires collected in all versions of NFIRS. Fires, in which the factor contributing to ignition was undetermined, not reported, or coded as "none" were allocated proportionally among fires with known factor contributing to ignition. Multiple factors can be entered per fire, which is why the number of entries is larger than the number of fires.

Source: NFIRS and NFPA survey.

Table 7B.
U.S. Bus and School Bus Fires, by Factor Contributing to Ignition
Based on Version 5.0 Data Percents
1999-2003 Annual Averages

Factor Contributing to Ignition	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Mechanical failure or malfunction	**1,300**	**(59%)**	**3**	**(100%)**	**12**	**(41%)**	**$13.2**	**(54%)**
Leak or break	300	(14%)	0	(0%)	2	(6%)	$3.7	(15%)
Worn out	110	(5%)	0	(0%)	0	(0%)	$0.2	(1%)
Backfire	60	(3%)	0	(0%)	0	(0%)	$0.2	(1%)
Manual control failure	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Unclassified mechanical failure or malfunction	800	(36%)	3	(100%)	10	(35%)	$8.5	(35%)
Electrical failure or malfunction	**550**	**(25%)**	**0**	**(0%)**	**9**	**(32%)**	**$4.6**	**(19%)**
Unspecified short circuit arc	140	(7%)	0	(0%)	3	(9%)	$0.8	(3%)
Short circuit arc from defective, worn insulation	110	(5%)	0	(0%)	0	(0%)	$0.5	(2%)
Arc or spark from operating equipment	30	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Short circuit arc from mechanical damage	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Arc from faulty contact or broken conductor	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Unclassified electrical failure or malfunction	220	(10%)	0	(0%)	7	(22%)	$3.2	(13%)
Misuse of material or product	**150**	**(7%)**	**0**	**(0%)**	**0**	**(0%)**	**$1.0**	**(4%)**
Flammable liquid or gas spilled	30	(2%)	0	(0%)	0	(0%)	$0.7	(3%)
Cutting or welding too close to combustible	30	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Heat source too close to combustible	30	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Unclassified misuse of material or product	40	(2%)	0	(0%)	0	(0%)	$0.3	(1%)
	0							
Fire spread or control	**110**	**(5%)**	**0**	**(0%)**	**0**	**(0%)**	**$2.0**	**(8%)**
Exposure fire	90	(4%)	0	(0%)	0	(0%)	$1.7	(7%)
Rekindle	20	(1%)	0	(0%)	0	(0%)	$0.3	(1%)
	0							
Operational deficiency	**70**	**(3%)**	**0**	**(0%)**	**3**	**(9%)**	**$0.6**	**(3%)**
Unclassified operational deficiency	30	(1%)	0	(0%)	0	(0%)	$0.6	(3%)
Collision or turn over	*10*	*(0%)*	*0*	*(0%)*	*0*	*(0%)*	*$0.0*	*(0%)*
Design, manufacturing or installation deficiency	**20**	**(1%)**	**0**	**(0%)**	**0**	**(0%)**	**$0.0**	**(0%)**
	0							
Natural condition	**20**	**(1%)**	**0**	**(0%)**	**3**	**(9%)**	**$0.0**	**(0%)**
	0							
Unclassified factor	**80**	**(4%)**	**0**	**(0%)**	**3**	**(9%)**	**$3.2**	**(13%)**
	0							
Total factor-contributing entries	**2,290**	**(104%)**	**3**	**(100%)**	**30**	**(100%)**	**$24.6**	**(102%)**
Total fires	**2,210**	**(100%)**	**3**	**(100%)**	**30**	**(100%)**	**$24.2**	**(100%)**

Table 7B.
U.S. Bus and School Bus Fires, by Factor Contributing to Ignition
Based on Version 5.0 Data Percents
1999-2003 Annual Averages
(Continued)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages.

Groups are shown in descending order, and within groups, factors exceeding 1% are also shown in descending order. Unclassified type factors are shown last. Group sums include all factors within the group, even when the factors were under 1% and consequently not shown. The one exception is for collision or turnover under operational deficiency, included because of its relevance. Multiple factors can be entered per fire, which is why total entries exceed total fires. All sums are sums of factor entries.

This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable. The percentages are based on the data collected originally in Version 5.0. The estimates were developed by applying these percentages to the combined total of bus fires collected in all versions of NFIRS. Fires, in which the factor contributing to ignition was undetermined, not reported, or coded as "none" were allocated proportionally among fires with known factor contributing to ignition.

Source: NFIRS and NFPA survey.

Table 8.
U.S. Bus and School Bus Fires, by Heat Source
1999-2003 Annual Averages

Heat Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Radiated or conducted heat from operating equipment	440	(20%)	1	(22%)	6	(20%)	$3.6	(15%)
Arcing	440	(20%)	0	(0%)	10	(32%)	$2.9	(12%)
Unclassified heat from powered equipment	330	(15%)	0	(0%)	1	(2%)	$2.8	(12%)
Heat or spark from friction	260	(12%)	1	(30%)	2	(7%)	$3.9	(16%)
Unclassified hot or smoldering object	190	(9%)	0	(0%)	1	(3%)	$1.1	(5%)
Unclassified heat source	160	(7%)	1	(26%)	2	(8%)	$3.8	(16%)
Spark, ember or flame from operating equipment	100	(5%)	0	(0%)	2	(7%)	$0.5	(2%)
Backfire from internal combustion engine	90	(4%)	0	(0%)	0	(0%)	$1.1	(4%)
Match	40	(2%)	0	(0%)	6	(20%)	$0.7	(3%)
Heat from direct flame or convection currents	30	(1%)	0	(0%)	0	(0%)	$2.2	(9%)
Cigarette lighter	20	(1%)	0	(0%)	0	(0%)	$0.4	(2%)
Multiple heat sources including multiple ignitions	20	(1%)	0	(0%)	0	(0%)	$0.1	(1%)
Molten or hot material	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Radiated heat from another fire	10	(1%)	1	(22%)	0	(0%)	$0.1	(0%)
Other known heat source	70	(3%)	0	(0%)	0	(0%)	$0.9	(4%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable. Fires in which the heat source was undetermined or not reported were allocated proportionally among fires with known heat source.

Source: NFIRS and NFPA survey.

Table 9.
U.S. Bus and School Bus Fires, by Area of Fire Origin
1999-2003 Annual Averages

Area of Fire Origin	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Vehicle engine area, running gear or wheel area	1,520	(69%)	2	(63%)	19	(62%)	$16.4	(68%)
Vehicle operator or passenger area	270	(12%)	0	(0%)	7	(24%)	$3.7	(15%)
Unclassified vehicle area	120	(6%)	1	(20%)	2	(5%)	$0.7	(3%)
Exterior exposed surface of vehicle	80	(4%)	0	(0%)	1	(2%)	$1.8	(8%)
Separate operator or control area of vehicle	70	(3%)	0	(0%)	0	(0%)	$0.6	(2%)
Unclassified area of origin	30	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
On or near highway, parking lot or street	20	(1%)	0	(0%)	1	(2%)	$0.1	(0%)
Vehicle cargo or trunk area	20	(1%)	0	(0%)	0	(0%)	$0.1	(0%)
Vehicle fuel tank or fuel line	20	(1%)	0	(17%)	0	(0%)	$0.2	(1%)
Other known area of origin	50	(2%)	0	(0%)	1	(5%)	$0.6	(2%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable. Fires in which the area or origin was unknown or not reported were allocated proportionally among fires with known area of origin.

Source: NFIRS and NFPA survey.

Table 10.
U.S. Bus and School Bus Fires, by Item First Ignited
1999-2003 Annual Averages
Based on Version 5.0 Data Percents

Item First Ignited	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Electrical wire or cable insulation	650	(29%)	1	(27%)	0	(0%)	$7.1	(29%)
Flammable or combustible liquid or gas, piping or filter	600	(27%)	1	(39%)	0	(0%)	$7.0	(29%)
Unclassified item first ignited	420	(19%)	1	(21%)	30	(100%)	$4.2	(17%)
Tire	190	(8%)	0	(0%)	0	(0%)	$2.8	(12%)
Vehicle seat or upholstered furniture	80	(4%)	0	(0%)	0	(0%)	$1.0	(4%)
Conveyor belt, drive belt or V-belt	50	(2%)	0	(0%)	0	(0%)	$0.4	(2%)
Multiple items first ignited	50	(2%)	0	(0%)	0	(0%)	$0.7	(3%)
Unclassified general materials	30	(1%)	0	(7%)	0	(0%)	$0.3	(1%)
Film or residue, including paint or resin	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Magazine, newspaper or writing paper	20	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Dust, fiber or lint, including sawdust and excelsior	10	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Mattress or pillow	10	(1%)	0	(0%)	0	(0%)	$0.3	(1%)
Rubbish, trash, or waste	10	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Unclassified organic material	10	(1%)	0	(0%)	0	(0%)	$0.0	(0%)
Other known item first ignited	50	(2%)	0	(7%)	0	(0%)	$0.2	(1%)
Total	2,210	(100%)	3	(100%)	30	(100%)	$24.2	(100%)

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage is rounded to the hundred thousand. Sums may not equal totals due to rounding errors. Property damage figures are not adjusted for inflation. Percentages were calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. This table includes a proportional share of vehicle fires in which the mobile property type was unknown, unreported or not applicable. The percentages are based on the data collected originally in Version 5.0. The estimates were developed by applying these percentages to the combined total of bus fires collected in all versions of NFIRS. Fires in which the item first ignited was unknown or not reported were allocated proportionally among fires with known item first ignited.

Source: NFIRS and NFPA survey.

Appendix
How National Estimates Statistics Are Calculated

Estimates are made using the National Fire Incident Reporting System (NFIRS) of the Federal Emergency Management Agency's (FEMA's) United States Fire Administration (USFA), supplemented by the annual stratified random-sample survey of fire experience conducted by the National Fire Protection Association (NFPA), which is used for calibration.

Databases Used

NFIRS provides annual computerized databases of fire incidents, with data classified according to a standard format based on the NFPA 901 Standard. Roughly three-fourths of all states have NFIRS coordinators, who receive fire incident data from participating fire departments and combine the data into a state database. These data are then transmitted to FEMA/USFA. Participation by the states, and by local fire departments within participating states, is voluntary. NFIRS captures roughly one-third to one-half of all U.S. fires each year. More than one-third of all U.S. fire departments are listed as participants in NFIRS, although not all of these departments provide data every year.

The strength of NFIRS is that it provides the most detailed incident information of any national database not limited to large fires. NFIRS is the only database capable of addressing national patterns for fires of all sizes by specific property use and specific fire cause. (The NFPA survey separates fewer than 20 of the hundreds of property use categories defined by NFPA 901 and solicits no cause-related information except for incendiary and suspicious fires.) NFIRS also captures information on the avenues and extent of flame spread and smoke spread and on the performance of detectors and sprinklers. For more information about NFIRS visit http://www.usfa.fema.gov/nfirs.

The NFPA survey is based on a stratified random sample of roughly 3,000 U.S. fire departments (or just over one of every ten fire departments in the country). The survey includes the following information: (1) the total number of fire incidents, civilian deaths, and civilian injuries, and the total estimated property damage (in dollars), for each of the major property use classes defined by the NFPA 901 Standard; (2) the number of on-duty firefighter injuries, by type of duty and nature of illness; and (3) information on the type of community protected (e.g., county versus township versus city) and the size of the population protected, which is used in the statistical formula for projecting national totals from sample results.

The NFPA survey begins with the NFPA Fire Service Inventory, a computerized file of about 30,000 U.S. fire departments, which is the most complete and thoroughly validated such listing in existence. The survey is stratified by size of population protected to reduce the uncertainty of the final estimate. Small rural communities protect fewer people per department and are less likely to respond to the survey, so a large number must be surveyed to obtain an adequate sample of those departments. (NFPA also makes follow-up calls to a sample of the smaller fire departments that do not respond, to confirm

that those that did respond are truly representative of fire departments their size.) On the other hand, large city departments are so few in number and protect such a large proportion of the total U.S. population that it makes sense to survey all of them. Most respond, resulting in excellent precision for their part of the final estimate. The results of the survey are published in the annual report Fire Loss in the United States. To download a free copy of the report visit http://www.nfpa.org/assets/files/PDF/OS.fireloss.pdf.

Projecting NFIRS to National Estimates

To project NFIRS results to national estimates, one needs at least an estimate of the NFIRS fires as a fraction of the total so that the fraction can be inverted and used as a multiplier or scaling ratio to generate national estimates from NFIRS data. But NFIRS is a sample from a universe whose size cannot be inferred from NFIRS alone. Also, participation rates in NFIRS are not necessarily uniform across regions and sizes of community, both of which are factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that a second database - the NFPA survey - is needed to project NFIRS to national estimates and to project different parts of NFIRS separately. This multiple calibration approach makes use of the annual NFPA survey where its statistical design advantages are strongest.

There are separate projection formulas for four major property classes (residential structures, non-residential structures, vehicles, and other) and for each measure of fire severity (fire incidents, civilian deaths, and civilian injuries, and direct property damage).

For example, the scaling ratio for 2002 civilian deaths in residential structures is equal to the total number of 2002 civilian deaths in residential structure fires reported to fire departments, according to the NFPA survey (2,695), divided by the total number of 2002 civilian deaths in residential structure fires reported to NFIRS (1,029). Therefore, the scaling ratio is 2,695/1,029 = 2.62.

The scaling ratios for civilian deaths and injuries and direct property damage are often significantly different from those for fire incidents. Except for fire service injuries, average severity per fire is generally higher for NFIRS than for the NFPA survey. Use of different scaling ratios for each measure of severity is equivalent to assuming that these differences are due either to NFIRS under-reporting of small fires, resulting in a higher-than-actual loss-per-fire ratio, or possible biases in the NFIRS sample representation by region or size of community, resulting in severity-per-fire ratios characteristic only of the oversampled regions or community sizes.

Note that this approach also means that the NFPA survey results for detailed property-use classes (e.g., fires in storage structures) may not match the national estimates of the same value.

Calculating National Estimates of Particular Types of Fires

Most analyses of interest involve the calculation of the estimated number of fires not only within a particular occupancy but also of a particular type. The types that are mostly frequently of interest are those defined by some ignition-cause characteristic. The six cause-related characteristics most commonly used to describe fires are: form of the heat that caused the ignition, equipment involved in ignition, form or type of material first ignited, the ignition factor that brought heat source and ignited material together, and area of origin. Other characteristics of interest are victim characteristics, such as ages of persons killed or injured in fire.

For any characteristic of interest in NFIRS, some reported fires have that characteristic unknown or not reported. If the unknowns are not taken into account, then the propensity to report or not report a characteristic may influence the results far more than the actual patterns on that characteristic. For example, suppose the number of fires remained the same for several consecutive years, but the percentage of fires with cause unreported steadily declined over those years. If the unknown-cause fires were ignored, it would appear as if fires due to every specific cause increased over time while total fires remained unchanged. This, of course, does not make sense.

Consequently, most national estimates analyses allocate unknowns. This is done by using scaling ratios defined by NFPA survey estimates of totals divided by only those NFIRS fires for which the dimension in question was known and reported. This approach is equivalent to assuming that the fires with unreported characteristics, if known, would show the same proportions as the fires with known characteristics. For example, it assumes that the fires with unknown item first ignited contain the same relative share of fires beginning with: cooking materials or food; rubbish, trash or waste; upholstered furniture; structural members or framing; and so forth, as are found in the fires where the item first ignited was reported.

Note that percentages are calculated from unrounded values, and so it is quite possible to have a percentage entry of up to 100%, even if the rounded number entry is zero.