HIGH-RISE BUILDING FIRES

John R. Hall, Jr.

September 2013

National Fire Protection Association
Fire Analysis and Research Division

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Abstract

In 2007-2011, there were an average of 15,400 reported structure fires in high-rise buildings per year and associated losses of 46 civilian deaths, 530 civilian injuries, and $219 million in direct property damage per year. Four property classes account for half of high-rise fires: apartment buildings, hotels, office buildings, and facilities that care for the sick. Automatic fire protection equipment and fire-resistive construction are more common in high-rise buildings that have fires than in other buildings of the same property use that have fires. The risks of fire, fire death, and direct property damage due to fire tend to be lower in high-rise buildings than in shorter buildings of the same property use.

Keywords: fire statistics, high-rise, apartments, care of sick, office, hotel, fire protection, hospital, clinic, doctor's office

Acknowledgements

The National Fire Protection Association thanks all the fire departments and state fire authorities who participate in the National Fire Incident Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that make this analysis possible. Their contributions allow us to estimate the size of the fire problem.

We are also grateful to the U.S. Fire Administration for its work in developing, coordinating, and maintaining NFIRS.

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National Fire Protection Association
One-Stop Data Shop
1 Batterymarch Park
Quincy, MA 02169-7471
www.nfpa.org
e-mail: osds@nfpa.org
phone: 617-984-7443

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Executive Summary

In 2007-2011, an estimated 15,400 reported high-rise structure fires per year resulted in associated losses of 46 civilian deaths, 530 civilian injuries, and $219 million in direct property damage per year. An estimated 3% of all 2007-2011 reported structure fires were in high-rise buildings.

The trends in high-rise fires and associated losses (inflation-adjusted for property damage) are clearly down, but the sharp post-1998 reduction appears to be mostly due to the change to NFIRS Version 5.0, which is shifting estimates to lower levels that also appear to be more accurate.

Four property classes account for half of high-rise fires: apartments, hotels, offices, and facilities that care for the sick. In 2007-2011, in these four property classes combined, there were 7,700 reported high-rise structure fires per year and associated losses of 27 civilian deaths, 370 civilian injuries, and $92 million in direct property damage per year. The property damage average is inflated by the influence of one 2008 hotel fire, whose $100 million loss projected to nearly $40 million a year in the analysis.

This report emphasizes these four property classes. Some other property uses – such as stores and restaurants – may represent only a single floor in a tall building primarily devoted to other uses. Some property uses – such as grain elevators and factories – can be as tall as a high-rise building but without a large number of separate floors or stories. For these reasons, the four property use groups listed above define most of the buildings we think of as high-rise buildings, and their fires come closest to defining what we think of as the high-rise building fire problem.

By most measures of loss, the risks of fire and of associated fire loss are lower in high-rise buildings than in other buildings of the same property loss. This statement applies to risk of fire, civilian fire deaths, civilian fire injuries, and direct property damage due to fire, relative to housing units, for apartments, and risk of fire for hotels, offices, and facilities that care for the sick.

The usage of wet pipe sprinklers and fire detection equipment is higher in high-rise buildings than in other buildings, for each property use group. Even so, considering the extensive requirements in NFPA 101®, *Life Safety Code*, for fire and life safety features in both new and existing high-rise buildings, the findings in this report suggest that there are still major gaps, particularly in adoption and enforcement of the provisions requiring retrofit of automatic sprinkler systems and other life safety systems in existing high-rise buildings. NFPA 1®, *Fire Code,* has sprinkler retrofit requirements.

This has implications for public officials and ordinary citizens in any city. Public officials should make sure that the latest editions of NFPA 1®, *Fire Code,* and NFPA 101®, *Life Safety Code,* are in place and that the codes they have are supported by effective code enforcement provisions, including plan review and inspection processes,

both for new construction and for continued supervision of code compliance in existing buildings. The public can take responsibility for their own safety by insisting that their public officials take these steps. As in so many areas of fire safety, we know what to do, but we still need to do it.

The trend had been toward a smaller share of fires being reported each year as occurring in buildings with fire-resistive construction, both for high-rise and other buildings, with the decline being most dramatic in facilities that care for the sick. This statistical decline could reflect any or all of the following: (a) a shift in construction between the two types permitted by codes, from Type I (442 or 332) construction, which is coded as fire-resistive, to Type II (222) construction, which is coded as protected non-combustible; (b) a shift to acceptable alternative designs using more sprinklers and less fire-resistive construction; or (c) enough success in containing fires that a rising fraction never are reported to fire departments, because the fires are caught and controlled so early by occupants.

Most high-rise building fires begin on floors no higher than the 6th story. The fraction of 2007-2011 high-rise fires that began on the 7th floor or higher was 37% for apartments, 28% for hotels and motels, 19% for facilities that care for the sick, and 36% for office buildings. The risk of a fire start is greater on the lower floors for apartments, hotels and motels, and facilities that care for the sick, but greater on the upper floors for office buildings.

High-rise apartments have a slightly larger share of their fires originating in means of egress than do their shorter counterparts (3% vs. 2%). The same is true of hotels (6% vs. 4%) but not of facilities that care for the sick (both 4%). In offices (3% vs. 6%), the differences in percentages are in the opposite direction, which means that high-rise buildings in those properties have a smaller share of their fires originating in means of egress. In all four property classes, the differences are so small that one can say there is no evidence that high-rise buildings have a bigger problem with fires starting in means of egress.

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U.S. High-Rise Building Fires Fact Sheet

In 2007-2011, U.S. fire departments responded to an average of **15,400** structure fires in high-rise buildings.[1] These fires caused an annual average of

- 46 civilian fire deaths
- 530 civilian fire injuries
- $219 million in direct property damage

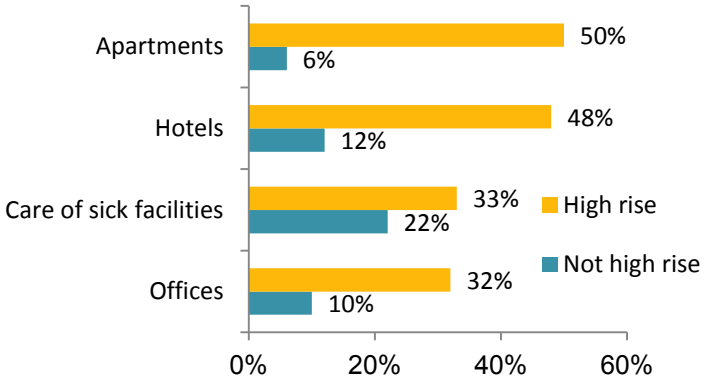
- Four property use groups account for half of high-rise fires:
  - Apartments (45% of all high-rise fires)
  - Hotels (3% of high-rise fires)
  - Facilities that care for the sick (1% of high-rise fires)
  - Offices (2% of high-rise fires)
  - The rest were mostly property uses found in mixed-use residential or office buildings (such as restaurants, stores, and parking garages) or probable miscodes of properties that cannot be high-rise (such as dwellings and sheds)

- By most measures, the risks of fire and of associated losses are **lower** in high-rise buildings than in other buildings of the same property use.

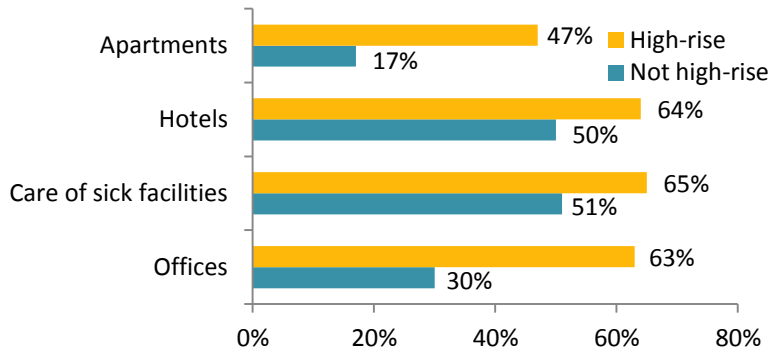
- A major reason why risks are lower is probably the much greater use of fire protection systems and features[2] in high-rise buildings as compared to shorter buildings.

- High-rise buildings have lower percentages of fires with flame damage beyond room of origin, providing further evidence of impact from fire protection systems and features :
  - Apartments (6% of high-rise fires vs. 10% in shorter buildings)
  - Hotels (6% of high-rise fires vs. 10% in shorter buildings)
  - Facilities that care for the sick (5% of high-rise fires vs. 8% in shorter buildings)
  - Offices (14% of high-rise fires vs. 21% in shorter buildings)

Presence of Fire-Resistive Construction in Fires, 1994-1998



Presence of Wet-Pipe Sprinklers in Fires Excluding Partial Systems and Buildings Under Construction, 2007-2011



1 "High rise" is defined here as 7 stories above grade. This is roughly consistent with the Life Safety Code definition of high rise as 75 feet (23 meters) in height, measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story.

2 Construction type of building involved in fire is not reported after 1998.

What is a High-Rise?

Paragraph 3.3.36.7 of NFPA 101®, *Life Safety Code*, 2012 edition, defines a high-rise building as a building more than 75 feet (23 meters) in height, measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story. A height of 75 feet translates into roughly seven stories.

The number of stories was first captured in U.S. national fire incident coding in Version 4.0 of the National Fire Incident Reporting System (NFIRS). This version was in widespread use by 1985. Version 5.0, introduced in 1999, provides separate coding for the total number of stories and the number of stories above and below ground. In keeping with the definition in NFPA 101®, *Life Safety Code*, a height above ground of seven or more stories is used to define high-rise from 1999 on.

Prior to 1999, the National Fire Incident Reporting System (NFIRS) coded building height in ranges, including four that may be considered high-rise: 7-12 stories, 13-24 stories, 25-49 stories, and 50 stories or more.

NFPA and other analysts have long used lists of particularly memorable incidents to study the high-rise fire problem, but these and other available special data bases are heavily weighted toward larger and more severe incidents. They should be viewed as illustrative but not representative.

The Council on Tall Buildings and Urban Habitat was created in 1969 in part to disseminate information on tall building technology. Visit their website at www.ctbuh.org for more information on their resources.

Also, for more information on high-rise fires and fire safety visit www.nfpa.org/highrise.

High-Rise Building Fires

In 2007-2011, an estimated 15,400 reported high-rise structure fires per year resulted in associated losses of 46 civilian deaths, 530 civilian injuries, and $219 million in direct property damage per year[1].

Four property classes account for half (50%) of high-rise fires:

- Apartments (Property Use codes 420-429) (45% of all high-rise fires),
- Hotels (Property Use codes 440-449) (3% of all high-rise fires),
- Facilities that care for the sick – hospitals, clinics, and doctor's offices (Property Use codes 330-339; also includes code 593 (medical or research office) prior to 1999; also includes codes 340-349 in and after 1999 under NFIRS Version 5.0) (1% of all high-rise fires),
- Offices, excluding doctor's offices (Property Use codes 590-599, excluding 593 prior to 1999) (2% of all high-rise fires).

In 2007-2011, in these four property classes combined, there were 7,700 reported high-rise structure fires per year and associated losses of 27 civilian deaths, 370 civilian injuries, and $92 million in direct property damage per year. Overall, 3% of all 2007-2011 structure fires occurred in high-rise properties, as well as 7% of 2007-2011 structure fires in the four primary property uses.

Most reported high-rise fires not in these four primary property uses were in (a) property uses commonly found in a mixed-use high-rise building whose primary use is residential or office, such as mercantile properties, eating or drinking establishments, or parking garages, and (b) apparently miscoded property uses that cannot be high-rise, such as single family homes, duplexes, or sheds.

See Table 1 for statistics for each year of 1985 to 1998 and for the average for 2007-2011, for each of the four primary property use classes and for these four property uses combined.

Beginning in 1999, limited reporting is permitted by NFIRS for six types of confined fires – confined to cooking vessel, chimney or flue, burner or boiler, trash, commercial compactor, or incinerator. Because height of building need not be reported for confined fire, estimates must be based on a small percentage of confined fires with reported height of building. This can create significant year-to-year variation and is the reason why year-by-year results are not provided after 1998.

[1] Beginning in 1999, limited reporting is permitted by NFIRS for six types of confined fires – confined to cooking vessel, chimney or flue, burner or boiler, trash, commercial compactor, or incinerator. Because height of building need not be reported for confined fire, estimates must be based on a small percentage of confined fires with reported height of building. This can create significant year-to-year variation and is the reason why year-by-year results are not provided after 1998.

This report emphasizes the four primary property classes. Some property uses – such as grain elevators and factories – can be as tall as a high-rise building but without a large number of separate floors or stories. For these reasons, the four property use groups listed above define most of the buildings we think of as high-rise buildings, and their fires come closest to defining what we think of as the high-rise building fire problem.

The calculations for Table 1 were done so as to proportionally allocate fires with height of structure unreported, with the allocation done separately for the four property classes and the four measures of loss – incidents, deaths, injuries, and property damage. Fires with number of stories above ground reported as zero nearly always also report stories below ground as unknown or zero. This suggests a zero value nearly always means unknown height, and so zeros are treated as unknowns. See Appendix A for more details on statistical methods.

These statistics generally show a declining fire problem from 1985 to 1998. After 1998, fires and losses declined more rapidly for apartments, hotels, and facilities that care for the sick. For various technical reasons (discussed more in Appendix B) it is likely that the new numbers are more accurate than the old numbers – in a direction that reduces the estimates – which would mean the more rapid decline may not be real.

It is worth noting, in Table 1, that most high-rise building fires and associated losses occur in apartment buildings. This may seem surprising, but it shouldn't. Homes dominate the U.S. fire problem so completely that it is always a good bet that any newly examined fire problem, unless it is one that cannot occur in homes, will have its largest share in homes.

Table 2 provides more detail, indicating 2007-2011 structure fires by number of stories, for each of the four property classes.

Table 3 shows how the percentage of structure fires that are in high-rise buildings varies for a range of mixed-use properties, from a high of 8% in medical use properties to a low of 0% in military use properties.

Table 1. High-Rise Building Fires in Selected Property Classes, by Year

A. Apartments

Year	Fire	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)		What Percentage of All Fires
				As Reported	2011 Dollars	Were High-Rise?
1985	11,700	54	470	$15	$32	10%
1986	10,300	32	380	$21	$44	9%
1987	8,900	46	520	$22	$43	8%
1988	10,300	83	640	$48	$91	9%
1989	11,000	97	610	$30	$55	10%
1990	9,400	76	460	$22	$39	9%
1991	9,900	23	590	$129*	$212*	9%
1992	10,300	31	640	$19	$31	9%
1993	9,600	43	600	$41	$63	9%
1994	8,900	51	830	$36	$55	9%
1995	7,700	53	530	$31	$45	8%
1996	9,600	56	650	$33	$48	10%
1997	9,200	27	480	$30	$42	10%
1998	8,100	35	570	$23	$31	9%
2007-2011 average	6,800	27	340	$39	$40	7%

*Property damage figures for apartments in 1991 are inflated by problems in handling the Oakland wildfire in the estimates.

Note: Analysis of 2007-2011 fires is done separately for fires reported as confined fires – confined to fuel burner or boiler, cooking vessel, chimney or flue, trash, incinerator, or commercial compactor. These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional share of fires with unknown building height (until 1998) or number of stories above ground coded as unknown, blank or zero (from 1999 on). Fires are rounded to the nearest hundred, civilian deaths to the nearest one, civilian injuries are rounded to the nearest ten, and direct property damage to the nearest million dollars. Property damage has been adjusted for inflation, using the Consumer Price Index, to 2011 dollars. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 1. High-Rise Building Fires in Selected Property Classes, by Year (Continued)

B. Hotels

Year	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)		What Percentage of all Hotel and Motel Fires
				As Reported	2011 Dollars	Were High-Rise?
1985	1,800	0	70	$2	$4	21%
1986	1,600	0	50	$2	$4	20%
1987	1,500	5	40	$6	$12	20%
1988	1,800	8	60	$20	$38	24%
1989	1,600	5	60	$4	$8	22%
1990	1,600	7	120	$6	$10	24%
1991	1,300	0	90	$6	$10	21%
1992	1,300	0	80	$4	$6	21%
1993	1,000	0	60	$6	$10	17%
1994	900	0	70	$4	$7	17%
1995	1,000	0	70	$5	$8	20%
1996	1,100	8	100	$17	$24	21%
1997	800	6	40	$9	$12	18%
1998	800	0	20	$11	$15	19%
2007-2011 average	400	0	20	$46	$48*	11%

* Average damages in 2007-2011 are greatly inflated due to one 2008 fire in a 32-story building, with damages of $100 million, which projected to nearly $40 million a year.

Note: Analysis of 2007-2011 fires is done separately for fires reported as confined fires – confined to fuel burner or boiler, cooking vessel, chimney or flue, trash, incinerator, or commercial compactor. These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional share of fires with unknown building height (until 1998) or number of stories above ground coded as unknown, blank or zero (from 1999 on). Fires are rounded to the nearest hundred, civilian deaths to the nearest one, civilian injuries are rounded to the nearest ten, and direct property damage to the nearest million dollars. Property damage has been adjusted for inflation, using the Consumer Price Index, to 2011 dollars. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 1. High-Rise Building Fires in Selected Property Classes, by Year (Continued)

C. Facilities That Care for the Sick

Year	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)		What Percentage of All Fires in Facilities That Care for the Sick
				As Reported	2011 Dollars	Were High Rise?
1985	2,500	11	120	$2	$5	34%
1986	2,000	4	30	$1	$1	32%
1987	1,700	0	70	$2	$3	28%
1988	1,500	2	70	$1	$2	30%
1989	1,400	9	110	$5	$9	30%
1990	1,400	0	40	$3	$6	33%
1991	1,200	0	50	$3	$5	31%
1992	1,100	2	20	$3	$5	27%
1993	1,000	0	30	$3	$4	28%
1994	900	6	40	$4	$6	26%
1995	800	2*	40	$3	$4	26%
1996	900	0*	20	$4	$6	28%
1997	800	0	30	$1	$2	25%
1998	600	2	80	$6	$9	24%
2007-2011	200	0	10	$2	$2	12%

*Based on high-rise share of fires in 1995 and 1996, because all deaths were in buildings with unknown height.

Note: Analysis of 2007-2011 fires is done separately for fires reported as confined fires – confined to fuel burner or boiler, cooking vessel, chimney or flue, trash, incinerator, or commercial compactor. These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional share of fires with unknown building height (until 1998) or number of stories above ground coded as unknown, blank or zero (from 1999 on). Fires are rounded to the nearest hundred, civilian deaths to the nearest one, civilian injuries are rounded to the nearest ten, and direct property damage to the nearest million dollars. Property damage has been adjusted for inflation, using the Consumer Price Index, to 2011 dollars. Facilities that care for the sick include hospitals, clinics, and doctor's offices. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 1. High-Rise Building Fires in Selected Property Classes, by Year (Continued)

D. Offices

Year	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)		What Percentage of All Office Fires
				As Reported	2011 Dollars	Were High Rise?
1985	1,200	1	10	$6	$12	14%
1986	1,100	1	80	$17	$35	13%
1987	900	2	10	$7	$14	11%
1988	1,000	0	20	$34	$65	14%
1989	900	0*	20	$18	$33	13%
1990	900	0	10	$15	$27	14%
1991	800	0	10	$12	$20*	12%*
1992	1,000	1	90	$57	$91	13%
1993	800	0	20*	$10	$16*	13%*
1994	600	0	16	$16	$24	11%
1995	500	0	50	$6	$8	10%
1996	500	0	20	$14	$20	9%
1997	600	0	10	$3	$5	11%
1998	500	0	10	$3	$4	10%
2007-2011 average	300	0	10	$6	$6	8%

* Property damage figures for office buildings are underestimated in several years due to problems in handling some large-loss fires, such as the $325 million One Meridian Plaza fire in Pennsylvania in 1991 and the $230 million World Trade Center incident in 1993, whose more than 1,000 injuries also are not reflected in national estimates. Also, the deaths in a 1989 Georgia high-rise office building fire are not reflected in the estimates.

Note: Analysis of 2007-2011 fires is done separately for fires reported as confined fires – confined to fuel burner or boiler, cooking vessel, chimney or flue, trash, incinerator, or commercial compactor. These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional share of fires with unknown building height (until 1998) or number of stories above ground coded as unknown, blank or zero (from 1999 on). Fires are rounded to the nearest hundred, civilian deaths to the nearest one, civilian injuries are rounded to the nearest ten, and direct property damage to the nearest million dollars. Property damage has been adjusted for inflation, using the Consumer Price Index, to 2011 dollars. Offices include general business offices, bank buildings, and post offices, but exclude doctor's offices, which are included in facilities that care for the sick. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

In 1985, 1986, 1989, 1991, and 1992, all office fire deaths, were in buildings with unreported height. An estimated three deaths were allocated.

Source: NFIRS and NFPA survey.

Table 1. High-Rise Building Fires in Selected Property Classes, by Year (Continued)

E. Four Property Use Groups Combined

Year	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)	
				As Reported	2011 Dollars
1985	17,200	66	670	$25	$53
1986	15,100	38	550	$41	$85
1987	13,000	52	640	$36	$72
1988	14,600	94	780	$104	$197
1989	14,800	111	800	$58	$105
1990	13,300	84	620	$47	$81
1991	13,100	23	750	$150*	$248*
1992	13,600	35	830	$83	$133
1993	12,400	43	700*	$60*	$93*
1994	11,400	57	950	$60	$91
1995	10,000	55	690	$44	$65
1996	12,100	64	790	$69	$99
1997	11,400	33	560	$43	$61
1998	10,000	37	680	$42	$58
2007-2011 average	7,700	27	370	$92*	$96*

* Average damages in 2007-2011 are greatly inflated due to one 2008 fire in a 32-story hotel, with damages of $100 million, which projected to nearly $40 million per year. Property damage figures for apartments in 1991 are inflated by problems in handling the Oakland wildfire in the estimates. Property damage figures for office buildings are underestimated in several years due to problems in handling some large-loss fires, such as the $325 million One Meridian Plaza fire in Pennsylvania in 1991 and the $230 million World Trade Center incident in 1993, whose more than 1,000 injuries also are not properly reflected in national estimates.

Note: Analysis of 2007-2011 fires is done separately for fires reported as confined fires – confined to fuel burner or boiler, cooking vessel, chimney or flue, trash, incinerator, or commercial compactor. These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional share of fires with unknown building height (until 1998) or number of stories above ground coded as unknown, blank or zero (from 1999 on). Fires are rounded to the nearest hundred, civilian deaths to the nearest one, civilian injuries are rounded to the nearest ten, and direct property damage to the nearest million dollars. Property damage has been adjusted for inflation, using the Consumer Price Index, to 2011 dollars. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 2. Fires in Selected Properties, by Number of Stories Above Ground
Annual Average of 2007-2011 Structure Fires Reported to U.S. Fire Departments

A. Apartments

	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
1 story	17,650	(17%)	65	(16%)	471	(11%)	$130	(10%)
2 stories	43,400	(42%)	201	(49%)	1,866	(44%)	$613	(49%)
3 stories	26,090	(25%)	79	(19%)	1,110	(26%)	$359	(29%)
4 stories	5,660	(5%)	16	(4%)	235	(5%)	$80	(6%)
5 stories	2,290	(2%)	13	(3%)	98	(2%)	$19	(2%)
6 stories	1,960	(2%)	8	(2%)	144	(3%)	$9	(1%)
Total not high-rise (1-6 stories)	**97,040**	**(93%)**	**409**	**(93%)**	**3,915**	**(92%)**	**$1,248**	**(97%)**
7 stories	1,250	(1%)	7	(2%)	48	(1%)	$5	(0%)
8 stories	940	(1%)	1	(0%)	30	(1%)	$2	(0%)
9 stories	630	(1%)	2	(0%)	19	(0%)	$2	(0%)
10 stories	1,270	(1%)	3	(1%)	35	(1%)	$2	(0%)
11 stories	570	(1%)	1	(0%)	21	(0%)	$1	(0%)
12 stories	840	(1%)	2	(1%)	23	(1%)	$2	(0%)
13 or more stories	1,350	(1%)	11	(3%)	160	(4%)	$24	(2%)
Total high-rise (7 or more stories)	**6,850**	**(7%)**	**27**	**(7%)**	**336**	**(8%)**	**$39**	**(3%)**

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional shares of fire with number of stories above ground coded as unknown, blank or zero. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage to the nearest million dollars without adjustment for inflation. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 2. Fires in Selected Properties, by Number of Stories Above Ground (Continued)
Annual Average of 2007-2011 Structure Fires Reported to U.S. Fire Departments

B. Hotels

	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
1 story	700	(20%)	4	(37%)	27	(20%)	$15	(12%)
2 stories	780	(22%)	6	(51%)	54	(38%)	$32	(26%)
3 stories	820	(24%)	1	(6%)	21	(15%)	$16	(13%)
4 stories	460	(13%)	1	(6%)	15	(11%)	$13	(10%)
5 stories	180	(5%)	0	(0%)	2	(1%)	$1	(1%)
6 stories	150	(4%)	0	(0%)	3	(2%)	$2	(2%)
Total not high-rise (1-6 stories)	**3,080**	**(89%)**	**11**	**(100%)**	**122**	**(87%)**	**$79**	**(63%)**
7 stories	50	(1%)	0	(0%)	1	(1%)	$1	(1%)
8 stories	40	(1%)	0	(0%)	1	(1%)	$0	(0%)
9 stories	40	(1%)	0	(0%)	4	(3%)	$0	(0%)
10 stories	70	(2%)	0	(0%)	1	(1%)	$0	(0%)
11 stories	20	(0%)	0	(0%)	1	(1%)	$2	(2%)
12 stories	50	(1%)	0	(0%)	3	(2%)	$0	(0%)
13 or more stories	140	(4%)	0	(0%)	6	(4%)	$42	(34%)
Total high-rise (7 or more stories)	**390**	**(11%)**	**0**	**(0%)**	**18**	**(13%)**	**$46**	**(37%)**

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional shares of fire with number of stories above ground coded as unknown, blank or zero. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage to the nearest million dollars without adjustment for inflation. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 2. Fires in Selected Properties, by Number of Stories Above Ground (Continued)
Annual Average of 2007-2011 Structure Fires Reported to U.S. Fire Departments

C. Facilities That Care for the Sick

	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
1 story	710	(36%)	0	(0%)	5	(16%)	$16	(45%)
2 stories	350	(18%)	0	(0%)	5	(18%)	$8	(23%)
3 stories	210	(11%)	0	(0%)	5	(19%)	$6	(17%)
4 stories	170	(9%)	0	(0%)	0	(1%)	$2	(6%)
5 stories	140	(7%)	0	(100%)	3	(11%)	$1	(3%)
6 stories	140	(7%)	0	(0%)	2	(7%)	$0	(1%)
Total not high-rise (1-6 stories)	**1,730**	**(88%)**	**0**	**(100%)**	**21**	**(72%)**	**$32**	**(94%)**
7 stories	60	(3%)	0	(0%)	1	(2%)	$1	(3%)
8 stories	80	(4%)	0	(0%)	2	(8%)	$0	(1%)
9 stories	30	(1%)	0	(0%)	4	(13%)	$0	(0%)
10 stories	20	(1%)	0	(0%)	0	(0%)	$0	(0%)
11 stories	10	(1%)	0	(0%)	0	(0%)	$0	(0%)
12 stories	10	(0%)	0	(0%)	0	(0%)	$0	(1%)
13 or more stories	20	(1%)	0	(0%)	2	(5%)	$1	(1%)
Total high-rise (7 or more stories)	**230**	**(12%)**	**0**	**(0%)**	**8**	**(28%)**	**$2**	**(6%)**

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional shares of fire with number of stories above ground coded as unknown, blank or zero. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage to the nearest million dollars without adjustment for inflation. Facilities that care for the sick include hospitals, clinics, and doctor's offices. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 2. Fires in Selected Properties, by Number of Stories Above Ground (Continued)
Annual Average of 2007-2011 Structure Fires Reported to U.S. Fire Departments

D. Offices

	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
1 story	1,580	(49%)	0	(5%)	16	(36%)	$47	(42%)
2 stories	760	(24%)	1	(32%)	8	(18%)	$35	(31%)
3 stories	330	(10%)	1	(25%)	10	(22%)	$9	(8%)
4 stories	170	(5%)	0	(12%)	2	(4%)	$5	(5%)
5 stories	80	(2%)	0	(0%)	0	(0%)	$8	(7%)
6 stories	50	(2%)	1	(26%)	1	(3%)	$2	(2%)
Total not high-rise (1-6 stories)	**2,970**	**(92%)**	**4**	**(100%)**	**37**	**(84%)**	**$106**	**(95%)**
7 stories	40	(1%)	0	(0%)	0	(0%)	$0	(0%)
8 stories	20	(1%)	0	(0%)	0	(0%)	$0	(0%)
9 stories	20	(1%)	0	(0%)	0	(0%)	$0	(0%)
10 stories	20	(1%)	0	(0%)	0	(0%)	$0	(0%)
11 stories	10	(0%)	0	(0%)	0	(0%)	$0	(0%)
12 stories	40	(1%)	0	(0%)	1	(3%)	$0	(0%)
13 or more stories	100	(3%)	0	(0%)	6	(13%)	$5	(5%)
Total high-rise (7 or more stories)	**250**	**(8%)**	**0**	**(0%)**	**7**	**(16%)**	**$6**	**(5%)**

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional shares of fire with number of stories above ground coded as unknown, blank or zero. Fires are rounded to the nearest ten, civilian deaths and injuries to the nearest one, and direct property damage to the nearest million dollars without adjustment for inflation. Offices include general business offices, bank buildings, and post offices, but exclude doctor's offices, which are included in facilities that care for the sick. Estimates of deaths, injuries, or property damage can be significantly affected by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 3. High-Rise Percentage of Structure Fires in Mixed-Use Properties
Percentage of 2007-2011 Structure Fires Reported to U.S. Fire Departments
(Including Fires Reported as Confined Fires)

Mixed Use Status	Percentage of Fires in High-Rise Properties
Medical use	8%
Office use	7%
Business and residential	7%
Unclassified mixed-use status	5%
Assembly use	5%
Residential use	4%
Industrial use	3%
Educational use	3%
Not mixed use	2%
Row of stores (mercantile properties)	2%
Enclosed mall	1%
Farm use	1%
Military use	0%
Unknown mixed-use status	3%
All structures	3%

Note: "Mixed use" refers to buildings with more than one property use, such as a building with stores and restaurants on some floors, apartment units on other floors, and hotel rooms on still other floors. These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Estimates include proportional shares of fire with number of stories above ground coded as unknown, blank or zero.

Source: NFIRS and NFPA survey.

Is There More or Less Fire-Related Risk in a High-Rise Building?

By most measures of loss, the risks of fire and of associated fire loss are lower in high-rise buildings than in other buildings of the same property uses. For apartments, this statement applies to risk of fire, civilian fire deaths, civilian fire injuries, and direct property damage due to fire, relative to housing units. It also applies to risk of fire for hotels, offices, and facilities that care for the sick.

Statistics on the U.S. building inventory by height of building are scarce and not ideally suited to calculations of relative fire risk, but some analysis is possible.

The best data is on apartment buildings. Statistics are published on U.S. housing units in every odd-numbered year. In 2007-2011, an average of 9% of occupied year-round housing units in apartment buildings (defined as buildings with 3 or more housing units) were in high-rise buildings.[2]

Risk can be calculated as fires (or fire loss) per million housing units (or per million buildings, per million occupants, or per billion square feet). Risk is therefore a ratio of a measure of fire loss to a measure of units of exposure, where "exposure" refers to people, space, or value exposed to potential harm if fire occurs.

Suppose high-rise risk is expressed as follows:

[loss in high-rise buildings]/[units of exposure of high-rise buildings]

= [(high-rise % of loss) x (total loss)]/
[(high-rise % of exposure units) x (total exposure units)].

Non-high-rise risk would be defined comparably. Then a comparison measure for high-rise vs. non-high-rise risk could be expressed as follows:

[high-rise risk]/[non-high-rise risk]
= [(high-rise % of loss)/(high-rise % of exposure units)]/
[(non-high-rise % of loss)/(non-high-rise % of exposure units)]

= [(high-rise % of loss)/(high-rise % of exposure units)]/
[(100% - high-rise % of loss)/(100% - high-rise % of exposure units)].

Because both risk measures include total loss divided by total exposure in their formulas, you can cancel those terms and compare ratios of percentages only. And because the high-rise and non-high-rise percentages add to 100%, you need only the high-rise percentages of loss and exposure to make the comparison.

[2] Analysis based on data from the 2007, 2009 and 2011 editions of the *American Housing Survey* and the *American Community Survey*, both published by the U.S. Census Bureau..

Now suppose that for high-rise buildings the percentage of fire loss is less than the percentage of exposure. If the high-rise percentage of fire loss is less than the high-rise percentage of exposure, then the high-rise risk is lower than the non-high-rise risk.[3]

In 2007-2011, 7% of apartment fires were in high-rise buildings. (See Table 2A.) Because 7% is lower than 9%, the risk of fire in a high-rise apartment building is lower than in an apartment building that is not a high-rise.

Also in 2007-2011, high-rise buildings accounted for 7% of civilian deaths in apartment fires, 8% of civilian injuries in apartment fires, and 3% of direct property damage in apartment fires. (See Table 2A.) For all these loss measures, the risk is lower in a high-rise apartment than in other apartments.

For the other three property classes, other data must be used, and it is necessary to measure exposure by square feet rather than number of buildings or housing units. The U.S. Energy Information Administration published figures on floor space for properties with defined ranges of square feet of floor space.[4] (The latest available is from 2003. Data from the 2007 survey did not support valid estimates and was not published, and the first survey since 2007 began data collection only a few months ago.) Breakdowns are available by defined ranges of number of stories or by principal economic activity in the building, but not by both simultaneously.

An estimate can be made of the percent of exposure (floor space) occurring in high-rise buildings for a particular property use by taking the sum over the various floor-space ranges of: (fraction of that property use's total floor space occurring in buildings with floor space in the defined range) times (combining all types of property uses, fraction of total floor space in buildings with a defined range of floor space occurring in high-rise buildings). Because the defined ranges of number of stories do not include a break at seven stories (the minimum for a high-rise), three estimates are useful. The lower bound is for buildings with ten or more stories, and the upper bound is for buildings with four or more stories. The middle estimate is based on assuming that buildings of various heights have comparable footprints, so that their total floor space is proportional to their number of stories. If that is true, then the 7-9 story share of floor space in buildings with 4-9 stories will be (7+8+9)/(4+5+6+7+8+9) or 62%.

These crude formulas produce the following estimates for the high-rise share of exposure (floor space):

- For lodging properties, the estimate is 17-57%, with a middle estimate of 41%. (These numbers may be depressed by the inclusion of lodging properties other than hotels and motels. The former tend to be smaller.)
- For office buildings, the estimate is 25-46%, with a middle estimate of 38%.
- For health care properties, the estimate is 18-55%, with a middle estimate of 41%.

[3] In that case the risk-related ratio will be less than one (e.g., if the high-rise percentage of fire loss were 7% and the high-rise percentage of exposure were 8%, a higher number, then 7%/8% is less than one). Moreover, the corresponding percentages for low-rise buildings will be 100% minus the high-rise percentages (because every building has to be high-rise or low-rise and cannot be both). The low-rise ratio will be greater than one if the high-rise ratio is less than one (e.g., 93%/92% is more than one).

[4] See the 2003 Commercial Buildings Energy Consumption Survey, Energy Information Administration website, http://www.eia.doe.gov/emeu/cbecs.

These compare to high-rise shares of 2007-2011 reported structure fires of 11% for hotels and motels, 8% for office buildings and 12% for facilities that care for the sick. (See Tables 2B to 2D.)

The combination of all these statistics is sufficient to indicate that the high-rise share of fires is lower, indicating lower risk, than the high-rise share of square footage in use, for hotels, offices, and facilities that care for the sick.

For direct property damage, the high-rise share was 37% for hotels, 6% for facilities that care for the sick, and 5% for offices. (See Tables 2B to 2D.) Except for hotels, these are all well below the corresponding ranges for high-rise share of square footage, indicating a clearly lower risk of property damage in high-rise buildings compared to other buildings, for offices and facilities that care for the sick. The hotel percentage is distorted by the effect of a single 2008 fire in a 32-story hotel with $100 million in loss. Without that fire, the high-rise percentage for property damage in hotels would be well under 10%.

Fire Protection in High-Rise Buildings

NFPA 101®, *Life Safety Code* has for decades had provisions for existing as well as new high-rise buildings. Where NFPA 101®, *Life Safety Code*, is adopted into law or otherwise followed in practice, these required practices should be in place.

In NFPA 101®, *Life Safety Code*, 2012 edition, section 11.8 contains requirements potentially applicable to a high-rise building. The chapter for a particular occupancy determines whether all or some of the section 11.8 requirements are required for that occupancy and determines whether the requirements are for new or existing buildings. Among the section 11.8 requirements are an approved supervised automatic sprinkler system; a Class I standpipe system; a fire alarm system with an approved emergency voice/alarm communication system; two-way telephone service for fire department use; emergency lighting; standby power; and an emergency command center.

Existing high-rise hotels must be protected throughout by an approved supervised automatic sprinkler system.

Existing high-rise health care occupancies must be Type I (442 or 332) or Type II (222) construction (as must existing health care occupancies 4-6 stories in height). (See NFPA 220®, *Standard on Types of Building Construction*, for more details on the different types of construction.) This corresponds to the "fire resistive" construction type category previously used in NFIRS as well as a subpart of the "protected noncombustible" category. A provision added to the code in 2009 and modified in the 2012 edition requires existing high-rise hospitals to be protected with automatic sprinklers within a nine-year period. Since 2006, the code has required all nursing homes, regardless of height, to be protected with automatic sprinklers.

The defined construction types can be briefly summarized by these major characteristics:

- Fire resistive – Concrete or fire-resistant-covered steel construction rated for 2 hours;
- Heavy timber – Construction where any exposed wood load-bearing members has no dimension less than 2 inches;
- Protected non-combustible – Concrete or fire-resistant-covered steel construction rated for 1 hours;
- Unprotected non-combustible – Exposed steel construction without fire-resistant covering;
- Protected ordinary – Masonry load-bearing walls with columns, wood floors, and roof decks all protected by fire-resistive coating rated for 1 hour;
- Unprotected ordinary – Masonry load-bearing walls with exposed columns, wood floors, and roof decks without fire-resistive coating;
- Protected wood frame – Wood frame construction with wall and ceiling surfaces protected by fire-resistive covering, such as gypsum board; and
- Unprotected wood frame – Wood frame construction without fire-resistive covering.

Existing high-rise apartment buildings are required to have an approved supervised automatic sprinkler system, installed throughout, with two exceptions. One is if every living unit has exterior exit access in accordance with section 7.5.3; the other is if the building has an "approved, engineered life safety system" in accordance with section 31.3.5.11.4. The latter exception for an engineered life safety system, (see section 39.4.2.1(2)) is also the only exception to the requirement for a complete, approved, supervised automatic sprinkler system in existing high-rise office buildings. NFPA 1®, *Fire Code*, requires sprinkler retrofitting in all high-rise buildings.

Changes in fire incident coding, effective in 1999, have affected the comparability of statistics from before and after this year. Since 1999, NFIRS (the national fire incident data base) has included an option to report fires as confined fires, in which case very little detail is required. This change encourages the reporting of very small fires, but introduces a high degree of uncertainty in the analysis of detailed characteristics of those fires.

Table 4 provides statistics on percentage of fires with fire protection present for three types of fire protection for three groups of years (1986-1989[5], 1994-1998, and 2007-2011):

- Automatic extinguishing equipment. In 2007-2011, partial systems and equipment other than wet-pipe sprinklers can be identified and have been excluded. This refinement of the statistics is partly to mostly responsible for the drops in fires reported with equipment present.
- Fire detection equipment.
- Fire resistive construction. Type of construction is no longer collected and is not available for 2007-2011.

Some conclusions can be seen in Table 4.

- The usage of wet pipe sprinklers is much greater in high-rise buildings than in other buildings, for each property use group. This is less true for facilities that care for the sick, where the usage of automatic extinguishing equipment has always been greater for buildings that are or are not high-rise. For hotels, the gap has become smaller, in part because of much greater reported sprinkler usage in low-rise buildings.

- The usage of fire detection equipment is greater in high-rise buildings than in other buildings, for each property use group, although usage is so high in apartment buildings, hotels, and facilities that care for the sick, regardless of height, that the gaps for those property use groups are all small.

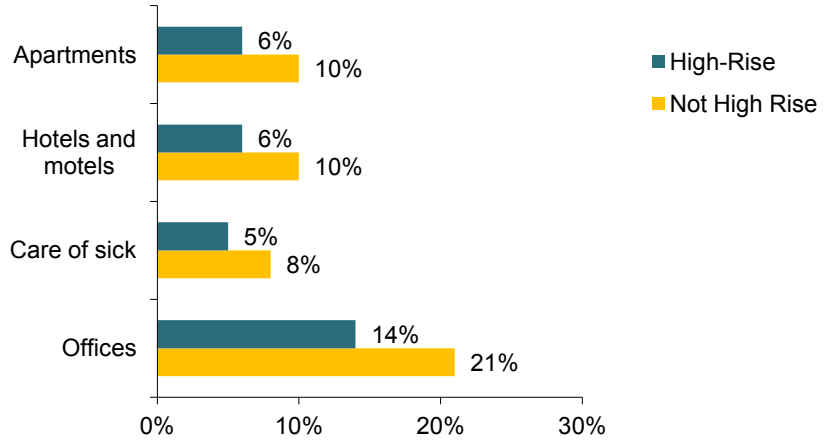
- For fire-resistive construction, the trend had been toward a smaller share of fires being reported each year as occurring in buildings with fire-resistive construction, both for high-rise and other buildings, with the decline being most dramatic in facilities that care for the sick. This statistical decline could reflect any or all of the following: (a) a shift in construction between the two types permitted by

[5] Height of building was first recorded in 1985, but participation in reporting on this new data element was low until 1986. These year groupings are roughly 10 years apart.

codes, from Type I (442 or 332) construction, which is coded as fire-resistive, to Type II (222) construction, which is coded as protected non-combustible; (b) a shift to acceptable alternative designs using more sprinklers and less fire-resistive construction; or (c) enough success in containing fires that a rising fraction never are reported to fire departments, because the fires are caught and controlled so early by occupants.

- The greater usage of fire protection systems and features is the most likely explanation of the lower statistical risk of property damage in high-rise buildings compared to other buildings, as noted in the previous section.
- The greater usage of fire protection systems and features also is the most likely explanation of the lower statistical risk of fire death in high-rise apartments compared to other apartments, as noted in the previous section. In the other property uses, there are not enough deaths per year for a stable analysis of differences between high-rise and other buildings.
- The value of these fire protection systems and features can also be seen in the differences in final extent of flame damage. See Figure 1.

Figure 1. Flame Damage Beyond Room of Origin, by Property Use and High-Rise versus Not High-Rise Percentage of 2007-2011 Structure Fires Reported to U.S. Fire Departments



Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height.

Source: NFIRS and NFPA survey.

Buildings under construction or major renovation may not have all fire protection features and systems in place and operational. NFPA has records of at least one large loss that started in a high-rise building under construction and then spread on many floors to an adjacent occupied high-rise building. For this reason, it may be useful to know how often high-rise building fires involve properties under construction or major renovation.

In 2007-2011, buildings under construction or major renovation accounted for:

- 1% of fires in high-rise apartments (compared to 1% of fires in apartments that were not high-rise);
- 3% of fires in high-rise hotels (compared to 2% of fires in hotels that were not high-rise); and
- 2% of fires in high-rise facilities that care for the sick (compared to 4% of fires in such facilities that were not high-rise);
- 3% of fires in high-rise offices (compared to 3% of fires in offices that were not high-rise).

Table 4. Fire Protection in High-Rise vs. Other Buildings, by Major Property Use

A. Apartments

1. Automatic Extinguishing Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Equipment present	23%	3%	5%
1994-1998: Equipment present	32%	5%	7%
2007-2011: Wet-pipe sprinklers present, excluding partial systems and buildings under construction	47%	17%	19%

2. Fire Detection Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Equipment present	69%	58%	59%
1994-1998: Equipment present	85%	76%	77%
2007-2011: Equipment present	90%	86%	86%

3. Fire Resistive Construction

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Construction is fire resistive	57%	7%	12%
1994-1998:Construction is fire resistive	50%	6%	10%

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Prior to 1999, fires with unknown structure height are not allocated before calculating percentages, and statistics for "all buildings" are based only on structures of known height. These statistics may differ from statistics based on calculations that include structures of unknown height.

Source: NFIRS and NFPA survey.

Table 4. Fire Protection in High-Rise vs. Other Buildings, by Major Property Use (Continued)

B. Hotels

1. Automatic Extinguishing Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Equipment present	62%	18%	28%
1994-1998: Equipment present	72%	26%	35%
2007-2011:Wet pipe sprinklers present, excluding partial systems and buildings under construction	64%	50%	52%

2. Fire Detection Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1986: Equipment present	84%	65%	69%
1994-1998: Equipment present	89%	76%	79%
2007-2011: Equipment present	92%	88%	88%

3. Fire Resistive Construction

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Construction is fire resistive	57%	14%	23%
1994-1998: Construction is fire resistive	48%	12%	19%

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Prior to 1999, fires with unknown structure height are not allocated before calculating percentages, and statistics for "all buildings" are based only on structures of known height. These statistics may differ from statistics based on calculations that include structures of unknown height.

Source: NFIRS and NFPA survey.

Table 4. Fire Protection in High-Rise vs. Other Buildings, by Major Property Use (Continued)

C. Facilities That Care for the Sick

1. Automatic Extinguishing Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Equipment present	62%	51%	54%
1994-1998: Equipment present	76%	57%	62%
2007-2011: Wet pipe sprinklers present, excluding partial systems and buildings under construction	65%	51%	54%

2. Fire Detection Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Equipment present	89%	76%	80%
1994-1998: Equipment present	94%	82%	85%
2007-2011: Equipment present	91%	87%	87%

3. Fire Resistive Construction

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Construction is fire resistive	39%	30%	33%
1994-1998: Construction is fire resistive	33%	22%	26%

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Prior to 1999, fires with unknown structure height are not allocated before calculating percentages, and statistics for "all buildings" are based only on structures of known height. These statistics may differ from statistics based on calculations that include structures of unknown height. Facilities that care for the sick include hospitals, clinics, and doctor's offices.

Source: NFIRS and NFPA survey.

Table 4. Fire Protection in High-Rise vs. Other Buildings, by Major Property Use (Continued)

D. Offices

1. Automatic Extinguishing Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Equipment present	47%	17%	21%
1994-1998: Equipment present	61%	21%	25%
2007-2011: Wet pipe sprinklers present, excluding partial systems and buildings under construction	63%	30%	33%

2. Fire Detection Equipment

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Equipment present	69%	33%	37%
1994-1998: Equipment present	79%	48%	51%
2007-2011: Equipment present	85%	67%	68%

3. Fire Resistive Construction

Year of Fire	High-Rise Buildings	Buildings That Are Not High-Rise	All Buildings
1986-1989: Construction is fire resistive	36%	14%	18%
1994-1998: Construction is fire resistive	32%	10%	13%

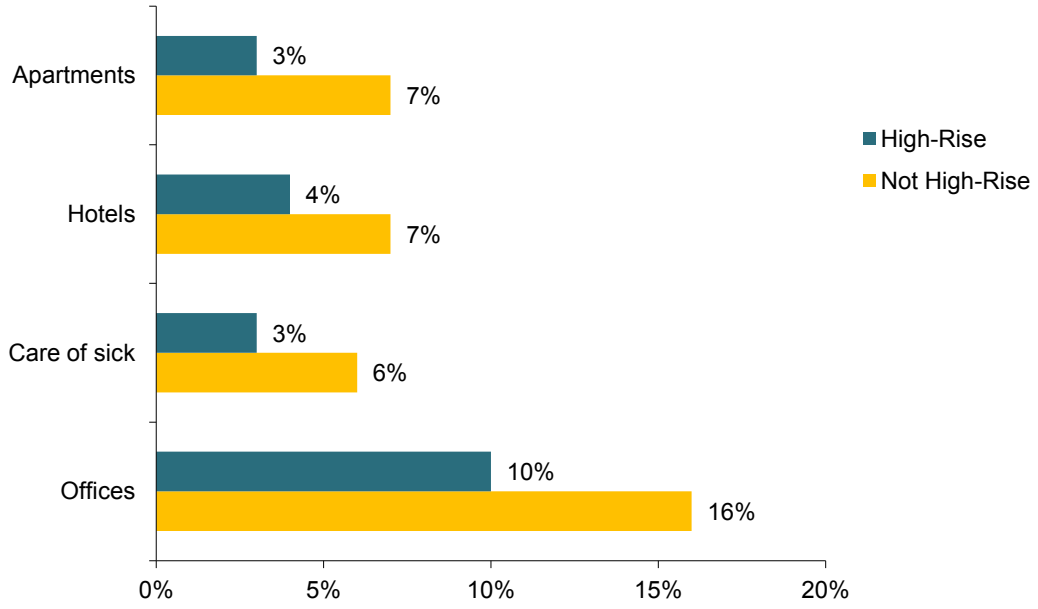
Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Prior to 1999, fires with unknown structure height are not allocated before calculating percentages, and statistics for "all buildings" are based only on structures of known height. These statistics may differ from statistics based on calculations that include structures of unknown height. Offices include general business offices, bank buildings, and post offices, but exclude doctor's offices, which are included in facilities that care for the sick.

Source: NFIRS and NFPA survey.

Other Patterns of High-Rise Building Fires

Figure 2 shows that flame damage beyond the floor of origin is rare in high-rise buildings. These are the fires that are most likely to extend into the stairways, although many of these fires begin outside the building or in ducts, shafts, or concealed spaces, where spread to another floor can easily follow a path that does not involve or affect the stairway.

Figure 2. Flame Damage Beyond Floor of Origin, by Property Use and High-Rise versus Not High-Rise Percentage of 2007-2011 Structure Fires Reported to U.S. Fire Departments



When a high-rise fire fatally injures people who were not on the floor of origin when the fire began, there is usually some type of failure to maintain protection of stairways or elevators. Here are some examples:

- *Elevator travels to fire-involved floor and opens*. This problem has been largely eliminated by elevator redesign and prominent display of warnings against elevator use during a fire. An older example of a fire where five people died under these conditions is documented in Laurence D. Watrous, "Fatal hotel fire: New Orleans," *Fire Journal*, January 1972, pp. 5-8.

- *Door to exit stairs is blocked open and allows smoke or fire to enter*. An example with multiple fatalities is documented in Mike Isner, "Smoking fire kills four in New York high-rise," *Fire Journal*, September/October 1988, pp. 72-77.

- *Substandard or other inadequate or non-compliant enclosure of stairs allows smoke into stairways*. This problem is particularly well illustrated in Richard Best and David P. Demers, "Fire at the MGM Grand," *Fire Journal*, January 1982, pp. 19-37.

To view a list of NFPA investigations of high-rise building fires, visit www.nfpa.org/investigations. They provide case-study evidence of the potential hazard in high-rise buildings that do not provide adequate fire protection.

Just because a fire occurs in a high-rise building, that does not mean the fire began at or above the 7th floor. Figure 3 shows that most high-rise building fires begin on floors no higher than the 6th story. The fraction of 2007-2011 high-rise fires that began on the 7th floor or higher was 37% for apartments, 28% for hotels and motels, 19% for facilities that care for the sick, and 36% for office buildings.

These results are due in part to the fact that a large percentage of floors in high-rise buildings are located below the 7th floor. For example, for a 7-story building (and ignoring floors below grade), only 1/7 of the floors are at or above the 7th floor. Using Tables 2A to 2D, we can calculate that 37-46% of the floors in high-rise apartments are 7th floor or higher (where the range reflects the fact that we do not show statistics for different building heights when the building is at least 13 stories tall). Similar statistics for other property uses are 34-35% for hotels and motels, 26-27% for facilities that care for the sick, and 34-35% for offices.

For apartments, hotels, and facilities that care for the sick, the percentage of floors that are 7th floor or higher in high-rise buildings with reported fires is as great as or greater than the percentage of those same fires *starting* on the 7th floor or higher. In other words, the risk of a fire starting is as great as or greater on the lower floors.

For offices, the fraction of floors in high-rise buildings with reported fires is slightly lower than the percentage of those same fires starting on the 7th floor or higher. Therefore, the risk of a fire start is slightly higher in the upper floors for office buildings.

One special concern with high-rise building fires could be fires originating in a means of egress. Means of egress include the following areas of origin:

- Hallway or corridor
- Interior stairway
- Exterior stairway
- Entrance way or lobby
- Escalator
- Unclassified means of egress

Table 5 shows that high-rise apartments have a slightly larger share of their fires originating in means of egress than do their shorter counterparts (3% vs. 2%). The same is true of hotels (6% vs. 4%) but not of facilities that care for the sick (both 4%). In offices (3% vs. 6%), the differences are in the opposite direction; high-rise buildings in these properties have a smaller share of their fires originating in means of egress. In all four property classes, the differences are so small that one can say there is no evidence that high-rise buildings have a bigger problem than shorter buildings with fires starting in means of egress.

Table 6 shows differences between the cause profiles of high-rise and other buildings, by property use. Some differences could reflect differences in activity correlated with building height.

For example, shorter hotels and motels might be less likely to have restaurants or room service and so more likely to have in-room cooking, either approved (in-room ranges and microwave ovens, which are found in some suite-type rooms) or unapproved (guests' hot plates).

Many shorter facilities that care for the sick are medical office buildings that are less likely to have patients checked in for overnight stays and so may have less cooking activity.

Cooking equipment accounts for a larger share of fires in shorter hotels and motels, paralleling what may be differences in degree of cooking activity, but not in taller facilities that care for the sick.

Another element in surviving a high-rise building fire is the ability of occupants to escape effectively. A 2007 survey study by NuStats for the Fire Protection Research Foundation found that levels of knowledge and preparedness related to escape readiness were quite different for residents of commercial high-rise buildings (presumably offices) compared to residential high-rise buildings (presumably apartments).[6] The following are two examples:

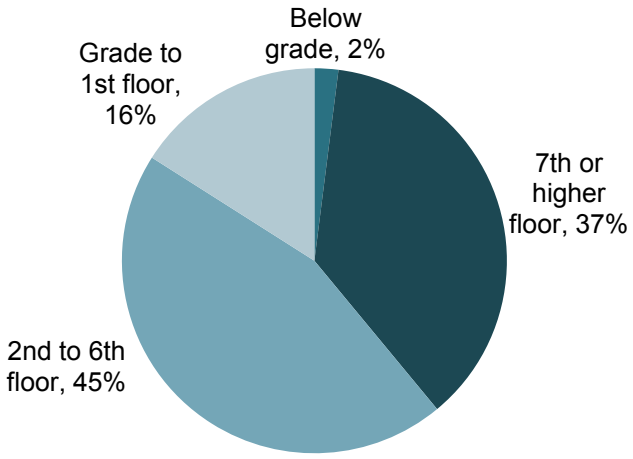
- Fire drills are much more common among residents of high-rise commercial buildings (83% had participated in a drill within the last year) than in residential buildings (19%).

- Flashlights are much more commonly in the possession of residents of high-rise residential buildings (76%) than in commercial buildings (30%).

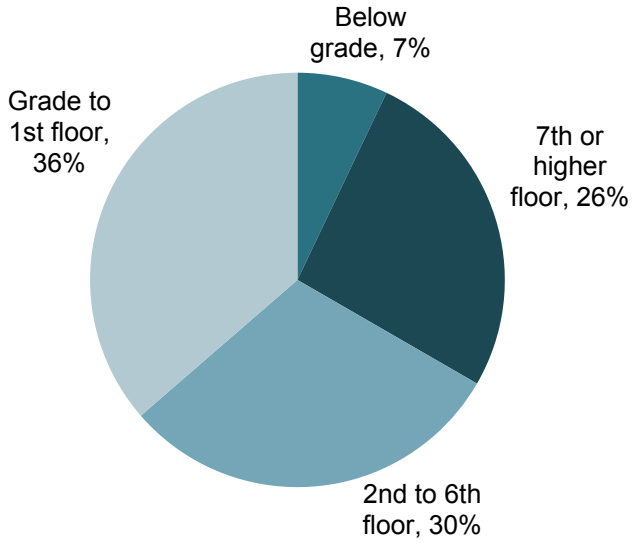
[6] Mia Zmud, *Public Perceptions of High-Rise Building Safety and Emergency Evacuation Procedures Research Project – Final Report,* Fire Protection Research Foundation, July 2007.

Figure 3. High-Rise Building Fires, by Level of Fire Origin
Percentage of 2007-2011 Structure Fires Reported to U.S. Fire Departments

A. Apartments



B. Hotels

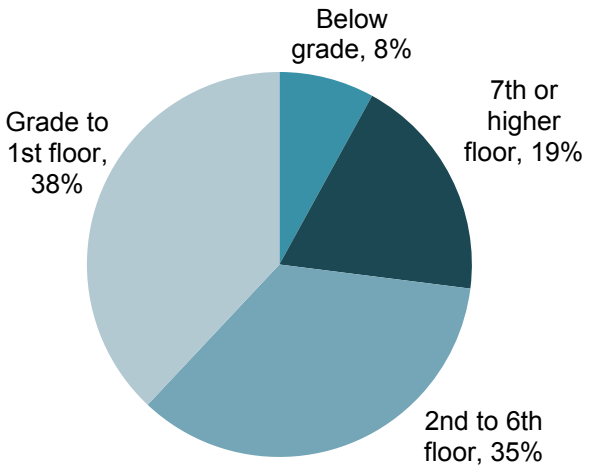


Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Includes proportional share of fires with level of fire origin or height of building unknown. There are six types of confined fires – confined to fuel burner or boiler, chimney or flue, cooking vessel, trash, incinerator or commercial compactor – which are analyzed separately. Fires coded as confined do not require reporting of most details, including building height.

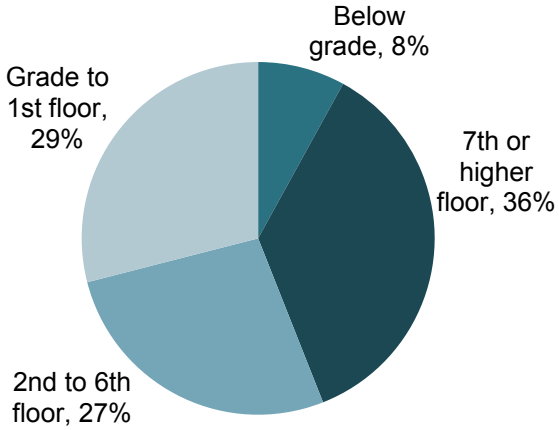
Source: NFIRS and NFPA survey.

Figure 3. High-Rise Building Fires, by Level of Fire Origin (Continued)
Percentage of 2007-2011 Structure Fires Reported to U.S. Fire Departments

C. Facilities That Care for the Sick



D. Offices



Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Includes proportional share of fires with level of fire origin or height of building unknown. There are six types of confined fires – confined to fuel burner or boiler, chimney or flue, cooking vessel, trash, incinerator or commercial compactor – which are analyzed separately. Fires coded as confined do not require reporting of most details, including building height.

Source: NFIRS and NFPA survey.

Table 5. High-Rise and Other Building Fires, by Leading Areas of Origin
Annual Average of 2007-2011 Structure Fires Reported to U.S. Fire Departments

A. Apartments

High-Rise			Non High-Rise		
Area of Origin	**Fires**		**Area of Origin**	**Fires**	
Kitchen	4,980	(73%)	Kitchen	67,810	(70%)
Bedroom	330	(5%)	Bedroom	4,790	(5%)
Trash room or area	260	(4%)	ALL MEANS OF EGRESS	2,370	(2%)
ALL MEANS OF EGRESS	250	(4%)	*Exterior stairway*	*600*	*(1%)*
Hallway or corridor	*80*	*(1%)*	*Interior stairway*	*470*	*(0%)*
Interior stairway	*70*	*(1%)*	*Unclassified means of egress*	*440*	*(0%)*
Unclassified means of egress	*40*	*(1%)*	*Entrance way or lobby*	*430*	*(0%)*
Entrance way or lobby	*30*	*(0%)*	*Hallway or corridor*	*420*	*(0%)*
Exterior stairway	*20*	*(0%)*	*Escalator*	*10*	*(0%)*
Living room, family room or den	230	(3%)	Living room, family room, or den	2,360	(2%)
			Exterior balcony or unenclosed porch	1,930	(2%)
			Laundry room	1,850	(2%)
			Bathroom	1,730	(2%)

B. Hotels and Motels

High-Rise			Non High-Rise		
Area of Origin	**Fires**		**Area of Origin**	**Fires**	
Kitchen	113	(29%)	Kitchen	1,228	(40%)
Bedroom (including guest room)	54	(14%)	Bedroom (including guest room)	414	(13%)
Laundry room or area	31	(8%)	Laundry room or area	222	(7%)
ALL MEANS OF EGRESS	22	(6%)	Bathroom or cloak room	130	(4%)
Entrance way or lobby	*7*	*(2%)*	ALL MEANS OF EGRESS	126	(4%)
Hallway or corridor	*5*	*(1%)*	*Hallway or corridor*	*38*	*(1%)*
Unclassified means of egress	*4*	*(1%)*	*Exterior stairway*	*33*	*(1%)*
Interior stairway	*3*	*(1%)*	*Entrance way or lobby*	*26*	*(1%)*
Exterior stairway	*2*	*(0%)*	*Unclassified means of egress*	*19*	*(1%)*
Bathroom or cloak room	18	(5%)	*Interior stairway*	*10*	*(0%)*
Trash room or area	14	(4%)			

Table 5. High-Rise and Other Building Fires, by Leading Areas of Origin (Continued)
Annual Average of 2007-2011 Structure Fires Reported to U.S. Fire Departments

C. Facilities That Care for the Sick

High-Rise		Non High-Rise	
Area of Origin	**Fires**	**Area of Origin**	**Percent of Fires**
Kitchen	93 (40%)	Kitchen	639 (37%)
Bathroom or locker room	11 (5%)	Office	104 (6%)
Bedroom (including patient room)	11 (5%)	Bathroom or locker room	103 (6%)
ALL MEANS OF EGRESS	9 (4%)	ALL MEANS OF EGRESS	62 (4%)
Unclassified means of egress	*5 (2%)*	*Hallway or corridor*	*20 (1%)*
Hallway	*3 (1%)*	*Entrance way or lobby*	*18 (1%)*
Unclassified function room	9 (4%)	*Exterior stairway*	*9 (1%)*
Laundry room or area	9 (4%)	*Interior stairway*	*8 (0%)*
Office	8 (4%)	*Unclassified means of egress*	*5 (0%)*
Unclassified service or equipment area	8 (4%)	*Escalator*	*1 (0%)*
		Heating equipment room or area	58 (3%)
Machinery room or area	8 (4%)	Bedroom (including patient room)	52 (3%)
		Laundry room	49 (3%)
		Exterior roof surface	47 (3%)
		Unclassified area of origin	44 (3%)

D. Offices

High-Rise		Non High-Rise	
Area of Origin	**Fires**	**Area of Origin**	**Percent of Fires**
Kitchen	58 (23%)	Kitchen	682 (23%)
Office	33 (13%)	Office	424 (14%)
Machinery room or area	21 (8%)	ALL MEANS OF EGRESS	172 (6%)
Unclassified service or equipment area	13 (5%)	*Entrance way or lobby*	*68 (2%)*
		Hallway or corridor	*29 (1%)*
ALL MEANS OF EGRESS	13 (5%)	*Unclassified means of egress*	*26 (1%)*
Entrance way or lobby	*5 (2%)*	*Interior stairway*	*24 (1%)*
Hallway or corridor	*2 (1%)*	*Exterior stairway*	*21 (1%)*
Unclassified means of egress	*2 (1%)*	*Escalator*	*4 (0%)*
Interior stairway	*2 (1%)*	Bathroom	143 (5%)
Exterior stairway	*2 (1%)*	Heating equipment room or area	114 (4%)
		Exterior wall surface	109 (4%)
		Exterior roof surface	90 (3%)
		Unclassified outdoor area	83 (3%)
		Attic or ceiling/roof assembly or concealed space	80 (3%)

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Includes proportional share of fires with level of fire origin or height of building unknown. There are six types of confined fires – confined to fuel burner or boiler, chimney or flue, cooking vessel, trash, incinerator or commercial compactor, which are analyzed separately. Fires coded as confined do not require reporting of most details, including building height. Fires are rounded to nearest ten for apartments and nearest one for all other tables. Fires with unknown area of origin are proportionally allocated.

Source: NFIRS and NFPA survey.

Table 6. High-Rise and Other Building Fires, by Leading Causes
Annual Average of 2007-2011 Structure Fires Reported to U.S. Fire Departments

A. Apartments

High-Rise			Non High-Rise		
Cause	**Fires**		**Cause**	**Fires**	
Cooking equipment	4,200	(61%)	Cooking equipment	55,580	(57%)
Heating equipment	880	(13%)	Heating equipment	14,870	(15%)
Smoking materials	430	(6%)	Smoking materials	5,260	(5%)
Intentional	260	(4%)	Intentional	5,170	(5%)
Exposure to other fire	240	(4%)	Exposure to other fire	4,540	(5%)

B. Hotels

High-Rise			Non High-Rise		
Area of Origin	**Fires**		**Area of Origin**	**Fires**	
Cooking equipment	127	(33%)	Cooking equipment	1,257	(41%)
Clothes dryer or washer	47	(12%)	Heating equipment	424	(14%)
Electrical distribution or lighting equipment	39	(10%)	Clothes dryer or washer	311	(10%)
			Intentional	232	(8%)
Heating equipment	34	(9%)	Smoking materials	217	(7%)
Smoking materials	33	(9%)	Air conditioning or fan	169	(5%)
Air conditioning or fan	26	(7%)	Electrical distribution or lighting equipment	158	(5%)

C. Facilities That Care for the Sick

High-Rise			Non High-Rise		
Area of Origin	**Fires**		**Area of Origin**	**Fires**	
Cooking equipment	103	(45%)	Cooking equipment	908	(52%)
Intentional	25	(11%)	Intentional	172	(10%)
Electrical distribution or lighting equipment	23	(10%)	Clothes dryer or washer	128	(7%)
			Electrical distribution or lighting equipment	124	(7%)
Air conditioning or fan	12	(5%)			
			Heating equipment	113	(7%)

D. Offices

High-Rise			Non High-Rise		
Area of Origin	**Fires**		**Area of Origin**	**Fires**	
Cooking equipment	82	(33%)	Cooking equipment	797	(27%)
Electrical distribution or lighting equipment	34	(13%)	Electrical distribution or lighting equipment	379	(13%)
Air conditioning or fan	16	(6%)	Intentional	287	(10%)
Intentional	13	(5%)	Heating equipment	278	(9%)
Smoking materials	12	(5%)	Air conditioning or fan	265	(9%)
			Smoking materials	254	(9%)

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Includes proportional share of fires with level of fire origin or height of building unknown. There are six types of confined fires – confined to fuel burner or boiler, chimney or flue, cooking vessel, trash, incinerator or commercial compactor – which are analyzed separately. Fires coded as confined do not require reporting of most details, including building height. Fires with unknown heat source, cause of ignition, or equipment involved in ignition have been proportionally allocated.

Source: NFIRS and NFPA survey.

Appendix A.
How National Estimates Statistics Are Calculated

The statistics in this analysis are estimates derived from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual survey of U.S. fire departments. NFIRS is a voluntary system by which participating fire departments report detailed factors about the fires to which they respond. Roughly two-thirds of U.S. fire departments participate, although not all of these departments provide data every year. Fires reported to federal or state fire departments or industrial fire brigades are not included in these estimates.

NFIRS 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. NFIRS also captures information on the extent of flame spread, and automatic detection and suppression equipment. For more information about NFIRS visit http://www.nfirs.fema.gov/. Copies of the paper forms may be downloaded from http://www.nfirs.fema.gov/documentation/design/NFIRS_Paper_Forms_2008.pdf.

NFIRS has a wide variety of data elements and code choices. The NFIRS database contains coded information. Many code choices describe several conditions. These cannot be broken down further. For example, area of origin code 83 captures fires starting in vehicle engine areas, running gear areas or wheel areas. It is impossible to tell the portion of each from the coded data.

Methodology may change slightly from year to year.
NFPA is continually examining its methodology to provide the best possible answers to specific questions, methodological and definitional changes can occur. *Earlier editions of the same report may have used different methodologies to produce the same analysis, meaning that the estimates are not directly comparable from year to year.*

NFPA's fire department experience survey provides estimates of the big picture.
Each year, NFPA conducts an annual survey of fire departments which enables us to capture a summary of fire department experience on a larger scale. Surveys are sent to all municipal departments protecting populations of 50,000 or more and a random sample, stratified by community size, of the smaller departments. Typically, a total of roughly 3,000 surveys are returned, representing about one of every ten U.S. municipal fire departments and about one third of the U.S. population.

The survey is stratified by size of population protected to reduce the uncertainty of the final estimate. Small rural communities have fewer people protected per department and are less likely to respond to the survey. A larger 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 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 in NFIRS; (2) the number of on-duty firefighter injuries, by type of duty and nature of illness; 3) the number and nature of non-fire incidents; and (4) 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 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 Fire Loss in the U.S. 2010.

Projecting NFIRS to National Estimates

As noted, NFIRS is a voluntary system. Different states and jurisdictions have different reporting requirements and practices. Participation rates in NFIRS are not necessarily uniform across regions and community sizes, both 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.

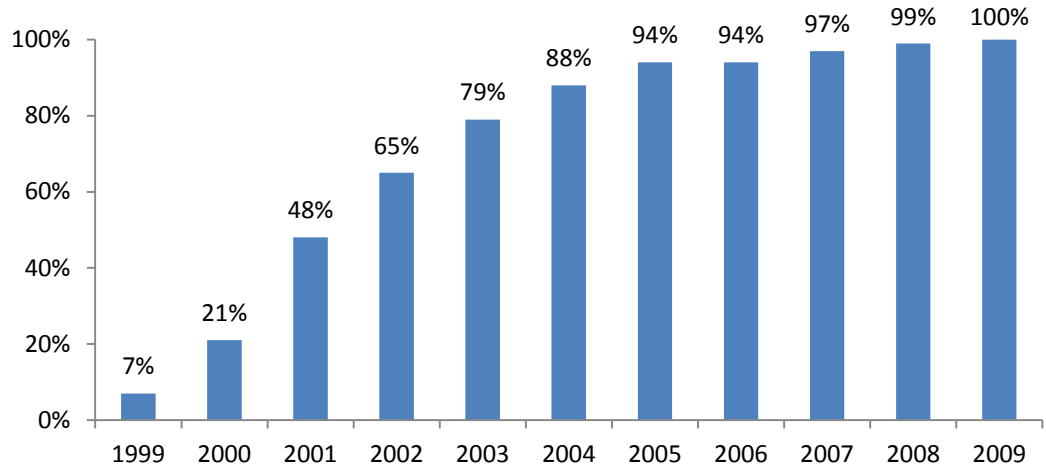
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific fire problems and circumstances are obtained by multiplying the NFIRS data by the scaling ratios. Reports for incidents in which mutual aid was given are excluded from NFPA's analyses.

Analysts at the NFPA, the USFA and the Consumer Product Safety Commission developed the specific basic analytical rules used for this procedure. "The National Estimates Approach to U.S. Fire Statistics," by John R. Hall, Jr. and Beatrice Harwood, provides a more detailed explanation of national estimates. A copy of the article is available online at http://www.nfpa.org/osds or through NFPA's One-Stop Data Shop.

Version 5.0 of NFIRS, first introduced in 1999, used a different coding structure for many data elements, added some property use codes, and dropped others. The essentials of the approach described by Hall and Harwood are still used, but some modifications have been necessary to accommodate the changes in NFIRS 5.0.

Figure A.1 shows the percentage of fires originally collected in the NFIRS 5.0 system. Each year's release version of NFIRS data also includes data collected in older versions of NFIRS that were converted to NFIRS 5.0 codes.

Figure A.1. Fires Originally Collected in NFIRS 5.0 by Year



From 1999 data on, analyses are based on scaling ratios using only data originally collected in NFIRS 5.0:

NFPA survey projections
NFIRS totals (Version 5.0)

For 1999 to 2001, the same rules may be applied, but estimates for these years in this form will be less reliable due to the smaller amount of data originally collected in NFIRS 5.0; they should be viewed with extreme caution.

NFIRS 5.0 introduced six categories of confined structure fires, including:

- cooking fires confined to the cooking vessel,
- confined chimney or flue fires,
- confined incinerator fire,
- confined fuel burner or boiler fire or delayed ignition,
- confined commercial compactor fire, and
- trash or rubbish fires in a structure with no flame damage to the structure or its contents.

Although causal and other detailed information is typically not required for these incidents, it is provided in some cases. Some analyses, particularly those that examine cooking equipment, heating equipment, fires caused by smoking materials, and fires started by playing with fire, may examine the confined fires in greater detail. Because the confined fire incident types describe certain scenarios, the distribution of unknown data differs from that of all fires. Consequently, allocation of unknowns must be done separately.

Some analyses of structure fires show only non-confined fires. In these tables, percentages shown are of non-confined structure fires rather than all structure fires. This

approach has the advantage of showing the frequency of specific factors in fire causes, but the disadvantage of possibly overstating the percentage of factors that are seldom seen in the confined fire incident types and of understating the factors specifically associated with the confined fire incident types.

Other analyses include entries for confined fire incident types in the causal tables and show percentages based on total structure fires. In these cases, the confined fire incident type is treated as a general causal factor.

For most fields other than Property Use and Incident Type, NFPA allocates unknown data proportionally among known data. This approach assumes that if the missing data were known, it would be distributed in the same manner as the known data. NFPA makes additional adjustments to several fields. *Casualty and loss projections can be heavily influenced by the inclusion or exclusion of unusually serious fire.*

In the formulas that follow, the term "all fires" refers to all fires in NFIRS on the dimension studied. The percentages of fires with known or unknown data are provided for non-confined fires and associated losses, and for confined fires only.

Cause of Ignition: This field is used chiefly to identify intentional fires. "Unintentional" in this field is a specific entry and does not include other fires that were not intentionally set: failure of equipment or heat source, act of nature, or "other" (unclassified)." The last should be used for exposures but has been used for other situations as well. Fires that were coded as under investigation and those that were coded as undetermined after investigation were treated as unknown.

Factor Contributing to Ignition: In this field, the code "none" is treated as an unknown and allocated proportionally. For Human Factor Contributing to Ignition, NFPA enters a code for "not reported" when no factors are recorded. "Not reported" is treated as an unknown, but the code "none" is treated as a known code and not allocated. Multiple entries are allowed in both of these fields. Percentages are calculated on the total number of fires, not entries, resulting in sums greater than 100%. Although Factor Contributing to Ignition is only required when the cause of ignition was coded as: 2) unintentional, 3) failure of equipment or heat source; or 4) act of nature, data is often present when not required. Consequently, any fire in which no factor contributing to ignition was entered was treated as unknown.

In some analyses, all entries in the category of mechanical failure, malfunction (factor contributing to ignition 20-29) are combined and shown as one entry, "mechanical failure or malfunction." This category includes:

21. Automatic control failure;
22. Manual control failure;
23. Leak or break. Includes leaks or breaks from containers or pipes. Excludes operational deficiencies and spill mishaps;
25. Worn out;
26. Backfire. Excludes fires originating as a result of hot catalytic converters;
27. Improper fuel used; Includes the use of gasoline in a kerosene heater and the like; and
20. Mechanical failure or malfunction, other.

Entries in "electrical failure, malfunction" (factor contributing to ignition 30-39) may also be combined into one entry, "electrical failure or malfunction." This category includes:

31. Water-caused short circuit arc;
32. Short-circuit arc from mechanical damage;
33. Short-circuit arc from defective or worn insulation;
34. Unspecified short circuit arc;
35. Arc from faulty contact or broken connector, including broken power lines and loose connections;
36. Arc or spark from operating equipment, switch, or electric fence;
37. Fluorescent light ballast; and
30. Electrical failure or malfunction, other.

Heat Source. In NFIRS 5.0, one grouping of codes encompasses various types of open flames and smoking materials. In the past, these had been two separate groupings. A new code was added to NFIRS 5.0, which is code 60: "Heat from open flame or smoking material, other." NFPA treats this code as a partial unknown and allocates it proportionally across the codes in the 61-69 range, shown below.

61. Cigarette;
62. Pipe or cigar;
63. Heat from undetermined smoking material;
64. Match;
65. Lighter: cigarette lighter, cigar lighter;
66. Candle;
67 Warning or road flare, fuse;
68. Backfire from internal combustion engine. Excludes flames and sparks from an exhaust system, (11); and
69. Flame/torch used for lighting. Includes gas light and gas-/liquid-fueled lantern.

In addition to the conventional allocation of missing and undetermined fires, NFPA multiplies fires with codes in the 61-69 range by

$$\frac{\text{All fires in range 60-69}}{\text{All fires in range 61-69}}$$

The downside of this approach is that heat sources that are truly a different type of open flame or smoking material are erroneously assigned to other categories. The grouping "smoking materials" includes codes 61-63 (cigarettes, pipes or cigars, and heat from undetermined smoking material, with a proportional share of the code 60s and true unknown data.

Equipment Involved in Ignition (EII). NFIRS 5.0 originally defined EII as the piece of equipment that provided the principal heat source to cause ignition if the equipment malfunctioned or was used improperly. In 2006, the definition was modified to "the piece of equipment that provided the principal heat source to cause ignition." However, much of the data predates the change. Individuals who have already been trained with the older definition may not change their practices. To compensate, NFPA treats fires in which EII = NNN and heat source is not in the range of 40-99 as an additional unknown.

To allocate unknown data for EII, the known data is multiplied by

$$\frac{\text{All fires}}{\text{(All fires – blank – undetermined – [fires in which EII =NNN and heat source <>40-99])}}$$

In addition, the partially unclassified codes for broad equipment groupings (i.e., code 100 - heating, ventilation, and air conditioning, other; code 200 - electrical distribution, lighting and power transfer, other; etc.) were allocated proportionally across the individual code choices in their respective broad groupings (heating, ventilation, and air conditioning; electrical distribution, lighting and power transfer, other; etc.). Equipment that is totally unclassified is not allocated further. This approach has the same downside as the allocation of heat source 60 described above. Equipment that is truly different is erroneously assigned to other categories.

In some analyses, various types of equipment are grouped together.

Code Grouping	**EII Co**	**NFIRS definitions**
Central heat	132	Furnace or central heating unit
	133	Boiler (power, process or heating)
Fixed or portable space heater	131	Furnace, local heating unit, built-in
	123	Fireplace with insert or stove
	124	Heating stove
	141	Heater, excluding catalytic and oil-filled
	142	Catalytic heater
	143	Oil-filled heater
Fireplace or chimney	120	Fireplace or chimney
	121	Fireplace, masonry
	122	Fireplace, factory-built
	125	Chimney connector or vent connector
	126	Chimney – brick, stone or masonry
	127	Chimney-metal, including stovepipe or flue
Fixed wiring and related equipment	210	Unclassified electrical wiring
	211	Electrical power or utility line
	212	Electrical service supply wires from utility
	213	Electric meter or meter box
	214	Wiring from meter box to circuit breaker
	215	Panel board, switch board or circuit breaker board
	216	Electrical branch circuit
	217	Outlet or receptacle
	218	Wall switch
	219	Ground fault interrupter

Transformers and power supplies	221	Distribution-type transformer
	222	Overcurrent, disconnect equipment
	223	Low-voltage transformer
	224	Generator
	225	Inverter
	226	Uninterrupted power supply (UPS)
	227	Surge protector
	228	Battery charger or rectifier
	229	Battery (all types)
Lamp, bulb or lighting	230	Unclassified lamp or lighting
	231	Lamp-tabletop, floor or desk
	232	Lantern or flashlight
	233	Incandescent lighting fixture
	234	Fluorescent light fixture or ballast
	235	Halogen light fixture or lamp
	236	Sodium or mercury vapor light fixture or lamp
	237	Work or trouble light
	238	Light bulb
	241	Nightlight
	242	Decorative lights – line voltage
	243	Decorative or landscape lighting – low voltage
	244	Sign
Cord or plug	260	Unclassified cord or plug
	261	Power cord or plug, detachable from appliance
	262	Power cord or plug- permanently attached
	263	Extension cord
Torch, burner or soldering iron	331	Welding torch
	332	Cutting torch
	333	Burner, including Bunsen burners
	334	Soldering equipment
Portable cooking or warming equipm	631	Coffee maker or teapot
	632	Food warmer or hot plate
	633	Kettle
	634	Popcorn popper
	635	Pressure cooker or canner
	636	Slow cooker
	637	Toaster, toaster oven, counter-top broiler
	638	Waffle iron, griddle
	639	Wok, frying pan, skillet
	641	Breadmaking machine

Equipment was not analyzed separately for confined fires. Instead, each confined fire incident type was listed with the equipment or as other known equipment.

Item First Ignited. In most analyses, mattress and pillows (item first ignited 31) and bedding, blankets, sheets, and comforters (item first ignited 32) are combined and shown as "mattresses and bedding." In many analyses, wearing apparel not on a person (code 34) and wearing apparel on a person (code 35) are combined and shown as "clothing." In some analyses, flammable and combustible liquids and gases, piping and filters (item first ignited 60-69) are combined and shown together.

Area of Origin. Two areas of origin: bedroom for more than five people (code 21) and bedroom for less than five people (code 22) are combined and shown as simply "bedroom." Chimney is no longer a valid area of origin code for non-confined fires.

Rounding and percentages. The data shown are estimates and generally rounded. An entry of zero may be a true zero or it may mean that the value rounds to zero. Percentages are calculated from unrounded values. It is quite possible to have a percentage entry of up to 100% even if the rounded number entry is zero. The same rounded value may account for a slightly different percentage share. Because percentages are expressed in integers and not carried out to several decimal places, percentages that appear identical may be associated with slightly different values.

Appendix B
Reasons Why High-Rise Share of Building Fires Appears to Decline More Rapidly Under NFIRS 5.0

After 1998, fires and losses in high-rise buildings declined more rapidly than would have been expected from the historic trend, for apartments, hotels, and facilities that care for the sick. These accelerated declines may not be real but may be associated with changes associated with or occurring at the same time as the change to NFIRS Version 5.0.

- In some recent years, fewer large cities participated in NFIRS. These communities account for a disproportionately large share of high-rises. This could be a significant factor in the observed decline in estimated high-rise fires.

- NFIRS Version 5.0 permitted high-rise to be defined, more appropriately, by floors above ground rather than total floors. Some of the changes in the percentage of buildings that are high-rise can be explained by this change in how high-rise buildings are identified. Specifically, a building with seven or more total stories but fewer than seven stories above ground would have been counted as high-rise before 1999 (because the old NFIRS coding did not distinguish stories above ground from stories below ground) but as not high-rise after 1999.

- Structure height is not required, and typically is not captured, for fires reported as confined fires, which are fires confined to fuel burner or boiler, cooking vessel, chimney or flue, trash, incinerator, or commercial compactor. This will increase the share of fires with unknown structure height but would not affect the high-rise estimates, which include allocation of unknowns, unless confined fires are unusually likely or unlikely in high-rise structures.

- Another change appears likely to account for much of the decline. In NFIRS Version 4.1, height of building is coded by ranges, with codes 4-7 corresponding to high-rise (7 or more stories) and codes 1-3 corresponding to shorter buildings. In such a system, if the height of the building is incorrectly entered as the code, then a 4- to 6-story building will be incorrectly recorded as high-rise. Such an error is not possible in NFIRS Version 5.0.

  As evidence that this may be a significant problem for 1998 and earlier data, consider the three years before 1999 that show unusual spikes in estimated direct property damage – 1991, 1995, and 1996. These spikes are driven by six individual large-loss incidents. One of the six had its loss amount entered incorrectly, one was a tall manufacturing plant (equivalent to 18 stories), three were 5-story buildings coded incorrectly, and the sixth also had questions about its height.

  The error potential in NFIRS Version 5.0 arises if the building's height is recorded in the left of the three-digit field. For example, a 1-story building could be recorded as 100 stories and a 25-story building could be recorded as 250 stories. Such errors would show up as 100, 200, 300, 400, 400, 500, or 600-story buildings. Very few such buildings are recorded.

Most of these factors mean that the new numbers are more accurate than the older numbers – in a direction that would reduce the estimates – which means any apparent larger decline is not real. The exception is declining large-city participation, which would mean that the old numbers were more accurate. However, the factors other than declining large-city participation are enough to explain all the unusually large declines.

Appendix C
Deadliest High-Rise Building Fires in History

Table C-1 lists the deadliest high-rise building fires in world history.

Table C-1. Deadliest High-Rise Building Fires

Incident	Civilian and Firefighter Deaths	Height in Stories	Floor of Origin
1. Office complex (2 towers) New York, September 2001	2,791	110	94-98 (tower 1) 78-84 (tower 2)
2.Office Brazil, February 1974	179	25	12
3. Office Oklahoma, April 1995	168	9	Outside
4. Hotel South Korea, December 1971	163	21	2
5. Clothing manufacture New York, March 1911	146	10	8
6. Hotel Georgia, December 1946	119	15	3
7. Department store Japan, May 1972	118	7	3
8. Department store Japan, November 1973	104	9	Unknown
9. Hotel Puerto Rico, December 1986	96	20	1
10. Hotel Thailand, July 1977	90	17	1
11. Hotel Nevada, November 1980	85	23	1
12.Hotel Illinois, June 1946	61	22	1
13. Apartment building China, November 2010	58	30	Outside
14.Office Hong Kong, November 1996	40	16	Basement
15. Hotel South Korea, January 1984	38	10	4
16. Hotel Japan, February 1982	32	10	9
17. Hotel Arizona, December 1970	28	11	4
18A. Office Brazil, February 1986	23	13	Unknown
18B. Plastic manufacturing plant Texas, October 1989	23	20	Unknown
20. Hotel Florida, December 1963	22	14	1

Source: NFPA incident records.