

HIGH-RISE BUILDING FIRES

John R. Hall, Jr.

December 2011



**National Fire Protection Association
Fire Analysis and Research Division**

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Abstract

In 2005-2009, there were an average of 15,700 reported structure fires in high-rise buildings per year and associated losses of 53 civilian deaths, 546 civilian injuries, and \$235 million in direct property damage per year. Four property classes account for roughly half of high-rise fires: office buildings, hotels, apartment 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

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

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Executive Summary

In 2005-2009, an estimated 15,700 reported high-rise structure fires per year resulted in associated losses of 53 civilian deaths, 546 civilian injuries, and \$235 million in direct property damage per year. An estimated 2.6% of all 2005-2009 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 roughly half of high-rise fires: apartments, hotels, facilities that care for the sick, and offices. In 2005-2009, in these four property classes combined, there were 7,800 reported high-rise structure fires per year and associated losses of 30 civilian deaths, 352 civilian injuries, and \$99 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, it seems clear 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 2005-2009 high-rise fires that began on the 7th floor or higher was 32% for apartments, 22% for hotels and motels, 21% for facilities that care for the sick, and 39% 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 (4% vs. 3%). The same is true of hotels (7% vs. 5%) and facilities that care for the sick (6% vs. 4%). In offices (4% 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.

Table of Contents

| | Page |
|--|-------------|
| Executive Summary | i |
| Table of Contents | iii |
| List of Tables and Figures | iv |
| U.S. High-Rise Building Fires Fact Sheet | v |
| What is a High-Rise? | 1 |
| High-Rise Building Fires | 2 |
| Is There More or Less Fire-Related Risk in a High-Rise Building? | 14 |
| Fire Protection in High-Rise Buildings | 17 |
| Other Patterns of High-Rise Building Fires | 24 |
| Appendix A – How National Estimates Statistics Are Calculated | 32 |
| Appendix B – Reasons Why High-Rise Share of Building Fires Appears to Decline More Rapidly Under NFIRS Version 5.0 | 40 |
| Appendix C – Deadliest High-Rise Building Fires in History | 42 |

List of Tables and Figures

| | |
|---|----|
| Table 1. High-Rise Building Fires in Selected Property Classes, by Year | 4 |
| A. Apartments | 4 |
| B. Hotels | 5 |
| C. Facilities That Care for the Sick | 6 |
| D. Offices | 7 |
| E. Four Property Use Groups Combined | 8 |
| Table 2. Fires in Selected Properties, by Number of Stories Above Ground | 9 |
| A. Apartments | 9 |
| B. Hotels | 10 |
| C. Facilities That Care for the Sick | 11 |
| D. Offices | 12 |
| Table 3. High-Rise Percentage of Structure Fires in Mixed-Use Properties | 13 |
| Figure 1. Flame Damage Beyond Room of Origin, by Property Use and High-Rise versus Not High-Rise | 19 |
| Table 4. Fire Protection in High-Rise vs. Other Buildings, by Major Property Use | 20 |
| A. Apartments | 20 |
| B. Hotels | 21 |
| C. Facilities That Care for the Sick | 22 |
| D. Offices | 23 |
| Figure 2. Flame Damage Beyond Floor of Origin, by Property Use and High-Rise versus Not High-Rise | 24 |
| Figure 3. High-Rise Building Fires, by Level of Origin | 27 |
| A. Apartments | 27 |
| B. Hotels | 27 |
| C. Facilities That Care for the Sick | 28 |
| D. Offices | 28 |
| Table 5. High-Rise and Other Building Fires, by Leading Areas of Origin | 29 |
| A. Apartments | 29 |
| B. Hotels | 29 |
| C. Facilities That Care for the Sick | 30 |
| D. Offices | 30 |
| Table 6. High-Rise and Other Building Fires, by Leading Causes | 31 |
| A. Apartments | 31 |
| B. Hotels | 31 |
| C. Facilities That Care for the Sick | 31 |
| D. Offices | 31 |
| Table C-1. Deadliest High-Rise Building Fires | 42 |

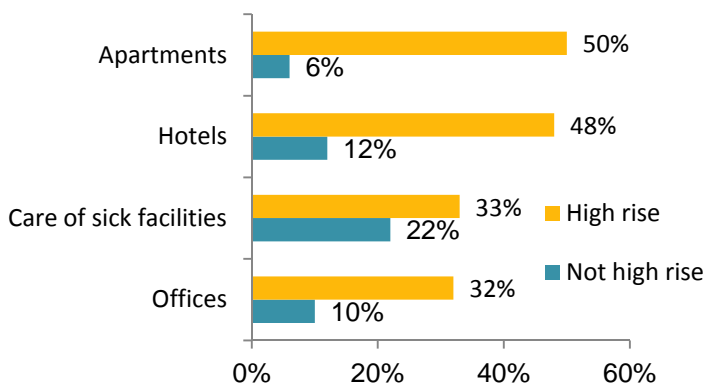


U.S. High-Rise Building Fires Fact Sheet

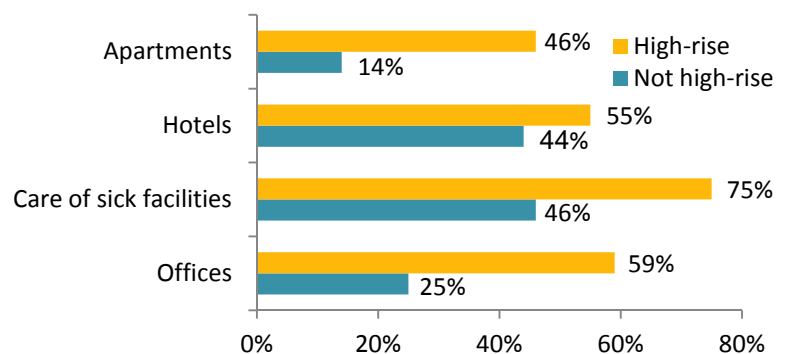
In 2005-2009, U.S. fire departments responded to an average of **15,700** structure fires in high-rise buildings.¹ These fires caused an annual average of

- 53 civilian fire deaths
 - 546 civilian fire injuries
 - \$235 million in direct property damage
- Four property use groups account for roughly half of high-rise fires:
 - Apartments (44% of all high-rise fires, 55% of deaths, 18% of damages)
 - Hotels (2% of high-rise fires, 2% of deaths, 21% of damages)
 - Facilities that care for the sick (2% of high-rise fires, 0% of deaths, 1% of damages)
 - Offices (2% of high-rise fires, 0% of deaths, 2% of damages)
 - The rest were nearly all 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 features² in high-rise buildings as compared to shorter buildings.
 - Further evidence of greater impact from fire protection systems and features in high-rise buildings is in *percentage of fires with flame damage beyond room of origin*:
 - Apartments (7% of high-rise fires vs. 10% in shorter buildings)
 - Hotels (7% of high-rise fires vs. 10% in shorter buildings)
 - Facilities that care for the sick (16% of high-rise fires vs. 19% in shorter buildings)
 - Offices (4% of high-rise fires vs. 7% 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, 2005-2009



Additional information can be found at www.nfpa.org/highrise

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 2005-2009, an estimated 15,700 reported high-rise structure fires per year resulted in associated losses of 53 civilian deaths, 546 civilian injuries, and \$235 million in direct property damage per year.

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

- Apartments (Property Use codes 420-429) (44% of all high-rise fires),
- Hotels (Property Use codes 440-449) (2% 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 and NFIRS Version 5.0; also includes codes 340-349 in and after 1999 under NFIRS Version 5.0) (2% 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 2005-2009, in these four property classes combined, there were 7,800 reported high-rise structure fires per year and associated losses of 30 civilian deaths, 352 civilian injuries, and \$99 million in direct property damage per year. Overall, 3% of all 2005-2009 structure fires occurred in high-rise properties, as well as 7% of 2005-2009 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 dwellings, duplexes, or sheds. See Table 1 for statistics for each year of 1985 to 1998 and for the average for 2005-2009, 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.

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 2005-2009 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 10% in medical use properties to a low of 1% in farm use properties.

Buildings under construction or major renovation accounted for 4% of high-rise office fires in 2005-2009, 2% of high-rise hotel fires, 2% of fires in high-rise facilities that care for the sick, and 1% of high-rise apartment fires (as well as 6% of associated direct property damage).

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

A. Apartments

| Year | Fires | Civilian Deaths | Civilian Injuries | Direct Property Damage (in Millions) | | What Percentage of All Apartment Fires Were High-Rise? |
|-------------------|--------|-----------------|-------------------|--------------------------------------|--------------|--|
| | | | | As Reported | 2009 Dollars | |
| 1985 | 11,700 | 54 | 470 | \$15 | \$31 | 10% |
| 1986 | 10,300 | 32 | 380 | \$21 | \$42 | 9% |
| 1987 | 8,900 | 46 | 520 | \$22 | \$41 | 8% |
| 1988 | 10,300 | 83 | 640 | \$48 | \$87 | 9% |
| 1989 | 11,000 | 97 | 610 | \$30 | \$52 | 10% |
| 1990 | 9,400 | 76 | 460 | \$22 | \$37 | 9% |
| 1991 | 9,900 | 23 | 590 | \$129* | \$203* | 9% |
| 1992 | 10,300 | 31 | 640 | \$19 | \$30 | 9% |
| 1993 | 9,600 | 43 | 600 | \$41 | \$60 | 9% |
| 1994 | 8,900 | 51 | 830 | \$36 | \$52 | 9% |
| 1995 | 7,700 | 53 | 530 | \$31 | \$43 | 8% |
| 1996 | 9,600 | 56 | 650 | \$33 | \$46 | 10% |
| 1997 | 9,200 | 27 | 480 | \$30 | \$40 | 10% |
| 1998 | 8,100 | 35 | 570 | \$23 | \$30 | 9% |
| 2005-2009 average | 6,900 | 29 | 320 | \$42 | \$44 | 6% |

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

Note: Analysis of 2005-2009 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 2009 dollars.

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 What Percentage of | | |
|-------------------|-------|-----------------|-------------------|------------------------------------|--------------|---|
| | | | | Damage (in Millions) As Reported | 2009 Dollars | All Hotel and Motel Fires 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 | \$11 | 20% |
| 1988 | 1,800 | 8 | 60 | \$20 | \$36 | 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 | \$9 | 17% |
| 1994 | 900 | 0 | 70 | \$4 | \$6 | 17% |
| 1995 | 1,000 | 0 | 70 | \$5 | \$8 | 20% |
| 1996 | 1,100 | 8 | 100 | \$17 | \$23 | 21% |
| 1997 | 800 | 6 | 40 | \$9 | \$12 | 18% |
| 1998 | 800 | 0 | 20 | \$11 | \$14 | 19% |
| 2005-2009 average | 400 | 1 | 30 | \$50 | \$49* | 11% |

* Average damages in 2005-2009 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 2005-2009 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 2009 dollars.

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 Were High-Rise? |
|-----------|-------|-----------------|-------------------|--------------------------------------|--------------|---|
| | | | | As Reported | 2009 Dollars | |
| 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 | \$8 | 30% |
| 1990 | 1,400 | 0 | 40 | \$3 | \$5 | 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 | \$8 | 24% |
| 2005-2009 | 300 | 0 | 10 | \$3 | \$3 | 13% |

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

Note: Analysis of 2005-2009 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 2009 dollars. Facilities that care for the sick include hospitals, clinics, and doctor’s offices.

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 Were High-Rise? |
|-------------------|-------|-----------------|-------------------|--------------------------------------|--------------|---|
| | | | | As Reported | 2009 Dollars | |
| 1985 | 1,200 | 1 | 10 | \$6 | \$12 | 14% |
| 1986 | 1,100 | 1 | 80 | \$17 | \$34 | 13% |
| 1987 | 900 | 2 | 10 | \$7 | \$13 | 11% |
| 1988 | 1,000 | 0 | 20 | \$34 | \$62 | 14% |
| 1989 | 900 | 0 | 20 | \$18 | \$32 | 13% |
| 1990 | 900 | 0 | 10 | \$15 | \$25 | 14% |
| 1991 | 800 | 0 | 10 | \$12 | \$19 | 12% |
| 1992 | 1,000 | 1 | 90 | \$57 | \$87 | 13% |
| 1993 | 800 | 0 | 20 | \$10 | \$15 | 13% |
| 1994 | 600 | 0 | 16 | \$16 | \$23 | 11% |
| 1995 | 500 | 0 | 50 | \$6 | \$8 | 10% |
| 1996 | 500 | 0 | 20 | \$14 | \$19 | 9% |
| 1997 | 600 | 0 | 10 | \$3 | \$5 | 11% |
| 1998 | 500 | 0 | 10 | \$3 | \$4 | 10% |
| 2005-2009 average | 300 | 0 | 0 | \$4 | \$4 | 7% |

Note: Analysis of 2005-2009 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 2009 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.

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

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 | 2009 Dollars |
| 1985 | 17,200 | 66 | 670 | \$25 | \$51 |
| 1986 | 15,100 | 38 | 550 | \$41 | \$81 |
| 1987 | 13,000 | 52 | 640 | \$36 | \$68 |
| 1988 | 14,600 | 94 | 780 | \$104 | \$188 |
| 1989 | 14,800 | 111 | 800 | \$58 | \$100 |
| 1990 | 13,300 | 84 | 620 | \$47 | \$78 |
| 1991 | 13,100 | 23 | 750 | \$150 | \$237 |
| 1992 | 13,600 | 35 | 830 | \$83 | \$127 |
| 1993 | 12,400 | 43 | 700 | \$60 | \$89 |
| 1994 | 11,400 | 57 | 950 | \$60 | \$87 |
| 1995 | 10,000 | 55 | 690 | \$44 | \$62 |
| 1996 | 12,100 | 64 | 790 | \$69 | \$94 |
| 1997 | 11,400 | 33 | 560 | \$43 | \$58 |
| 1998 | 10,000 | 37 | 680 | \$42 | \$56 |
| 2005-2009 average | 7,800 | 30 | 350 | \$99* | \$99 |

* Average damages in 2005-2009 are greatly inflated due to one 2008 fire in a 32-story building, with damages of \$100 million, which is projected to nearly \$40 million a year.

Note: Analysis of 2005-2009 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 2006 dollars.

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. The events of September 11, 2001, are not reflected in these figures.

Source: NFIRS and NFPA survey.

**Table 2. Fires in Selected Properties, by Number of Stories Above Ground
Annual Average of 2005-2009 Structure Fires Reported to U.S. Fire Departments**

A. Apartments

| | Fires | | Civilian Deaths | | Civilian Injuries | | Direct Property Damage (in Millions) | |
|--|---------------|--------------|-----------------|--------------|-------------------|--------------|--------------------------------------|--------------|
| 1 story | 17,000 | (16%) | 77 | (18%) | 435 | (11%) | \$121 | (10%) |
| 2 stories | 47,350 | (44%) | 204 | (47%) | 1,849 | (46%) | \$610 | (49%) |
| 3 stories | 25,880 | (24%) | 90 | (21%) | 1,025 | (26%) | \$364 | (29%) |
| 4 stories | 5,190 | (5%) | 16 | (4%) | 171 | (4%) | \$82 | (7%) |
| 5 stories | 2,170 | (2%) | 12 | (3%) | 80 | (2%) | \$20 | (2%) |
| 6 stories | 1,940 | (2%) | 9 | (2%) | 120 | (3%) | \$11 | (1%) |
| Total not high-rise (1-6 stories) | 99,520 | (94%) | 409 | (93%) | 3,680 | (92%) | \$1,208 | (97%) |
| 7 stories | 1,130 | (1%) | 7 | (1%) | 35 | (1%) | \$6 | (0%) |
| 8 stories | 870 | (1%) | 3 | (1%) | 20 | (1%) | \$2 | (0%) |
| 9 stories | 550 | (1%) | 2 | (0%) | 25 | (1%) | \$2 | (0%) |
| 10 stories | 1,650 | (2%) | 3 | (1%) | 40 | (1%) | \$3 | (0%) |
| 11 stories | 430 | (0%) | 1 | (0%) | 23 | (1%) | \$1 | (0%) |
| 12 stories | 790 | (1%) | 1 | (0%) | 22 | (1%) | \$2 | (0%) |
| 13 or more stories | 1,490 | (1%) | 11 | (3%) | 150 | (4%) | \$27 | (2%) |
| Total high-rise (7 or more stories) | 6,910 | (6%) | 29 | (7%) | 315 | (8%) | \$42 | (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.

Source: NFIRS and NFPA survey.

**Table 2. Fires in Selected Properties, by Number of Stories Above Ground (Continued)
Annual Average of 2005-2009 Structure Fires Reported to U.S. Fire Departments**

B. Hotels

| | Fires | Civilian Deaths | Civilian Injuries | Direct Property Damage (in Millions) |
|--|--------------------|------------------------|--------------------------|---|
| 1 story | 780 (21%) | 6 (48%) | 21 (15%) | \$13 (10%) |
| 2 stories | 910 (25%) | 4 (31%) | 52 (37%) | \$31 (25%) |
| 3 stories | 840 (23%) | 1 (10%) | 23 (16%) | \$18 (15%) |
| 4 stories | 430 (12%) | 0 (0%) | 12 (9%) | \$11 (8%) |
| 5 stories | 180 (5%) | 0 (0%) | 2 (2%) | \$1 (1%) |
| 6 stories | 150 (4%) | 0 (0%) | 3 (2%) | \$1 (1%) |
| Total not high-rise (1-6 stories) | 3,460 (88%) | 12 (89%) | 115 (81%) | \$74 (60%) |
| 7 stories | 40 (1%) | 0 (3%) | 8 (6%) | \$3 (2%) |
| 8 stories | 40 (1%) | 0 (0%) | 3 (2%) | \$0 (0%) |
| 9 stories | 20 (0%) | 0 (0%) | 1 (1%) | \$0 (0%) |
| 10 stories | 60 (2%) | 0 (0%) | 0 (0%) | \$0 (0%) |
| 11 stories | 20 (1%) | 0 (0%) | 1 (1%) | \$0 (0%) |
| 12 stories | 50 (1%) | 0 (0%) | 5 (4%) | \$0 (0%) |
| 13 or more stories | 150 (4%) | 1 (8%) | 8 (6%) | \$46 (37%) |
| Total high-rise (7 or more stories) | 390 (11%) | 1 (11%) | 27 (19%) | \$50 (40%) |

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.

Source: NFIRS and NFPA survey.

**Table 2. Fires in Selected Properties, by Number of Stories Above Ground (Continued)
Annual Average of 2005-2009 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 | 760 (35%) | 0 (0%) | 5 (15%) | \$13 (40%) |
| 2 stories | 390 (18%) | 0 (0%) | 6 (18%) | \$9 (27%) |
| 3 stories | 260 (12%) | 0 (0%) | 8 (24%) | \$5 (15%) |
| 4 stories | 220 (10%) | 0 (0%) | 3 (10%) | \$3 (8%) |
| 5 stories | 160 (7%) | 0 (100%) | 1 (4%) | \$1 (2%) |
| 6 stories | 130 (6%) | 0 (0%) | 2 (7%) | \$0 (1%) |
| Total not high-rise (1-6 stories) | 1,900 (87%) | 0 (100%) | 25 (78%) | \$5 (96%) |
| 7 stories | 80 (4%) | 0 (0%) | 0 (0%) | \$1 (3%) |
| 8 stories | 80 (3%) | 0 (0%) | 2 (5%) | \$0 (1%) |
| 9 stories | 40 (2%) | 0 (0%) | 4 (13%) | \$0 (1%) |
| 10 stories | 20 (1%) | 0 (0%) | 1 (2%) | \$0 (0%) |
| 11 stories | 10 (1%) | 0 (0%) | 0 (0%) | \$0 (0%) |
| 12 stories | 20 (1%) | 0 (0%) | 0 (0%) | \$0 (1%) |
| 13 or more stories | 30 (1%) | 0 (0%) | 0 (1%) | \$0 (1%) |
| Total high-rise (7 or more stories) | 280 (13%) | 0 (0%) | 7 (22%) | \$3 (8%) |

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.

Source: NFIRS and NFPA survey.

Table 2. Fires in Selected Properties, by Number of Stories Above Ground (Continued)
Annual Average of 2005-2009 Structure Fires Reported to U.S. Fire Departments

D. Offices

| | Fires | | Civilian Deaths | | Civilian Injuries | | Direct Property Damage (in Millions) | |
|--|--------------|--------------|------------------------|---------------|--------------------------|--------------|---|--------------|
| 1 story | 1,680 | (47%) | 0 | (4%) | 13 | (35%) | \$50 | (43%) |
| 2 stories | 940 | (26%) | 2 | (48%) | 14 | (38%) | \$43 | (36%) |
| 3 stories | 350 | (10%) | 1 | (23%) | 5 | (14%) | \$10 | (8%) |
| 4 stories | 150 | (4%) | 0 | (0%) | 1 | (3%) | \$2 | (2%) |
| 5 stories | 90 | (3%) | 0 | (0%) | 0 | (0%) | \$5 | (4%) |
| 6 stories | 80 | (2%) | 1 | (24%) | 1 | (3%) | \$3 | (2%) |
| Total not high-rise (1-6 stories) | 3,290 | (93%) | 4 | (100%) | 34 | (92%) | \$112 | (96%) |
| 7 stories | 50 | (1%) | 0 | (0%) | 0 | (0%) | \$0 | (0%) |
| 8 stories | 10 | (0%) | 0 | (0%) | 0 | (0%) | \$0 | (0%) |
| 9 stories | 30 | (1%) | 0 | (0%) | 0 | (0%) | \$0 | (0%) |
| 10 stories | 20 | (1%) | 0 | (0%) | 0 | (0%) | \$0 | (0%) |
| 11 stories | 20 | (1%) | 0 | (0%) | 0 | (0%) | \$0 | (0%) |
| 12 stories | 20 | (1%) | 0 | (0%) | 0 | (1%) | \$0 | (0%) |
| 13 or more stories | 110 | (3%) | 0 | (0%) | 3 | (7%) | \$3 | (2%) |
| Total high-rise (7 or more stories) | 260 | (10%) | 0 | (0%) | 3 | (8%) | \$4 | (4%) |

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.

Source: NFIRS and NFPA survey.

**Table 3. High-Rise Percentage of Structure Fires in Mixed-Use Properties
Percentage of 2005-2009 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 | 10% |
| Office use | 6% |
| Business and residential | 5% |
| Unclassified mixed-use status | 4% |
| Residential use | 3% |
| Assembly use | 3% |
| Industrial use | 3% |
| Not mixed use | 2% |
| Educational use | 2% |
| Row of stores (mercantile properties) | 2% |
| Enclosed mall | 1% |
| Farm use | 1% |
| 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. 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.

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 2005-2009, an average of 8-11% of occupied year-round housing units were in apartment buildings defined as buildings with 3 or more housing units.¹ The percentage range is necessary because the data on housing combines housing units in 2-unit buildings with housing units in buildings having 3-4 housing units. (In NFIRS coding, buildings with one or two housing units are grouped together and not called apartments.) If most buildings with 2-4 housing units are in 2-unit buildings, then the high-rise share of apartments is close to 11%. If most buildings with 2-4 housing units are not in 2-unit buildings, then the high-rise share of apartments is close to 8%.

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:

$$\begin{aligned} & \text{[loss in high-rise buildings]/[units of exposure of high-rise buildings]} \\ & = \text{[(high-rise \% of loss) x (total loss)]/} \\ & \quad \text{[(high-rise \% of exposure units) x (total exposure units)].} \end{aligned}$$

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

$$\begin{aligned} & \text{[high-rise risk]/[low-rise risk]} \\ & = \text{[(high-rise \% of loss)/(high-rise \% of exposure units)]/} \\ & \quad \text{[(low-rise \% of loss)/(low-rise \% of exposure units)]} \\ & = \text{[(high-rise \% of loss)/(high-rise \% of exposure units)]/} \\ & \quad \text{[(100% - high-rise \% of loss)/(100% - high-rise \% of exposure units)].} \end{aligned}$$

¹ See *Statistical Abstract of the United States*, Washington, DC: U.S. Bureau of Census, 2004-2008.

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 low-rise percentages add to 100%, you need only the high-rise percentages of loss and exposure to make the comparison.

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 low-rise risk.²

In 2005-2009, 6% of apartment fires were in high-rise buildings. (See Table 2A.) Because 6% falls below the 8-11% range, 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 2005-2009, 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 (or as low, for injuries) 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 publishes figures (latest from 2003; data from the 2007 survey did not support valid estimates and was not published) on floor space for properties with defined ranges of square feet of floor space.³ 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):

² 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).

³ See the 2003 Commercial Buildings Energy Consumption Survey, Energy Information Administration website, <http://www.eia.doe.gov/emcu/cbecs>.

- 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%.

These compare to high-rise shares of 2005-2009 reported structure fires of 11% for hotels and motels, 7% for office buildings and 13% 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 40% for hotels, 8% for facilities that care for the sick, and 4% 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.

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). 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.

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.

Table 4 provides statistics on percentage of fires with fire protection present for three types of fire protection for three groups of years (1986-1989⁴, 1994-1998, and 2005-2009):

⁴ 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.

- Automatic extinguishing equipment. In 2005-2009, 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 2005-2009.

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.

From 1999 on, there is 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.

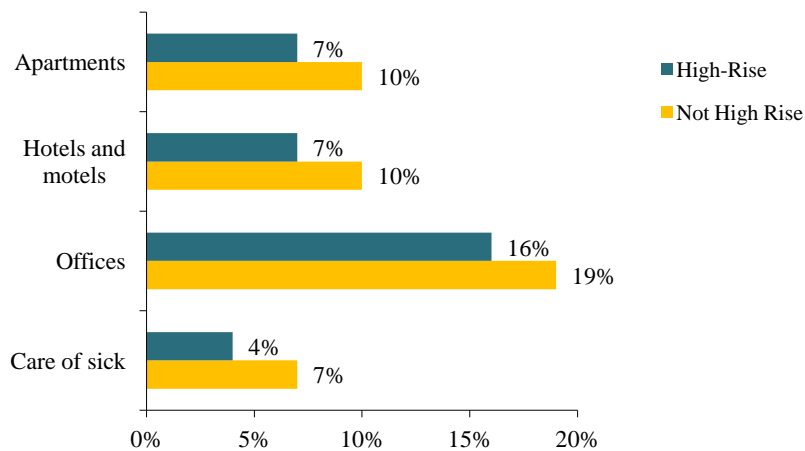
Some conclusions can be seen in Table 4.

- The usage of wet pipe sprinklers is much greater in high-rise buildings than in other buildings, for each property use group. This is also true for facilities that care for the sick, where the gap in automatic extinguishing equipment had been smaller before 1999. 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 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 2005-2009 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.

**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% |
| 2005-2009: Wet-pipe sprinklers present, excluding partial systems and buildings under construction | 46% | 14% | 16% |

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% |
| 2005-2009: Equipment present | 93% | 90% | 90% |

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 building height are not allocated before calculating percentages, and statistics for "all buildings" are based only on buildings of known height. These statistics may differ from statistics based on calculations that include buildings 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

| Year of Fire | High-Rise Buildings | Buildings That Are Not High-Rise | All Buildings |
|---------------------|----------------------------|---|----------------------|
|---------------------|----------------------------|---|----------------------|

1. Automatic Extinguishing Equipment

| | | | |
|--|-----|-----|-----|
| 1986-1989: Equipment present | 62% | 18% | 28% |
| 1994-1998: Equipment present | 72% | 26% | 35% |
| 2005-2009: Wet-pipe sprinklers present, excluding partial systems and buildings under construction | 55% | 44% | 45% |

| Year of Fire | High-Rise Buildings | Buildings That Are Not High-Rise | All Buildings |
|---------------------|----------------------------|---|----------------------|
|---------------------|----------------------------|---|----------------------|

2. Fire Detection Equipment

| | | | |
|------------------------------|-----|-----|-----|
| 1986-1989: Equipment present | 84% | 65% | 69% |
| 1994-1998: Equipment present | 89% | 76% | 79% |
| 2005-2009: Equipment present | 93% | 91% | 91% |

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 building height are not allocated before calculating percentages, and statistics for "all buildings" are based only on buildings of known height. These statistics may differ from statistics based on calculations that include buildings 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% |
| 2005-2009: Wet-pipe sprinklers present, excluding partial systems and buildings under construction | 75% | 46% | 51% |

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% |
| 2005-2009: Equipment present | 94% | 90% | 91% |

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 building height are not allocated before calculating percentages, and statistics for "all buildings" are based only on buildings of known height. These statistics may differ from statistics based on calculations that include buildings 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% |
| 2005-2009: Wet-pipe sprinkler present, excluding partial systems and buildings under construction | 59% | 25% | 28% |

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% |
| 2005-2009: Equipment present | 89% | 71% | 72% |

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% |

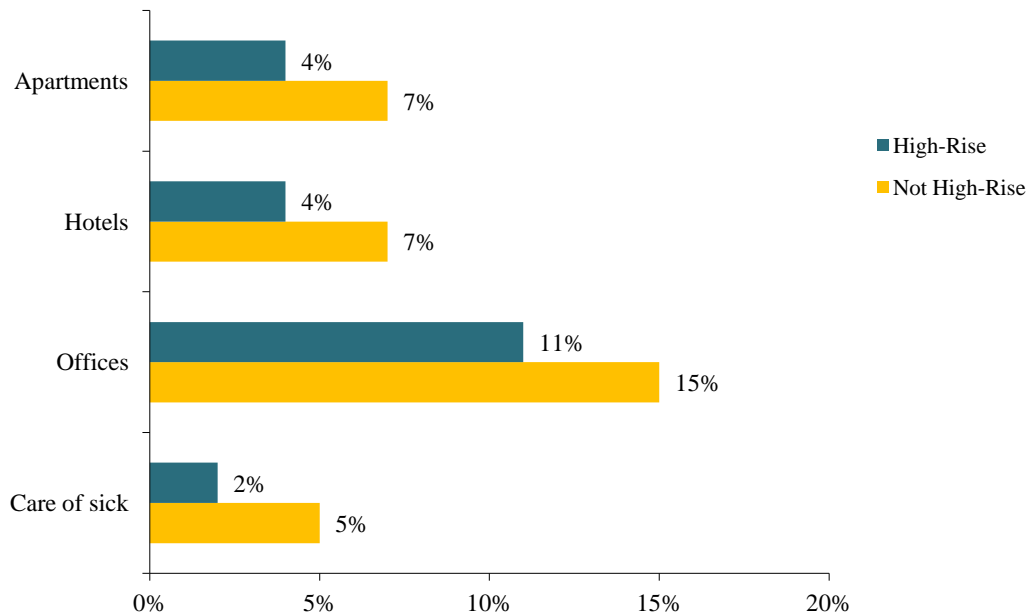
Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. "High-rise" means seven or more stories in height. Prior to 1999, fires with unknown building height are not allocated before calculating percentages, and statistics for "all buildings" are based only on buildings of known height. These statistics may differ from statistics based on calculations that include buildings 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 very 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 2005-2009 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 redesign of elevator 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.

When high-rise building fires do involve fire spread beyond the floor of fire origin, it is not unusual for the fire to be studied further by NFPA staff. 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 2005-2009 high-rise fires that began on the 7th floor or higher was 32% for apartments, 22% for hotels and motels, 21% for facilities that care for the sick, and 39% 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 at least 38% of the floors in high-rise apartments are 7th floor or higher (where “at least” 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 at least 35% for hotels and motels, at least 32% for facilities that care for the sick, and at least 27% 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 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 greater on the lower floors.

For offices, the fraction of floors in high-rise buildings with reported fires is at least 27% but at most 33% (if all the buildings that are at least 13 stories are extremely tall so that nearly all the floors are 7th floor or higher). Therefore, the risk of a fire start is 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 (4% vs. 3%). The same

is true of hotels (7% vs. 5%) and facilities that care for the sick (6% vs. 4%). In offices (4% 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 in what tend to be low-rise facilities) 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.

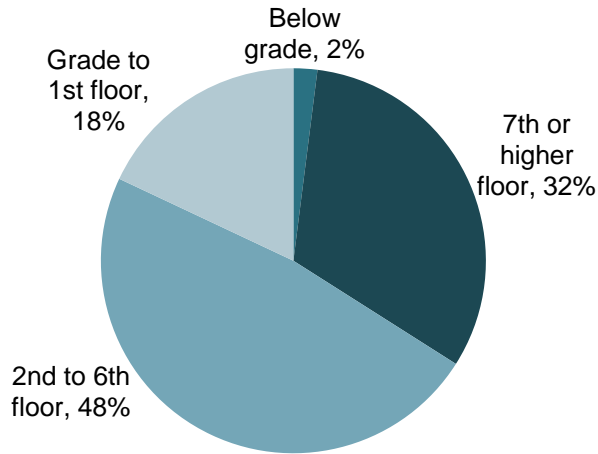
Another element in surviving a high-rise building fire is the ability of occupants to escape effectively. A 2007 survey study by NuStats for the Fire Protection Research Foundation found that levels of knowledge and preparedness related to escape readiness were quite different for residents of commercial high-rise buildings (presumably offices) compared to residential high-rise buildings (presumably apartments).⁵ 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%).

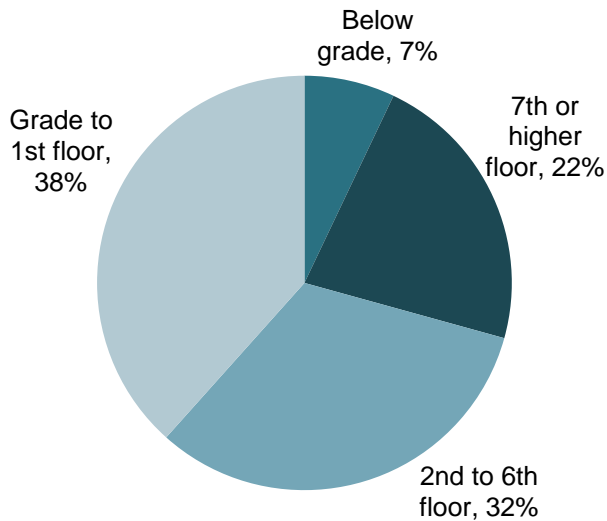
⁵ Mia Zmud, *Public Perceptions of High-Rise Building Safety and Emergency Evacuation Procedures Research Project – Final Report*, Fire Protection Research Foundation, July 2007.

**Figure 3. High-Rise Building Fires, by Level of Fire Origin
Percentage of 2005-2009 Structure Fires Reported to U.S. Fire Departments**

A. Apartments



B. Hotels

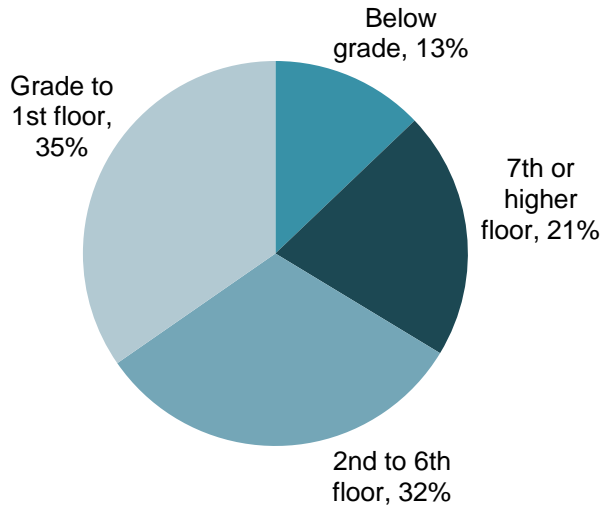


Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. “High-rise” means seven or more stories in height. Includes proportional share of fires with level of fire origin or height of building unknown. 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.

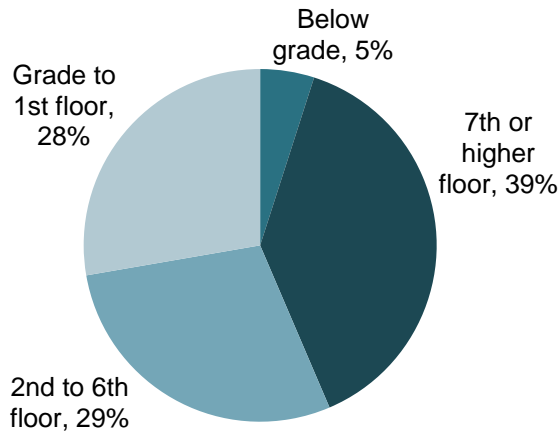
Source: NFIRS and NFPA survey.

**Figure 3. High-Rise Building Fires, by Level of Fire Origin (Continued)
Percentage of 2005-2009 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 2005-2009 Structure Fires Reported to U.S. Fire Departments**

A. Apartments

| High-Rise | | Not High-Rise | |
|-------------------------------------|--------------|-------------------------------------|--------------|
| Area of Origin | Fires | Area of Origin | Fires |
| Kitchen | 4,880 (71%) | Kitchen | 67,610 (68%) |
| Bedroom | 380 (5%) | Bedroom | 5,400 (6%) |
| ALL MEANS OF EGRESS | 260 (4%) | ALL MEANS OF EGRESS | 2,610 (3%) |
| <i>Hallway or corridor</i> | 90 (1%) | <i>Exterior stairway</i> | 630 (1%) |
| <i>Interior stairway</i> | 80 (1%) | <i>Hallway or corridor</i> | 560 (1%) |
| <i>Unclassified means of egress</i> | 40 (0%) | <i>Interior stairway</i> | 540 (1%) |
| <i>Entrance way or lobby</i> | 40 (1%) | <i>Entrance way or lobby</i> | 440 (0%) |
| <i>Exterior stairway</i> | 20 (0%) | <i>Unclassified means of egress</i> | 430 (0%) |
| <i>Escalator</i> | 10 (0%) | <i>Escalator</i> | 10 (0%) |
| Living room, family room, or den | 240 (3%) | Living room, family room, or den | 2,530 (3%) |
| Trash room or area | 240 (3%) | | |

B. Hotels and Motels

| High-Rise | | Not High-Rise | |
|-------------------------------------|--------------|-------------------------------------|--------------|
| Area of Origin | Fires | Area of Origin | Fires |
| Kitchen | 105 (27%) | Kitchen | 1,103 (33%) |
| Laundry room or area | 39 (10%) | Bedroom (including guest room) | 449 (14%) |
| Bedroom (including guest room) | 38 (10%) | Laundry room or area | 249 (8%) |
| ALL MEANS OF EGRESS | 31 (7%) | ALL MEANS OF EGRESS | 166 (5%) |
| <i>Hallway or corridor</i> | 15 (4%) | <i>Hallway or corridor</i> | 58 (2%) |
| <i>Entrance way or lobby</i> | 6 (2%) | <i>Exterior stairway</i> | 38 (1%) |
| <i>Interior stairway</i> | 5 (1%) | <i>Entrance way or lobby</i> | 33 (1%) |
| <i>Unclassified means of egress</i> | 1 (0%) | <i>Unclassified means of egress</i> | 28 (1%) |
| <i>Exterior stairway</i> | 1 (0%) | <i>Interior stairway</i> | 9 (0%) |
| Bathroom or cloak room | 18 (5%) | Bathroom or cloak room | 144 (4%) |
| Machinery room or area | 11 (3%) | Living room, family room, or den | 90 (3%) |
| Trash room or area | 11 (3%) | Confined chimney or flue fire | 83 (3%) |
| Unclassified storage area | 10 (3%) | | |

Table 5. High-Rise and Other Building Fires, by Leading Areas of Origin (Continued)
Annual Average of 2005-2009 Structure Fires Reported to U.S. Fire Departments

C. Facilities That Care for the Sick

| High-Rise | | Not High-Rise | |
|--|------------------|-------------------------------------|------------------|
| Area of Origin | Percent of Fires | Area of Origin | Percent of Fires |
| Kitchen | 112 (40%) | Kitchen | 715 (38%) |
| ALL MEANS OF EGRESS | 20 (6%) | Bathroom or locker room | 98 (5%) |
| <i>Unclassified means of egress</i> | 9 (3%) | Office | 87 (5%) |
| <i>Hallway</i> | 4 (1%) | ALL MEANS OF EGRESS | 80 (4%) |
| <i>Entrance way or lobby</i> | 1 (0%) | <i>Hallway or corridor</i> | 28 (1%) |
| <i>Interior stairway</i> | 1 (0%) | <i>Exterior stairway</i> | 13 (1%) |
| <i>Exterior stairway</i> | 1 (0%) | <i>Entrance way or lobby</i> | 13 (1%) |
| Office | 15 (5%) | <i>Unclassified means of egress</i> | 12 (1%) |
| Bedroom (including patient room) | 13 (5%) | <i>Interior stairway</i> | 1 (1%) |
| Machinery room or area | 12 (4%) | <i>Escalator</i> | 1 (0%) |
| Laundry room or area | 12 (4%) | Heating equipment room or area | 59 (3%) |
| Unclassified service or equipment area | 12 (4%) | Trash room or area | 58 (3%) |
| Heating equipment room or area | 9 (3%) | Bedroom (including patient room) | 54 (3%) |
| Process or manufacturing area | 9 (3%) | | |

D. Offices

| High-Rise | | Not High-Rise | |
|--|------------------|---|------------------|
| Area of Origin | Percent of Fires | Area of Origin | Percent of Fires |
| Kitchen | 62 (23%) | Kitchen | 719 (22%) |
| Office | 32 (12%) | Office | 470 (14%) |
| Machinery room or area | 16 (6%) | ALL MEANS OF EGRESS | 189 (6%) |
| Heating equipment room or area | 13 (5%) | <i>Entrance way or lobby</i> | 68 (2%) |
| Unclassified service or equipment area | 12 (5%) | <i>Unclassified means of egress</i> | 57 (2%) |
| Product storage area | 11 (4%) | <i>Hallway or corridor</i> | 29 (1%) |
| ALL MEANS OF EGRESS | 10 (4%) | <i>Exterior stairway</i> | 22 (1%) |
| <i>Entrance way or lobby</i> | 5 (2%) | <i>Interior stairway</i> | 12 (0%) |
| <i>Hallway or corridor</i> | 2 (1%) | <i>Escalator</i> | 1 (0%) |
| <i>Unclassified means of egress</i> | 1 (1%) | Bathroom | 148 (4%) |
| <i>Interior stairway</i> | 1 (0%) | Heating equipment room or area | 119 (4%) |
| <i>Exterior stairway</i> | 1 (0%) | Exterior wall surface | 118 (4%) |
| Exterior roof surface | 10 (4%) | Exterior roof surface | 97 (3%) |
| | | Attic or ceiling/roof assembly or concealed space | 84 (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 2005-2009 Structure Fires Reported to U.S. Fire Departments**

A. Apartments

| High-Rise | | Not High-Rise | |
|-------------------|--------------|----------------------|--------------|
| Cause | Fires | Cause | Fires |
| Cooking equipment | 4,350 (63%) | Cooking equipment | 56,690 (57%) |
| Heating equipment | 670 (10%) | Heating equipment | 16,440 (17%) |
| Smoking materials | 530 (8%) | Intentional | 5,620 (6%) |
| | | Smoking materials | 5,450 (5%) |

B. Hotels

| High-Rise | | Not High-Rise | |
|---|--------------|---|--------------|
| Cause | Fires | Cause | Fires |
| Cooking equipment | 99 (25%) | Cooking equipment | 1,352 (41%) |
| Clothes dryer or washer | 51 (13%) | Heating equipment | 375 (11%) |
| Electrical distribution or lighting equipment | 43 (11%) | Smoking materials | 317 (10%) |
| Smoking materials | 31 (8%) | Clothes dryer or washer | 310 (9%) |
| Air conditioning or fan | 31 (8%) | Intentional | 259 (9%) |
| Intentional | 20 (5%) | Electrical distribution or lighting equipment | 199 (6%) |
| | | Air conditioning or fan | 182 (6%) |

C. Facilities That Care for the Sick

| High-Rise | | Not High-Rise | |
|---|--------------|---|--------------|
| Cause | Fires | Cause | Fires |
| Cooking equipment | 111 (40%) | Cooking equipment | 997 (52%) |
| Electrical distribution or lighting equipment | 29 (11%) | Intentional | 185 (10%) |
| Heating equipment | 28 (10%) | Heating equipment | 143 (8%) |
| Intentional | 28 (10%) | Electrical distribution or lighting equipment | 133 (7%) |
| | | Smoking materials | 128 (7%) |

D. Offices

| High-Rise | | Not High-Rise | |
|---|--------------|---|--------------|
| Cause | Fires | Cause | Fires |
| Cooking equipment | 86 (32%) | Cooking equipment | 923 (28%) |
| Electrical distribution or lighting equipment | 45 (17%) | Electrical distribution or lighting equipment | 423 (13%) |
| Heating equipment | 13 (5%) | Heating equipment | 386 (12%) |
| | | Intentional | 353 (11%) |
| | | Air conditioning or fan | 325 (10%) |
| | | Smoking materials | 282 (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.

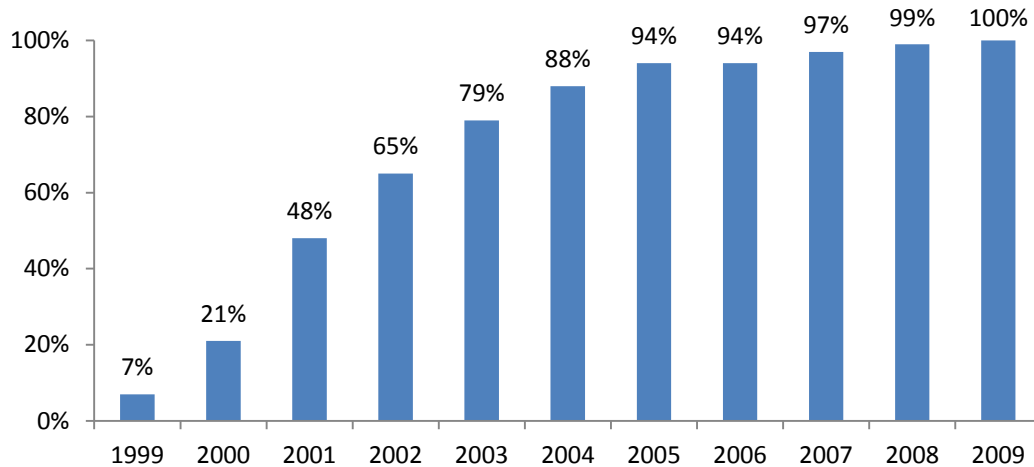
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific 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:

$$\frac{\text{NFPA survey projections}}{\text{NFIRS totals (Version 5.0)}}$$

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

All fires

(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 manufacturer 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.