

# **U.S. Fire Administration TOPICAL FIRE RESEARCH SERIES**

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## **Highrise Fires**

### **FINDINGS**

- Each year, an estimated 15,500 highrise structure fires cause 60 civilian deaths, 930 injuries, and \$252 million in property loss.
- Highrise fires are more injurious and cause more damage than all structure fires.
- Three-quarters of highrise fires are in residential structures, but these cause only 25% of dollar loss.
- The leading cause of all highrise fires is cooking (38%), but cause patterns vary by property type.
- 69% of highrise structure fires originate on the 4th floor or below; 60% occur in apartment buildings; 43% originate in the kitchen.
- Highrise fires are inherently more difficult for the fire service.

Sources: NFPA and NFIRS

Each year between 1996 and 1998, there were an estimated 15,500 highrise structure<sup>1</sup> fires in the United States. From data reported to the National Fire Incident Reporting System (NFIRS), these fires were responsible for 930 civilian injuries, 60 civilian fatalities, and nearly \$252.3 million in property loss annually.<sup>2</sup> In the wake of the tragic events of September 11, 2001, highrise fires and highrise firefighting tactics have assumed a more prominent role in the consciousness of the U.S. fire service and American society as a whole. This report briefly examines the causes and characteristics of highrise fires and the challenges inherent in controlling them.

### **LOSS MEASURES**

Figure 1 compares the loss measures for highrise structure fires with those for all structure fires, residential structure fires, non-residential structure fires, and residential and non-residential highrise structure fires. Fires in highrise structures tend to be more injurious and cause more damage than structure fires generally.

**Figure 1. Loss Measures**  
(3-year average, NFIRS data 1996–98)

LOSS MEASURE	HIGHRISE STRUCTURES			ALL STRUCTURES		
	ALL	RESIDENTIAL	NON-RESIDENTIAL	ALL	RESIDENTIAL	NON-RESIDENTIAL
Dollar Loss/Fire	\$17,515	\$6,102	\$45,441	\$14,115	\$11,271	\$21,878
Civilian Injuries/1,000 Fires	66.0	73.2	48.4	40.9	48.0	22.1
Civilian Fatalities/1,000 Fires	3.2	3.9	1.6	6.1	7.7	1.7

Source: NFIRS only

Even though the majority of highrise fires occur in residential highrise structures (nearly three-quarters), only about 25% of highrise dollar loss is incurred on these residential properties. In part, this is because non-residential highrise fires tend to be bigger—they are more likely to cause damage outside of the room of fire origin than residential highrise fires. More than 95% of residential highrise structure fires are contained to the room of origin. By contrast, only about 75% of fires in manufacturing, industrial, and storage highrises are contained to the room of origin. Further, it may be that the specialization associated with non-residential properties drives up the cost of replacing or renovating such structures after a fire.

Residential highrise fires tend to be smaller than those in non-residential highrises, but they are particularly injurious, more so than fires in residential structures generally. In part, this may be due to the higher population density found in a highrise. Also, residential highrise fires cause more injuries per fire than fires in non-residential highrises. Lastly, the design of highrises tends to allow toxic smoke and byproducts of fire to spread throughout a building and injure occupants who may be many floors away from the fire itself. By contrast, residential highrise death rates are half those of residential structures in general. Because the population in a highrise is higher than in a single-family home, more people may be available to alert residents of a fire and assist with evacuation.

Another potential explanation for the disparity in injury and death rates between residential structures and highrise residential structure fires is the role of smoke alarms. Most building codes require hardwired smoke alarms in highrises. This significantly increases the chance that an alarm will activate during a fire. A smoke alarm activates in 69% of residential highrise fires, as compared to only 38% in residential structure fires generally. As a result, people are more likely to escape a fire and, although they may be injured, they are far less likely to die than those in residential structures generally. As such, the injury rate increases while the death rate decreases. This demonstrates the role of smoke alarms in saving lives and underscores the continued need for the installation and maintenance of smoke alarms, particularly in highrises, where residences are smaller and occupants are likely to be closer to the seat of a fire than in a single-family home.

## CAUSES OF FIRES

Figure 2 compares the incidence of highrise structure fires by fixed property use (FPU). Cause patterns differ somewhat depending on the type of highrise occupancy involved in the fire. For example, in highrise structures used for public assembly, the leading cause of fires is smoking. For educational properties, the leading cause of highrise fires is arson. These variations are not particularly surprising, as one would expect a property's function to affect its fire experience.

**Figure 2. Causes of Highrise Structure Fires, by FPU**

(3-year average, NFIRS data 1996–98, adjusted percentage)

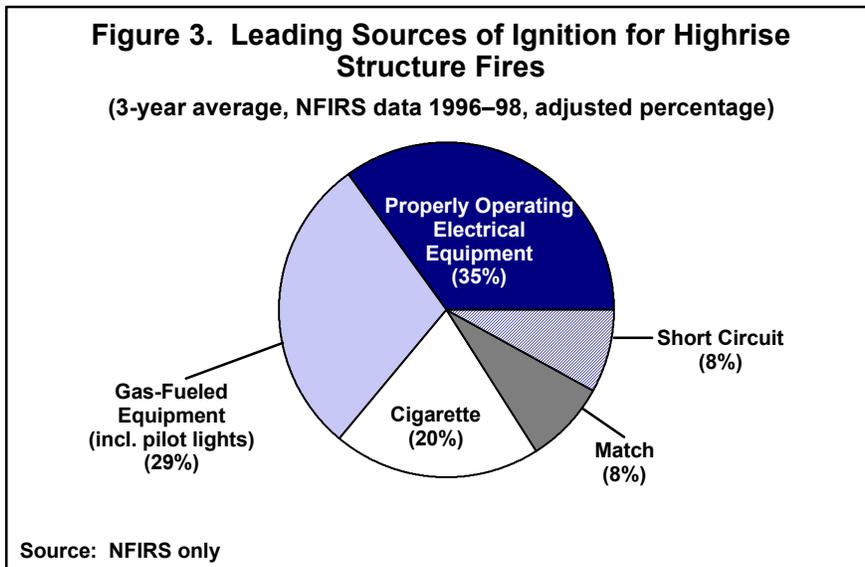
PRIORITY CAUSE GROUPING CODE	INDUSTRIAL/ MANUFACTURING/ STORAGE					
	ALL	EDUCATIONAL	RESIDENTIAL	COMMERCIAL	PUBLIC ASSEMBLY	
Incendiary/Suspicious	14		7	14	12	22
Children Playing	2	1	0	2	0	0
Smoking	13	9	2	14	13	
Heating	3	5	4	3	6	3
Cooking		10	2		10	16
Electrical Distribution	6	12	8	4		6
Appliances	6	5	3	5	9	5
Open Flame	7	11	17	6	9	6
Other Heat	2	1	5	2	2	1
Other Equipment	6	12		2	14	3
Natural	2	2	12	1	2	2
Exposure	1	1	4	1	1	0

Source: NFIRS only

Because of the number of residential properties involved, the leading cause of highrise structure fires is cooking, followed by incendiary/suspicious (arson) and smoking.

In 44% of highrise structure fires, an ignition source is left unattended or is abandoned. Of fires that involve unattended equipment, 70% involve stoves, which is consistent generally with the pattern seen in residential structure fires.

As shown in Figure 3, the leading ignition sources (NFIRS "Form of Heat of Ignition") for highrise structure fires are properly operating electrical and gas-fueled equipment, most often a stove (stoves are involved in 24% of highrise structure fires). Cigarettes also play a prominent role.



### WHERE FIRES START

Sixty percent of highrise fires occur in apartment buildings, 6% occur in hospitals, 4% in hotels, 3% in dormitories, and 3% in offices.

Forty-three percent of highrise structure fires originate in the kitchen, 9% begin in the bedroom, 6% in a trash/rubbish room, and 5% in a hallway. Recently, several large cities, including Boston and New York, have experienced a number of hallway fires in highrises. The incidence of fires in hallways is troubling in that occupants must generally travel through a hallway to exit the structure.

Fires in highrise structures do not necessarily originate on an upper floor of the building. Rather, as shown in Figure 4, nearly 69% of fires originate on the 4th floor or below.<sup>3</sup>

**Figure 4. Level of Fire Origin, Highrise Structure Fires**  
(3-year average, NFIRS data 1996–98, adjusted percentage)

FEET ABOVE GRADE	PERCENT OF HIGHRISE STRUCTURE—			
	FIRES	DOLLAR LOSS	INJURIES	FATALITIES
Below Grade	5	19	5	3
Grade to 9	27	22	21	12
10 to 19	12	8	9	15
20 to 29	10	13	10	10
30 to 49	15	9	17	13
50 to 70	14	16	22	22
Over 70	16	12	16	25

Source: NFIRS only

Fires that originate on a lower floor (9 or below) tend to cause more damage than fires that originate on a higher floor. However, fires that originate on an upper floor (30 or above) tend to cause a disproportionate share of injuries and fatalities. Although 45% of fires originate above the 30th floor, these fires account for 55% of injuries and 60% of fatalities.

## SMOKE ALARM/SPRINKLER PERFORMANCE

Highrise structures are generally required to meet specific building codes for fire resistance, smoke alarms, and sprinkler systems. (For further information, contact your local fire marshal.) Overall, a smoke alarm is present and activates in 62% of highrise structure fires (Figure 5). In contrast, a sprinkler system is activated in only 8% of such fires. The discrepancy is largely because highrise structure fires tend to be small, with 92% of fires contained to the object or room of origin.

**Figure 5. Smoke Alarm Performance in Highrise Structures, by FPU**

(3-year average, NFIRS data 1996–98, adjusted percentage)

SMOKE ALARM	ALL	EDUCATIONAL	INDUSTRIAL/ MANUFACTURING/ STORAGE	RESIDENTIAL	COMMERCIAL	PUBLIC ASSEMBLY
In Room, Operated	46	39	22	49	39	18
Not in Room, Operated	16	8	3	19	11	4
In Room, Did Not Operate	6	7	3	7	7	8
Not in Room, Did Not Operate	6	9	3	6	8	6
Fire Too Small To Activate	8	10	3	5	8	48
No Alarms Present	19	27	67	14	27	16

Source: NFIRS only

As with fire cause, however, smoke alarm performance also tends to vary depending on the type of highrise structure involved. Industrial/manufacturing/storage facilities are much less likely than other types of structures to have smoke alarms present. As such, these fires are more likely than those in other highrise structures to extend beyond the room of origin.

## CHALLENGES POSED BY HIGHRISE FIRES<sup>5</sup>

Highrise structure fires pose a number of challenges both to the occupants and to the fire service. Several of these include:

- By nature of their height, smoke movement in highrise structures is very different from that of other structures. Temperature gradients result in varying pressures throughout the structure, which can allow for the rapid, uncontrolled movement of smoke and flame (known as the “stack effect”).

- Highrises often contain multiple types of occupancies, including residential, commercial, restaurant, and underground parking. Each type of occupancy poses a challenge to firefighters and must be approached differently.
- By design, exits from highrise structures are limited. In an emergency, the movement of people out of a building is particularly difficult.
- The HVAC and other utilities in some highrises service multiple levels and can facilitate the spread of smoke and flame through a building.
- Highrise structure fires require significantly more personnel and equipment to extinguish than do other types of fires. This further strains the responding fire department and firefighters.

## EXAMPLES

- In December 1998, a fire ignited by an electric heater killed four residents of a Manhattan apartment building. The fire started on the 19th floor; the victims were found in a stairwell between the 27th and 29th floors. The residents of the apartment of origin left the front door open when they fled the fire, allowing the smoke and flames to spread.<sup>5</sup>
- In December 1998, three firefighters were killed by an early morning smoking fire in a 10-story apartment building. The fire was not reported for nearly 30 minutes while the apartment's resident attempted to douse the flames with pans of water. After leaving the apartment, the resident left the front door partially open, allowing smoke and gases to enter the hallway. When firefighters attempted to enter the apartment, a flashover occurred, killing the three firefighters.<sup>6</sup>
- In October 2001, a Houston fire captain and a civilian were killed by a five-alarm blaze in a 40-story highrise apartment complex. The fire originated in a 5th floor apartment and quickly spread. The captain and his crew were trapped on the 5th floor; he died from smoke inhalation. Several other firefighters and residents of the building were injured and required hospitalization for burns and smoke inhalation.<sup>7</sup>

## CONCLUSIONS

As with all fires, those that occur in highrise structures are largely preventable. Residents must exercise caution to prevent fires, but must also seek information to determine the appropriate actions in the event of a fire (e.g., whether to stay in place or evacuate, ensuring that all apartment doors are closed if one evacuates).

For further information, contact your local fire department or the USFA. Also see the USFA publication *Danger Above: A Factsheet on Highrise Safety* (<http://www.usfa.fema.gov/safety/fswy18.htm>).

## NOTES:

1. For the purposes of this report, a highrise structure is defined as a structure that is five stories or greater. This definition was based on the limitations of NFIRS data. Jurisdictions throughout the country use different definitions for regulatory and tactical purposes.
2. National estimates are based on data from the National Fire Incident Reporting System (NFIRS) (1996–1998) and the National Fire Protection Association’s (NFPA’s) annual survey, *Fire Loss in the United States*.
3. Assuming a floor is between 10 and 12 feet, 30 to 49 feet would approximate the 4th floor.
4. “Occupancies in Special Structures and Highrise Buildings, *Fire Protection Handbook, 18th Edition*, NFPA 2001.
5. “Christmas Tree May Have Ignited in Culkin Apartment Fire,” *CNN*, December 24, 1998.
6. “Three Firefighters Die in a 10-Story Highrise Apartment Building, New York,” *Firefighter Fatality Investigation Report 99F-01*, National Institute for Occupational Safety and Health, August 2, 1999.
7. “Houston Fire Captain, Man Killed in Highrise Blaze,” *Click2Houston*, October 17, 2001.

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