U.S. Fire Administration
TOPICAL FIRE RESEARCH SERIES

Volume 1, Issue 15
March 2001 (Rev. December 2001)

Smoke Alarm Performance in Residential Structure Fires

FINDINGS

- Smoke alarms save lives and money.
- 38% of residences had an operable alarm during a fire, but these fires accounted for only 8% of total property loss.
- Only 6% of U.S. homes are not equipped with smoke alarms, yet 40% of residences with fire had no installed alarm.
- Alarms operate with more frequency in apartments than in one- and two-family homes. The reason may be that professional property managers are generally responsible for maintaining the alarms, not the apartment dwellers.
- Multiple-fatality fires are less likely to have working smoke alarms.

Each year, there are an estimated 405,000 fires in residential structures, which cause nearly 3,600 fatalities, 18,600 injuries, and $4.7 billion in property loss.[1] Given the enormity of the U.S. fire problem, fire service and public health experts are constantly seeking programs/devices that will reduce the number of lives lost and property destroyed by fire.

Since 1970 when battery-powered smoke alarms[2] were first introduced, smoke alarms have become a familiar presence in American homes. By 2000, they were installed in nearly 94% of U.S. households.[3] This topical report examines the performance of smoke alarms in residential structure fires. Particular attention is given to fatal fires, especially those with multiple victims.

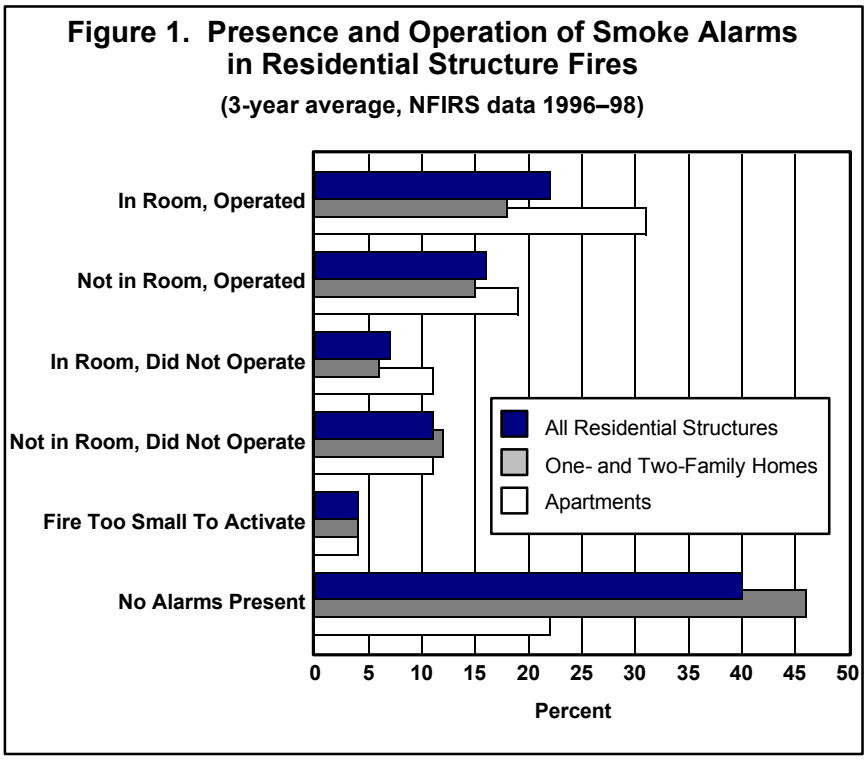
How Smoke Alarms Work

Smoke alarms in residences are of two general types: ionization and photoelectric. Ionization alarms monitor the level of ions (electrically charged particles) in the air. They are generally sensitive to small smoke particles, which are produced by flaming fires. If present, these particles conduct a current within the alarm's chamber, activating the de-

vice. Photoelectric smoke alarms use beams of light and sensors to detect the presence of larger smoke particles (produced by smoldering fires), which interrupt the light beams and trigger the alarm.[4]

Presence in Residential Fires

Figure 1 shows that the presence of smoke alarms varies by property type. Smoke alarms are present and operate in 38% of residential structure fires.[5] This figure demonstrates the value of smoke alarms: only 6% of U.S. homes are not equipped with alarms, but 40% of the homes with fires had no installed alarm.



Smoke alarms operate with greater frequency in apartments (50%) than in one- and two-family residences. This difference is likely due to variances in the codes governing building construction. NFPA Standard 101, *Life Safety Code,* has been widely adopted by jurisdictions throughout the United States. The Code requires smoke alarms and automatic suppression systems for apartment buildings higher than three stories or with more than 11 units. Responsibility for maintaining these systems is incumbent on the landlord or property owner.

The Code requires smoke alarms to be installed outside sleeping rooms in one- and two-family residences. However, since individual homeowners are responsible for the maintenance of the devices, they may be more likely to disable nuisance alarms that activate while cooking and less likely to test the unit and replace wornout batteries.

The presence and operation of smoke alarms also varies by cause of residential fire (Figure 2). In arson (incendiary/suspicious) fires, it is likely that a smoke alarm will not be present in the home. However, in cooking and heating fires, there is a higher likelihood that a smoke alarm is present and that it operated. This is probably due to the targeted placement of smoke alarms in kitchens and in the vicinity of heating equipment.

Figure 2. Alarm Performance by Fire Cause for Residential Structure Fires

(3-year average, NFIRS data 1996–98)

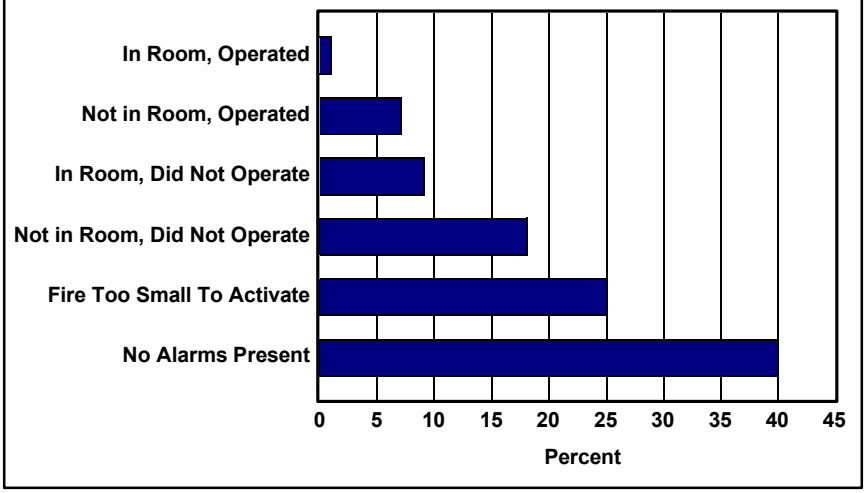
ALARM PERFORMANCE	INCENDIARY/ SUSPICIOUS	HEATING	COOKING	CHILDREN PLAYING	SMOKING	ALL RESIDENTIAL STRUCTURES
In Room, Operated	12%	31%	23%	18%	21%	22%
Not in Room, Operated	8	22	14	18	15	16
In Room, Did Not Operate	5	8	8	7	8	7
Not in Room, Did Not Operate	7	11	13	13	12	11
Fire Too Small To Activate Alarm	2	4	7	2	3	4
No Alarm Present	66	23	36	42	40	39

LOSSES

Figure 3 shows that dollar losses were substantially lower where an alarm operated. The 38% of residences that had an operating alarm resulted in only 8% of the total property loss. The loss in homes with no installed alarm is estimated at $1.1 billion annually.

Figure 3. Presence of Smoke Alarms vs. Dollar Loss in Residential Structure Fires

(3-year average, NFIRS data 1996–98)



As shown in Figure 4, no smoke alarms were present or they did not operate in nearly 75% of residences where a fire fatality occurred. In fact, as the number of fatalities per fire increased, the presence of operable smoke alarms decreased. In single-fatality fires, a smoke alarm operated in nearly 24% of fires. For fires with five or more fatalities, smoke alarms operated in only 13% of fires.

Figure 4. Smoke Alarm Performance in Fires With Casualties

(3-year average, NFIRS data 1996–98)

ALARM PERFORMANCE	PERCENT OF FIRES WITH INJURIES	PERCENT OF FIRES WITH FATALITIES
In Room, Operated	22	12
Not in Room, Operated	21	12
In Room, Did Not Operate	10	9
Not in Room, Did Not Operate	12	11
No Alarm Present	33	55

EXAMPLES

- In February 2001, an 11-year old boy was killed in an early morning fire. There were no smoke alarms in the home.[7]

- In April 2000, two young women were killed in an early morning cooking fire. One smoke alarm was found in a kitchen drawer with its battery removed.[8]

- In December 1999, three children and three firefighters were killed in a fire ignited by a 4-year old playing with the family stove. In the after-fire investigation, authorities cited a lack of functioning smoke alarms as having contributed to their deaths.[9]

CONCLUSIONS

The presence of an operable smoke alarm substantially reduces risk of death in residential fires; and property losses are significantly less. Check your smoke alarms regularly and change batteries at least yearly.

If you do not have smoke alarms in your home, they can be purchased at most hardware and home improvement stores. Should this cost pose a financial burden, contact your local fire department, state Fire Marshal Office, or USFA for information about programs that supply smoke alarms free of charge.

NOTES

1. National estimates are based on National Fire Incident Reporting System (NFIRS) data (1996–1998) and the National Fire Protection Association's (NFPA) annual survey, *Fire Loss in the United States.*
2. Prior to 1996, smoke alarms in the United States were generally referred to as *smoke detectors.* In 1996, manufacturers officially began using the term "smoke alarm" to be more consistent with international terminology and more accurate with regard to the device's function.

3. "Fire-Related Injuries," *Fact Book for the Year 2000*, Centers for Disease Control, National Center for Injury Prevention and Control, 2001.
4. "Smoke Detectors," *Encyclopedia Britannica*.
5. Percentages shown have been "adjusted," by apportioning the unkowns to the reported numbers.
6. *Multiple Fatality Fires Reported to NFIRS 1994–1996*, United States Fire Administration, Federal Emergency Management Agency, October 1999.
7. "Boy's Death Spurs Fire Officials To Repeat Smoke Detector Advice," *SunSpot*, February 6, 2001.
8. "Stove May Have Begun Fatal Fire," *The Buffalo News*, April 27, 2000.
9. "Smoke Detectors, Fire Service Resources Cited in Deaths of 3 Children, 3 Firefighters in Keokuk Fire," *Investigative Report*, NFPA, August 2000.

CLICK TO REVIEW THE DETAILED METHODOLOGY USED IN THIS ANALYSIS

CLICK TO SEE ALL THE REPORTS IN THIS TOPICAL FIRE RESEARCH SERIES