

**Reported Fires in High-Rise Structures in Selected Occupancies
with and without Automatic Extinguishing Systems
by Extent of Smoke Damage**

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**Reported Fires in High-Rise Structures in Selected Occupancies*
with and without Automatic Extinguishing Systems, by Extent of Smoke Damage**

The following two tables show the estimated average annual frequency of fires and associated civilian deaths, civilian injuries, and direct property damage with different extents of smoke damage in buildings of seven stories or more in selected occupancies during the 10-year period of 1989-1998. Because extent of smoke damage was dropped from Version 5.0 of the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS 5.0), the analysis was done on older data collected in Version 4.1 of NFIRS. Structure fires were identified by type of situation found 11. High-rise buildings were identified by number of stories codes 5-8. Performance of automatic extinguishing system (AES) codes 1-3 were used to identify fires in which automatic extinguishing systems were present. Code 8 in this field indicated such equipment was not present. Fires in which the AES was coded as unclassified were not analyzed.

The occupancies chosen are consistent with those used by John R. Hall, Jr. in his series of NFPA reports, *High-Rise Building Fires*. The selected occupancies include:

- Apartments (fixed property use 420-429);
- Hotels or motels (fixed property use 440-449);
- Office buildings (fixed property use 590-599); and
- Facilities that care for the sick (fixed property use 330-339).

The tables include proportional shares of fires and losses for which AES and number of stories were unknown or not reported. Fires in which the extent of smoke damage was unknown or not reported were allocated proportionally among fires with known extent of smoke damage. More detailed information about the methodology can be found in the Appendix.

Table 1 shows the extent of smoke damage in fires in which AES was present. Comparable data is shown in Table 2 for fires in properties without AES protection.

* Occupancies include apartments, hotels, office buildings, and facilities that care for the sick.

Table 1.
Reported Fires in High-Rise Structures in Selected Occupancies*
with Automatic Extinguishing Systems, by Extent of Smoke Damage
1989-1998 Annual Averages

Extent of Smoke Damage	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage	
							(in Millions)	
Confined to object of origin	800	(18%)	0	(11%)	11	(7%)	\$1	(4%)
Confined to part of room or area of origin	800	(18%)	0	(0%)	17	(11%)	\$1	(7%)
Confined to room of origin	700	(17%)	0	(0%)	29	(18%)	\$2	(12%)
Confined to fire-rated compartment of origin	200	(6%)	0	(11%)	10	(6%)	\$1	(6%)
Confined to floor of origin	700	(17%)	1	(41%)	36	(22%)	\$3	(23%)
Confined to structure of origin	400	(10%)	0	(11%)	48	(30%)	\$5	(33%)
Extended beyond structure of origin	0	(1%)	0	(13%)	2	(1%)	\$2	(14%)
No damage of this type	600	(14%)	0	(13%)	9	(5%)	\$0	(2%)
Total	4,200	(100%)	3	(100%)	162	(100%)	\$15	(100%)

* Occupancies include apartments, hotels, office buildings, and facilities that care for the sick.

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest hundred, deaths and injuries to the nearest one, and direct property damage to the nearest million dollars. Sums may not equal totals due to rounding errors. Property damage has not been adjusted for inflation. Sums may not equal due to rounding errors. Estimates of zero mean that the actual number rounded to zero – it may or may not actually be zero. Estimates include proportional shares of fires in which the number of stories and/or automatic extinguishing system performance was unknown or not reported. Fires in which the extent of smoke damage was unknown or not reported were allocated proportionally among fires with known extent of smoke damage.

Source: National estimates based on NFIRS and NFPA survey.

Table 2.
Reported Fires in High-Rise Structures in Selected Occupancies*
With No Automatic Extinguishing Systems, by Extent of Smoke Damage
1989-1998 Annual Averages

Extent of Smoke Damage	Fires		Civilian		Civilian		Direct	
			Deaths		Injuries		Property Damage	
							(in Millions)	
Confined to object of origin	1,000	(14%)	1	(3%)	10	(2%)	\$0	(1%)
Confined to part of room or area of origin	1,100	(15%)	1	(2%)	22	(4%)	\$1	(2%)
Confined to room of origin	1,100	(15%)	3	(5%)	36	(7%)	\$1	(4%)
Confined to fire-rated compartment of origin	600	(8%)	5	(9%)	34	(6%)	\$1	(4%)
Confined to floor of origin	1,400	(20%)	13	(26%)	128	(24%)	\$7	(19%)
Confined to structure of origin	800	(11%)	22	(45%)	244	(45%)	\$20	(56%)
Extended beyond structure of origin	300	(4%)	5	(9%)	50	(9%)	\$4	(12%)
No damage of this type	1,000	(14%)	0	(1%)	13	(2%)	\$0	(1%)
Total	7,200	(100%)	50	(100%)	536	(100%)	\$36	(100%)

* Occupancies include apartments, hotels, office buildings, and facilities that care for the sick.

Note: These are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest hundred, deaths and injuries to the nearest one, and direct property damage to the nearest million dollars. Sums may not equal totals due to rounding errors. Property damage has not been adjusted for inflation. Sums may not equal due to rounding errors. Estimates of zero mean that the actual number rounded to zero – it may or may not actually be zero. Estimates include proportional shares of fires in which the number of stories and/or automatic extinguishing system performance was unknown or not reported. Fires in which the extent of smoke damage was unknown or not reported were allocated proportionally among fires with known extent of smoke damage.

Source: National estimates based on NFIRS and NFPA survey.

Appendix A: How National Estimates Statistics Are Calculated

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

Data Bases Used

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

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

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

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

respond are truly representative of fire departments their size.) On the other hand, large city departments are so few in number and protect such a large proportion of the total U.S. population that it makes sense to survey all of them. Most respond, resulting in excellent precision for their part of the final estimate.

Projecting NFIRS to National Estimates

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

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

For example, the scaling ratio for 1998 civilian deaths in residential structures is equal to the total number of 1998 civilian deaths in residential structure fires reported to fire departments, according to the NFPA survey (3,250), divided by the total number of 1998 civilian deaths in residential structure fires reported to NFIRS (1,224). Therefore, the scaling ratio is $3,250/1,224 = 2.66$.

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

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

Calculating National Estimates of Particular Types of Fires

Most analyses of interest involve the calculation of the estimated number of fires not only within a particular occupancy but also of a particular type. The types that are mostly frequently of interest are those defined by some ignition-cause characteristic. The six

cause-related characteristics most commonly used to describe fires are: form of the heat that caused the ignition, equipment involved in ignition, form or type of material first ignited, the ignition factor that brought heat source and ignited material together, and area of origin. Other characteristics of interest are victim characteristics, such as ages of persons killed or injured in fire.

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

Consequently, most national estimates analyses allocate unknowns. This is done by using scaling ratios defined by NFPA survey estimates of totals divided by only those NFIRS fires for which the dimension in question was known and reported. This approach is equivalent to assuming that the fires with unreported characteristics, if known, would show the same proportions as the fires with known characteristics. For example, it assumes that the fires with unknown ignition factor contain the same relative shares of child-playing fires, incendiary-cause fires, short circuit fires, and so forth, as are found in the fires where ignition factor was reported.

Rounding Errors

The possibility of rounding errors exists in all our calculations. One of the notes on each table indicates the extent of rounding for that table, e.g., deaths rounded to the nearest one, fires rounded to the nearest hundred, property damage rounded to the nearest hundred thousand dollars. In rounding to the nearest one, functional values of 0.5 or more are rounded up and functional values less than 0.5 are rounded down. For example, 2.5 would round to 3, and 3.4 would round to 3. In rounding to the nearest one, a stated estimate of 1 could be any number from 0.5 to 1.49, a roughly threefold range.

The impact of rounding is greatest when the stated number is small relative to the degree of rounding. As noted, rounding to the nearest one means that stated values of 1 may vary by a factor of three. Similarly, the cumulative impact of rounding error - the potential gap between the estimated total and the sum of the estimated values as rounded - is greatest when there are a large number of values and the total is small relative to the extent of rounding.

Suppose a table presented 5-year averages of estimated deaths by item first ignited, all rounded to the nearest one. Suppose there were a total of 30 deaths in the 5 years, so the total average would be $30/5 = 6$.

In case 1, suppose 10 of the possible items first ignited each accounted for 3 deaths in 5 years. Then there would be 10 entries of $3/5 = 0.6$, rounded to 1, and the sum would be 10, compared to the true total of 6.

In case 2, suppose 15 of the possible items first ignited each accounted for 2 deaths in 5 years. Then there would be 15 entries of $2/5 = 0.4$, rounded to 0, and the sum would be 0, compared to the true total of 6.

Here is another example: Suppose there were an estimate of 7 deaths total in 1992 through 1996. The 5-year average would be 1.4, which would round to 1, the number we would show as the total. Each death would represent a 5-year average of 0.2.

If those 7 deaths split as 4 deaths in one category (e.g., smoking) and 3 deaths in a second category (e.g., heating), then we would show $4 \times 0.2 = 0.8$ deaths per year for smoking and $3 \times 0.2 = 0.6$ deaths per year for heating. Both would round to 1, there would be two entries of 1, and the sum would be 2, higher than the actual rounded total.

If those 7 deaths split as 1 death in each of 7 categories (quite possible since there are 12 major cause categories), then we would show 0.2 in each category, always rounding to 0, and the sum would be 0, lower than the actual rounded total. The more categories there are, the farther apart the sum and total can -- and often do -- get.

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