SELECTIONS FROM

THE U.S. FIRE PROBLEM OVERVIEW REPORT

LEADING CAUSES AND OTHER PATTERNS AND TRENDS

INDUSTRIAL AND MANUFACTURING PROPERTIES

Marty Ahrens
NFPA
Fire Analysis and Research Division
1 Batterymarch Park
Quincy, MA 02169-7471
www.nfpa.org

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Structure Fires in Industrial and Manufacturing Properties

Fires in two categories of facilities: utility, defense, agriculture and mining properties; and manufacturing and processing properties are examined together in this section. Agriculture, forestry, mining, laboratories, energy production, communication facilities and defense sites are included in the first group. Manufacturing and processing properties include those properties that make products of all kinds or are engaged in processing, assembling, mixing, packing, finishing, decorating, repairing and similar operations. Only fires reported to public fire departments are included in these statistics.

In Version 5.0 of NFIRS, no occupancy class distinctions were made within the manufacturing category. Instead, distinctions could be made by looking at the presence of specific on-site materials. Due to these and other changes in NFIRS, data from 1999 must be analyzed separately from earlier data. Because five-year annual averages are less likely to be skewed by random variation and the older data had some features not captured by NFIRS Version 5.0, separate tables are provided with the most recent data (1999) and five-year annual averages for 1994-1998.

Almost 17,000 of these structure fires were reported per year.
The frequency industrial and manufacturing property structure fires and associated losses during 1999 and the average number of these fires and losses per year from 1994 through 1998 are shown in the following tables. In 1999, an estimated 17,200 industrial and manufacturing structure fires caused 29 civilian deaths, 609 civilian injuries and $1.1 billion in direct property damage.

1999 Structure Fires in Industrial and Manufacturing Facilities

Occupancy	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)
Utility, defense, agriculture or mining	**3,800**	**23**	**162**	**$690.2**
Energy production plant	200	11	107	$626.8
Laboratory	300	0	11	$2.0
Defense, computer or communications center	100	0	0	$1.4
Utility or distribution system	400	2	21	$4.0
Agriculture	2,200	10	19	$47.7
Forest, timberland or woodland	100	0	2	$0.1
Mine or quarry	100	0	2	$2.6
Unclassified or unknown-type utility, defense, agriculture or mining	300	0	0	$5.6
Manufacturing or processing	**13,300**	**6**	**447**	**$420.3**
Total	**17,200**	**29**	**609**	**$1,110.5**

Structure Fires in Industrial and Manufacturing Facilities
1994-1998 Annual Averages

Occupancy	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)
Industry, Utility and Defense	**4,200**	**3**	**62**	**$136.0**
Energy production facility	200	1	6	$22.9
Laboratory	300	0	17	$4.8
Communication, defense or document facility	200	0	4	$7.1
Energy distribution property or utility facility	500	1	10	$12.2
Agricultural or farm production facility	2,300	2	11	$57.0
Forest, fish hatchery or hunting area	100	0	0	$0.8
Mine or quarry	200	0	3	$6.5
Nonmetallic mineral or mineral product manufacturing facility	300	0	10	$15.1
Unclassified or unknown-type industry, utility or defense	200	0	3	$9.7
Manufacturing	**12,700**	**15**	**494**	**$653.6**
Food product manufacturing	1,200	1	27	$77.2
Beverage, tobacco or related oil product manufacturing	200	0	9	$3.7
Textile manufacturing	500	1	21	$150.0
Wearing apparel or leather or rubber product manufacturing	400	0	19	$38.3
Wood, furniture, paper or printing product manufacturing	3,000	0	68	$112.8
Chemical, plastic or petroleum product manufacturing	1,300	6	106	$54.6
Metal or metal product manufacturing	3,700	4	166	$140.4
Vehicle assembly or manufacturing	600	1	28	$22.5
Other manufacturing	1,000	0	27	$30.9
Unclassified or unknown-type manufacturing	800	3	23	$23.1
Total	**16,900**	**18**	**556**	**$789.6**

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Fires are rounded to the nearest hundred, deaths and injuries to the nearest one, and direct property damage to the nearest hundred thousand dollars. Sums may not equal totals due to rounding errors. Damage has not been adjusted for inflation.

Source: National estimates based on NFIRS and NFPA survey.

During the five-year period of 1994 through 1998, an estimated average of 16,900 reported industrial and manufacturing structure fires caused 18 civilian deaths, 556 civilian injuries, and $789.6 million in direct property damage per year. One-fifth of these 1994-1998 fires occurred in facilities manufacturing metal or metal products.

3.3% of reported structure fires occurred in industrial or manufacturing properties.
During 1999, the 17,200 fires in basic industry and manufacturing properties accounted for 3.3% of the 523,600 structure fires, 1.0% of the 3,041 civilian fire deaths, 3.3% of the 18,519 civilian structure fire injuries, and 13.1% of the $8.5 billion in direct property damage.

Since 1980, these structure fires fell 59%.
Fires in industrial and manufacturing properties fell 59% from 42,100 in 1980 to 17,200 in 1999. From 1998 to 1999, structure fires in these occupancies rose 6% from 16,100 in 1998. In comparison, structure fires of all types declined 51% from 1980 to 1999. From 1998 to 1999, total structure fires increased by 1%.

"Other equipment" was the leading cause of these fires.
The "other equipment" cause includes fires caused by various types of equipment that are not involved in cooking, heating or electrical distribution, and are not considered appliances, tools, air conditioning or torches. In older versions of NFIRS, this category also included fires in which no equipment was reported to be involved, but the other causal factors indicated a mechanical or electrical failure. "Other equipment," much of it specific to industry, caused 33% of these fires in 1999 and 39% during the 1994-1998 period. In both time periods, "open flame, ember or torch" ranked second with 14-15% of the fires, electrical distribution equipment, with 10-12% ranked third, and heating equipment, with 7-10%, ranked fourth

Processing or manufacturing areas were the most frequent areas of origin.
One of every five reported structure fires in industrial or manufacturing properties started in processing or manufacturing areas, 10% started in machinery room or areas, 6% started in product storage room or areas, and 5% began in maintenance shops or areas. The rank order and percentages of the leading areas were remarkably similar in the two time periods.

One-third of these fires occurred in properties with smoke or fire alarms.
Only 33% of the reported fires in industrial and manufacturing properties occurred in facilities with smoke or fire alarms during the five-year period from 1994 through 1998. Automatic suppression systems were present in 41% of the fires in these properties. The average estimated direct property damage was almost three times as high when no automatic suppression system was present.

Data for 1999 is not provided because of difficulties introduced by the process of converting the data collected in the older version to NFIRS 5.0. Because the majority of data was collected in the older format and converted, drawing reliable conclusions on this topic from more recent data is difficult. Detailed analyses, projections and information about the specific data source issues will be available in the updated editions of *U.S. Experience with Sprinklers*, by Kimberly D. Rohr, and *U.S. Experience with Smoke Alarms*, by Marty Ahrens.

Fire Protection Features in Industrial and Manufacturing Structure Fires Reported to Public Fire Departments: 1994-1998 Annual Averages

Percent of fires in buildings with smoke or other fire alarms present	32.9%
Percent of fires in buildings having smoke or other fire alarms in which devices were operational	83.0%
Percent of fires in buildings with operational smoke or other fire alarms (product of first two statistics)	27.3%
Percent of fires in buildings with automatic suppression system	41.3%
Deaths per 1,000 fires with automatic suppression system present	0.9
Deaths per 1,000 fires with no automatic suppression system present	1.2
Reduction in deaths per 1,000 fires when automatic suppression systems were present	30.4%
Average loss per fire when automatic suppression system was present	$19,238
Average loss per fire with no automatic suppression system	$55,749
Reduction in loss per fire when automatic suppression systems were present	65.5%

Source: National estimates based on NFIRS and NFPA survey.

Several fires or explosions from these properties are in top 25 for dollar loss.
The deadliest U.S. fire or explosion in the industrial or manufacturing property class was the 1907 Monongha, West Virginia coal mine explosion which claimed 361 lives. Six industrial or manufacturing fires in the past 20 years rank among the costliest of all fires in U.S. history: the 1989 Pasadena, Texas vapor cloud explosion which also killed 23 people (#6 in dollar loss after adjusting for inflation); the 1999 Dearborn, Michigan power plant fire at an auto manufacturing complex (#10); the 1995 Methuen, Massachusetts textile mill fire (#12), the 1988 Norco, Louisiana refinery fire (#15); the 1987 Pampa, Texas chemical company plant fire (#22), and the 1999 Gramercy, Louisiana aluminum plant fire (#25).

Almost 51,000 outside fires were reported on these properties in 1999.
In 1999, an estimated 50,900 outside and other fires in or on industrial or manufacturing properties caused eight civilian deaths, 199 civilian injuries, and $75.8 million in direct property damage. Also in 1999, 5,600 vehicle fires on these properties caused 12 civilian deaths, 28 civilian injuries, and $52.1 million in direct property damage.

From 1994 through 1998, an estimated annual average of average of 53,400 per year outside and other fires caused an average of six civilian deaths, 180 civilian injuries, and $81.1 million in direct property damage per year on or in industrial or manufacturing properties. An average of 5,500 vehicle fires caused 19 civilian deaths, 56 civilian injuries, and $54.7 million in direct property damage per year.

Additional information sources

The Fire Analysis and Research Division's One-Stop Data Shop offers a package of statistics and published NFPA articles and reports about fires in refineries. The annual large-loss study provides examples of major industrial and manufacturing fires each year. NFPA members can download a number of investigation reports on specific industrial or manufacturing facility fires at no cost from http://www.nfpa.org/Research/FireInvestigation/FIReports/Industrial/Industrial.asp. Non-members may order these investigation reports through the NFPA library.

Section 13, Chapter 19, "Industrial Occupancies" by David P. Demers in the 19th edition of the NFPA *Fire Protection Handbook* provides an overview of some of the safety concerns for these properties. A number of other chapters provide information about specific industrial processes or occupancies.

Structure Fires in Industrial and Manufacturing Properties, by Year: 1980-1999

Year	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage (in Millions)
1980	42,100	21	775	$608.9
1981	39,000	31	1,322	$659.3
1982	35,000	50	1,118	$449.6
1983	29,900	51	1,091	$727.1
1984	30,400	88	853	$803.5
1985	30,900	37	779	$569.0
1986	26,400	24	821	$516.0
1987	25,800	44	991	$542.3
1988	24,100	30	847	$675.7
1989	21,700	60	783	$1,795.7
1990	18,700	79	830	$688.7
1991	18,300	21	641	$646.6
1992	17,500	11	545	$538.6
1993	16,400	13	893	$566.1
1994	18,000	16	648	$567.4
1995	16,300	32	587	$1,253.8
1996	16,500	8	540	$785.8
1997	17,800	16	485	$709.4
1998	16,100	20	520	$631.8
1999	17,200	29	609	$1,110.5

Note: These are fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Fires are expressed to the nearest hundred, deaths and injuries are rounded to the nearest one, and property damage is rounded to the nearest hundred thousand dollars. Property damage figures have not been adjusted for inflation.

Source: National estimates based on NFIRS and NFPA survey.

1999 Structure Fires in Industrial and Manufacturing Properties by Cause

Unknown-Cause Fires Allocated Proportionally

Cause	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Other equipment	5,600	(32.6%)	7	(25.0%)	238	(39.0%)	$408.0	(36.7%)
Working or shaping machine, processing equipment or unclassified industrial equipment	2,100	(12.1%)	2	(8.3%)	88	(14.4%)	$61.9	(5.6%)
Industrial furnace or kiln	1,000	(5.7%)	2	(8.3%)	42	(7.0%)	$129.3	(11.6%)
Heat treating equipment	300	(2.0%)	0	(0.0%)	29	(4.8%)	$47.0	(4.2%)
Extractor or waste recovery machine	300	(1.9%)	0	(0.0%)	20	(3.2%)	$4.8	(0.4%)
Casting, molding or forging equipment	300	(1.7%)	0	(0.0%)	16	(2.7%)	$68.3	(6.2%
Separate motor	300	(1.6%)	0	(0.0%)	0	(0.0%)	$5.1	(0.5%)
Conveyor	200	(1.3%)	0	(0.0%)	13	(2.1%)	$8.8	(0.8%)
Hydraulic equipment, including pump or compressor	200	(1.3%)	0	(0.0%)	0	(0.0%)	$26.2	(2.4%)
Painting tool	200	(1.0%)	0	(0.0%)	0	(0.0%)	$5.9	(0.5%)
Open flame, ember or torch	2,600	(15.0%)	2	(8.3%)	111	(18.2%)	$160.5	(14.5%)
Torch	1,900	(11.2%)	2	(8.3%)	97	(16.0%)	$146.9	(13.2%)
Hot ember or ash	200	(1.2%)	0	(0.0%)	7	(1.1%)	$6.9	(0.6%)
Electrical distribution	2,000	(11.8%)	2	(8.3%)	68	(11.2%)	$185.7	(16.7%)
Wiring, switch or outlet	700	(3.8%)	0	(0.0%)	7	(1.1%)	$66.7	(6.0%)
Lamp, bulb, lighting or sign	300	(2.0%)	0	(0.0%)	0	(0.0%)	$12.1	(1.1%)
Power switch gear or overcurrent protection device	300	(1.5%)	0	(0.0%)	39	(6.4%)	$17.7	(1.6%)
Transformer	200	(1.0%)	0	(0.0%)	10	(1.6%)	$33.4	(3.0%)
Heating equipment	1,700	(10.0%)	0	(0.0%)	46	(7.5%)	$66.8	(6.0%)
Fixed or portable space heater	500	(2.8%)	0	(0.0%)	13	(2.1%)	$12.0	(1.1%)
Central heat, furnace or boiler	300	(1.7%)	0	(0.0%)	26	(4.3%)	$3.7	(0.3%)
Fireplace or chimney	300	(1.5%)	0	(0.0%)	0	(0.0%)	$36.3	(3.3%)
Other heat source	1,600	(9.2%)	0	(0.0%)	75	(12.3%)	$45.2	(4.1%)
Intentional	1,000	(5.7%)	17	(58.3%)	29	(4.8%)	$129.5	(11.7%)
Appliance, tool or air conditioning	700	(4.3%)	0	(0.0%)	16	(2.7%)	$15.6	(1.4%)
Dryer	400	(2.1%)	0	(0.0%)	3	(0.5%)	$7.3	(0.7%)
Cooking equipment	700	(4.1%)	0	(0.0%)	7	(1.1%)	$18.8	(1.7%)
Oven or rotisserie	200	(1.3%)	0	(0.0%)	0	(0.0%)	$13.7	(1.2%)

1999 Structure Fires in Industrial and Manufacturing Properties by Cause

Unknown-Cause Fires Allocated Proportionally
(Continued)

Cause	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Exposure	500	(3.0%)	0	(0.0%)	3	(0.5%)	$22.1	(2.0%)
Smoking materials	400	(2.6%)	0	(0.0%)	13	(2.1%)	$44.9	(4.0%)
Natural causes	200	(1.3%)	0	(0.0%)	0	(0.0%)	$12.8	(1.1%)
Child playing	100	(0.4%)	0	(0.0%)	3	(0.5%)	$0.7	(0.1%)
Total	17,200	(100.0%)	29	(100.0%)	609	(100.0%)	$1,110.5	(100.0%)

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. Fires are rounded to the nearest hundred, civilian deaths and civilian injuries are expressed to the nearest one and property damage is rounded to the nearest hundred thousand dollars. Sums may not equal totals due to rounding errors. The 12 major cause categories are based on a hierarchy developed by the U.S. Fire Administration. Property damage has not been adjusted for inflation.

Source: National estimates based on NFIRS and NFPA survey.

Structure Fires in Industrial and Manufacturing Properties
by Cause
1994-1998 Annual Averages
Unknown-Cause Fires Allocated Proportionally

Cause	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Other equipment	6,600	(39.1%)	6	(34.4%)	257	(46.2%)	$277.4	(35.1%)
Working or shaping machine	1,000	(5.6%)	1	(3.0%)	24	(4.4%)	$21.0	(2.7%)
Unclassified or unknown type processing equipment	900	(5.5%)	3	(14.0%)	39	(7.1%)	$65.5	(8.3%)
Furnace, oven or kiln	900	(5.4%)	0	(0.0%)	39	(7.1%)	$26.4	(3.3%)
Unclassified or unknown-type special equipment	500	(2.9%)	1	(7.2%)	15	(2.8%)	$31.3	(4.0%)
Heat treating equipment	300	(1.8%)	0	(0.0%)	12	(2.2%)	$11.0	(1.4%)
Separate motor or generator	300	(1.7%)	0	(0.0%)	4	(0.8%)	$6.2	(0.8%)
Waste recovery equipment	300	(1.6%)	0	(0.0%)	12	(2.2%)	$4.4	(0.6%)
Casting, molding or forging equipment	300	(1.5%)	0	(1.6%)	35	(6.3%)	$14.9	(1.9%)
Conveyor	200	(1.1%)	0	(0.0%)	3	(0.5%)	$13.1	(1.7%)
Open flame, ember or torch	2,300	(13.8%)	4	(22.2%)	78	(14.0%)	$101.0	(12.8%)
Torch	1,400	(8.2%)	4	(22.2%)	63	(11.4%)	$75.3	(9.5%)
Camp fire, bon fire or other open fire	300	(1.6%)	0	(0.0%)	2	(0.3%)	$2.4	(0.3%)
Rekindle or reignition	200	(1.2%)	0	(0.0%)	0	(0.0%)	$2.6	(0.3%)
Electrical distribution	1,700	(10.3%)	4	(19.8%)	53	(9.6%)	$86.6	(11.0%)
Fixed wiring	500	(2.9%)	1	(3.6%)	12	(2.2%)	$29.1	(3.7%)
Light fixture, lamp holder, ballast or sign	200	(1.3%)	1	(2.8%)	5	(0.8%)	$12.0	(1.5%)
Power switch gear or overcurrent protection device	200	(1.2%)	1	(8.1%)	14	(2.5%)	$11.1	(1.4%)
Heating equipment	1,200	(7.1%)	0	(0.0%)	22	(3.9%)	$32.3	(4.1%)
Fixed space heater	300	(1.7%)	0	(0.0%)	6	(1.0%)	$10.5	(1.3%)
Central heating unit	200	(1.2%)	0	(0.0%)	1	(0.2%)	$6.8	(0.9%)
Natural causes	1,100	(6.6%)	3	(18.2%)	55	(9.9%)	$40.6	(5.1%)
Spontaneous ignition or chemical discharge	700	(4.1%)	3	(18.2%)	21	(3.9%)	$23.7	(3.0%)
Lightning	300	(1.5%)	0	(0.0%)	24	(4.4%)	$9.0	(1.1%)
Intentional	1,000	(6.1%)	1	(2.8%)	14	(2.6%)	$158.6	(20.1%)
Appliance, tool or air conditioning	800	(4.8%)	0	(0.0%)	26	(4.7%)	$21.5	(2.7%)
Dryer	300	(1.8%)	0	(0.0%)	4	(0.7%)	$3.9	(0.5%)
Other heat source	700	(3.9%)	0	(1.3%)	20	(3.6%)	$16.2	(2.1%)

Structure Fires in Industrial and Manufacturing Properties
by Cause
1994-1998 Annual Averages
Unknown-Cause Fires Allocated Proportionally
(Continued)

Cause	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Cooking equipment	500	(2.9%)	0	(1.3%)	16	(2.8%)	$24.1	(3.1%)
Exposure	500	(2.7%)	0	(0.0%)	4	(0.7%)	$17.1	(2.2%)
Smoking materials	400	(2.1%)	0	(0.0%)	8	(1.5%)	$13.1	(1.7%)
Child playing	100	(0.5%)	0	(0.0%)	2	(0.4%)	$1.1	(0.1%)
Total	16,900	(100.0%)	18	(100.0%)	556	(100.0%)	$789.6	(100.0%)

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. Fires are rounded to the nearest hundred, civilian deaths and civilian injuries are expressed to the nearest one and property damage is rounded to the nearest hundred thousand dollars. Sums may not equal totals due to rounding errors. The 12 major cause categories are based on a hierarchy developed by the U.S. Fire Administration. Property damage has not been adjusted for inflation.

Source: National estimates based on NFIRS and NFPA survey.

1999 Structure Fires in Industrial and Manufacturing Properties by Area of Origin

Unknown-Area Fires Allocated Proportionally

Area of Origin	Fires		Civilian Deaths		Civilian Injuries		Property Damage (in Millions)	
Process or manufacturing area or workroom	3,400	(19.6%)	13	(45.5%)	242	(39.7%)	$333.4	(30.0%)
Machinery room or area or elevator machinery room	1,800	(10.5%)	5	(18.2%)	79	(13.0%)	$76.3	(6.9%)
Storage room. area, tank or bin	1,000	(5.8%)	0	(0.0%)	27	(4.4%)	$154.2	(13.9%)
Maintenance or paint shop or area	800	(4.9%)	0	(0.0%)	29	(4.8%)	$44.0	(4.0%)
Duct for HVAC, cable, exhaust, heating or air conditioning	700	(3.9%)	0	(0.0%)	19	(3.1%)	$6.8	(0.6%)
Heating equipment room	600	(3.7%)	0	(0.0%)	27	(4.4%)	$12.7	(1.1%)
Attic or ceiling/roof assembly or concealed space	600	(3.6%)	0	(0.0%)	11	(1.9%)	$60.4	(5.4%)
Unclassified area of origin	500	(3.1%)	0	(0.0%)	11	(1.9%)	$47.0	(4.2%)
Exterior wall surface	500	(3.0%)	0	(0.0%)	3	(0.4%)	$15.1	(1.4%)
Exterior roof surface	500	(2.7%)	0	(0.0%)	8	(1.3%)	$14.9	(1.3%)
Unclassified structural area	400	(2.3%)	0	(0.0%)	0	(0.0%)	$21.8	(2.0%)
Unclassified equipment or service area	400	(2.3%)	0	(0.0%)	14	(2.3%)	$19.4	(1.8%)
Trash or rubbish chute, area or container	400	(2.3%)	0	(0.0%)	0	(0.0%)	$10.3	(0.9%)
Unclassified storage area	400	(2.1%)	0	(0.0%)	8	(1.3%)	$18.8	(1.7%)
Storage of supplies or tools or dead storage	300	(1.9%)	0	(0.0%)	19	(3.1%)	$34.6	(3.1%)
Wall assembly or concealed space	300	(1.9%)	0	(0.0%)	3	(0.4%)	$10.7	(1.0%)
Kitchen or cooking area	300	(1.8%)	0	(0.0%)	11	(1.9%)	$1.9	(0.2%)
Switchgear area or transformer vault	300	(1.5%)	5	(18.2%)	14	(2.3%)	$15.6	(1.4%)
Computer room, control room or center	200	(1.4%)	0	(0.0%)	0	(0.0%)	$18.4	(1.7%)
Laboratory	200	(1.4%)	0	(0.0%)	22	(3.6%)	$3.9	(0.4%)
Lawn, field or open area	200	(1.4%)	0	(0.0%)	0	(0.0%)	$3.5	(0.3%)
Conveyor	200	(1.4%)	0	(0.0%)	5	(0.8%)	$15.7	(1.4%)
Shipping, receiving or loading area	200	(1.3%)	0	(0.0%)	3	(0.4%)	$25.8	(2.3%)
Ceiling/floor assembly or concealed space	200	(1.2%)	0	(0.0%)	0	(0.0%)	$5.8	(0.5%)
Laundry room or area	200	(1.0%)	0	(0.0%)	0	(0.0%)	$15.8	(1.4%)
Office	200	(1.0%)	5	(18.2%)	3	(0.4%)	$16.1	(1.5%)
Chimney	200	(1.0%)	0	(0.0%)	0	(0.0%)	$1.3	(0.1%)
Other known service or equipment area	500	(2.9%)	0	(0.0%)	5	(0.8%)	$21.2	(1.9%)
Other known technical processing area	300	(1.9%)	0	(0.0%)	3	(0.4%)	$43.9	(4.0%)
Other known function area	200	(1.4%)	0	(0.0%)	8	(1.3%)	$1.7	(0.1%)
Other known sales or assembly area	200	(1.3%)	0	(0.0%)	3	(0.4%)	$7.9	(0.7%)
Other known storage area	200	(1.1%)	0	(0.0%)	8	(1.3%)	$17.5	(1.6%)
Other known vehicle area	200	(1.1%)	0	(0.0%)	8	(1.3%)	$6.8	(0.6%)
Other known area	400	(2.1%)	0	(0.0%)	19	(3.1%)	$7.2	(0.6%)
Total	17,200	(100.0%)	29	(100.0%)	609	(100.0%)	$1,110.5	(100.0%)

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. Fires are rounded to the nearest hundred, civilian deaths and civilian injuries are expressed to the nearest one and property damage is rounded to the nearest hundred thousand dollars. Sums may not equal totals due to rounding errors. Property damage figures have not been adjusted for inflation.
Source: National estimates based on NFIRS and NFPA survey.

Structure Fires in Industrial and Manufacturing Properties, by Area of Origin 1994-1998 Annual Averages

Unknown-Area Fires Allocated Proportionally

Area of Origin	Fires		Civilian Deaths		Civilian Injuries		Property Damage (in Millions)	
Process or manufacturing area	3,300	(19.7%)	6	(34.6%)	198	(35.6%)	$163.5	(20.7%)
Machinery room or area	1,800	(10.4%)	2	(9.5%)	76	(13.8%)	$67.8	(8.6%)
Product storage area, tank or bin	1,000	(5.7%)	2	(12.0%)	26	(4.8%)	$99.9	(12.7%)
Maintenance shop or area	800	(4.9%)	1	(7.9%)	38	(6.9%)	$42.8	(5.4%)
Unclassified area of origin	700	(4.3%)	0	(1.3%)	9	(1.6%)	$20.5	(2.6%)
Duct	700	(4.1%)	0	(1.0%)	17	(3.1%)	$25.1	(3.2%)
Attic or ceiling/roof assembly or concealed space	600	(3.6%)	0	(1.0%)	9	(1.7%)	$35.1	(4.4%)
Heating equipment room	500	(3.2%)	0	(0.0%)	16	(2.9%)	$52.3	(6.6%)
Exterior wall surface	500	(2.9%)	0	(0.0%)	3	(0.5%)	$24.3	(3.1%)
Exterior roof surface	400	(2.6%)	0	(0.0%)	5	(0.9%)	$7.0	(0.9%)
Unclassified service or equipment area	400	(2.1%)	0	(0.0%)	12	(2.2%)	$10.1	(1.3%)
Trash or rubbish area or container	400	(2.1%)	0	(0.0%)	6	(1.0%)	$4.9	(0.6%)
Supply storage room or area	400	(2.1%)	0	(1.3%)	12	(2.2%)	$18.4	(2.3%)
Unclassified storage area	300	(2.0%)	1	(2.9%)	4	(0.7%)	$19.4	(2.5%)
Unclassified structural area	300	(2.0%)	1	(3.2%)	5	(0.9%)	$14.5	(1.8%)
Wall assembly or concealed space	300	(1.7%)	0	(0.0%)	2	(0.4%)	$9.7	(1.2%)
Kitchen	300	(1.5%)	0	(0.0%)	6	(1.1%)	$4.4	(0.6%)
Switchgear area or transformer vault	300	(1.5%)	2	(10.4%)	12	(2.2%)	$13.1	(1.7%)
Shipping, receiving or loading area	200	(1.4%)	1	(5.0%)	9	(1.6%)	$15.5	(2.0%)
Lawn, field or open area	200	(1.3%)	0	(0.0%)	0	(0.0%)	$2.3	(0.3%)
Conveyor	200	(1.3%)	0	(0.0%)	3	(0.6%)	$4.8	(0.6%)
Office	200	(1.3%)	0	(1.3%)	3	(0.6%)	$13.6	(1.7%)
Electronic equipment room or area	200	(1.3%)	0	(0.0%)	4	(0.7%)	$11.7	(1.5%)
Unclassified function area	200	(1.2%)	0	(0.0%)	8	(1.5%)	$8.0	(1.0%)
Laboratory	200	(1.2%)	0	(0.0%)	18	(3.3%)	$3.2	(0.4%)
Ceiling/floor assembly or concealed space	200	(1.1%)	0	(0.0%)	1	(0.2%)	$13.2	(1.7%)
Laundry room or area	200	(1.0%)	0	(0.0%)	2	(0.3%)	$2.1	(0.3%)
Other known service or equipment area	600	(3.6%)	0	(0.0%)	9	(1.7%)	$11.0	(1.4%)
Other known function area	400	(2.3%)	1	(2.9%)	10	(1.7%)	$27.2	(3.4%)
Other known assembly area	200	(1.2%)	0	(2.2%)	4	(0.7%)	$7.7	(1.0%)
Other known means of egress	200	(1.1%)	0	(0.0%)	2	(0.4%)	$7.6	(1.0%)
Other known area	700	(4.2%)	1	(3.6%)	22	(4.0%)	$29.2	(3.7%)
Total	16,900	(100.0%)	18	(100.0%)	556	(100.0%)	$789.6	(100.0%)

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. Fires are rounded to the nearest hundred, deaths and injuries to the nearest one, and direct property damage to the nearest hundred thousand dollars. Sums may not equal totals due to rounding errors. Damage has not been adjusted for inflation.
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 databases 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 database. 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 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. (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 intentional fires.) NFIRS also captures information on the extent of flame and on the performance of smoke alarms and sprinklers.

The USFA allowed states to begin implementing Version 5.0 of NFIRS during 1999. All of Michigan's 1999 data was collected in the Version 5.0 format, and some other jurisdictions around the country also began using the new version. The vast majority of 1999 NFIRS data was collected according to the older rules, coding structure and definitions and converted to Version 5.0 before the national database was released. Consequently, 1999 data must be analyzed in the Version 5.0 format.

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 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.

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, intentional 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 215 = 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 x 0.2 = 0.8 deaths per year for smoking and 3 x 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.

Firefighter Deaths and Injuries

There are special procedures for fire service deaths and injuries. NFPA maintains a comprehensive listing of fire service on-duty deaths which can be used to produce answers not dependent on projection from samples. This is desirable because the number of fire service deaths at the fireground for fires of a particular cause is typically very small - less than 10 a year - so sample-based estimates would have very large uncertainty ranges, relative to the statistics being estimated.

For fire service injuries, the NFPA survey does not produce projections of fire service injuries at the fireground by major property type. Therefore, one must use a single scaling ratio instead of the four ratios (one each for residential structures, non-residential structures, vehicles, and other properties) that are used to scale up the other measures of fire severity.

General Comments on Fire Causes in Structure Fires

Hierarchy of Major Causes Defined

The 12 major known cause categories in this report were originally developed by analysts at the U.S. Fire Administration. They are based on a hierarchical sorting of fires based on three different factors from the NFPA 901, *Uniform Coding for Fire Protection, 1976.* These are also the codes used by the National Fire Incident Reporting System (NFIRS).

The definitions below summarize the hierarchy and specific descriptions found in the *1990 NFIRS System Documentation Manual, Version 4.1,* pp. 201 – 203 and the adaptations made for use with Version 5.0 of NFIRS.

In some situations, a fire may legitimately be assigned to two or more major causes. When that happens, a hierarchy is used to determine which cause has priority.

Analysis reports that focus on just one cause will generally show larger totals for that one cause. Part of the difference reflects fires assigned to a higher-priority cause which therefore do not show up in the totals for a lower-priority cause. For example, a child playing with a lit cigarette would be placed solely under children playing in a table showing all causes. However, this incident would also be included in smoking fires in a report solely about fires involving smoking materials.

Even more than the hierarchy itself, however, the totals for all-cause tables will tend to be smaller than the totals for single-cause analyses because of the handling of unknown-cause fires. In the hierarchy, unknown-cause fires are only those that were unknown on all of the involved cause dimensions. This means fewer fires to be proportionally allocated in the single-cause analyses where the unknown-cause fires need to be unknown on only one dimension.

Finally, bear in mind that every fire has at least three "causes" in the sense that it could have been prevented by changing behavior, heat source, or ignitability of first fuel, the last an aspect not reflected in any of the major cause categories. For example, several of the cause categories in this system refer to types of equipment (cooking, heating, electrical, appliances). However, the problem may be not with the equipment but with the way it is used. The equipment may be unattended, too close to something that can burn, or not maintained. Version 5.0's broad cause field with categories for intentional, unintentional, failure of equipment or heat source, etc. adds an additional dimension.

Some variation will be seen in the ranking of causes over time due to changes in the NFIRS system and the cause definitions themselves. The field for equipment involved in ignition has been expanded to use three digit codes, and it was necessary to combine some codes for meaningful subcategories.

Cause Categories

Intentional causes

Fires that were proven or believed to have been deliberately set are captured here. Prior to Version 5.0 of NFIRS, these were identified by ignition factor 11, 12, 21 or 22 In Version 5.0, these incidents are identified by cause code 1 - intentional (code 7 – incendiary on the wildland module.) All fires with intentional causes are included in this category regardless of the age of the person involved. Certain fires with a completed arson module are also captured here. The cause "suspicious" has been dropped from Version 5.0, although all suspicious fires converted to intentional. See also *U.S. Arson Trends and Patterns* from the Fire Analysis and Research Division.

Child playing

Incidents in which a child was playing with the form of heat of ignition or the material first ignited are captured here. Prior to Version 5.0, the age of the child is not specified or limited and incidents were identified by ignition factor 36 or 48. Version 5.0 rules capture incidents in which "playing with heat source (19) was the factor contributing to ignition and human factor "age was a factor" (code 7) and was age less than 10 or blank. Certain incidents in which the juvenile fire module was completed and all juveniles were less than ten are also included. Other groups or analysts may use different age cut-offs. Prior to Version 5.0, fire with an ignition factor of child playing could not simultaneously be intentional. In Version 5.0, if the cause is intentional, the fire will drop into the intentional bucket, regardless of any other factors. See *Children Playing with Fire* from the Fire Analysis and Research Division for more information on this topic.

Smoking materials

Incidents in which the form of heat was some form of lighted tobacco product are captured here. (Cigarettes and pipes can be based on other materials, like marijuana, but these form a negligible share of total fires.) This category does not capture incidents in which a match or lighter used to light a cigarette started a fire. Prior to Version 5.0 these were captured by form of heat of ignition 30–39. In Version 5.0, smoking material fires are identified by heat source 61-63. Code 60 – "heat from other open flame or smoking materials" is grouped with "other heat source" because of the lack of specific information. See also *U.S. Smoking-Material Fire Problem* from the Fire Analysis and Research Division.

Heating equipment

Incidents in which some form of heating equipment (central heating units, hot water heaters, fixed or portable space heaters, fireplaces, chimneys, heat transfer equipment such as hot air ducts or hot water pipes, or other heating equipment) was involved in the ignition are said to be caused by heating equipment. This category includes both equipment that functioned properly and equipment that malfunctioned. Prior to Version 5.0, this was identified by equipment involved 10–19. Confined chimney fires, confined fuel burner or boiler fires (incident types 114 or 116, respectively,) or equipment involved 100 or 120-152 identify heating equipment fires in Version 5.0. See also *U.S. Home Heating Fire Patterns and Trends* from the Fire Analysis and Research Division.

Cooking equipment
Incidents in which some form of cooking equipment (Ranges, ovens or microwave ovens, food warming appliances, fixed or portable cooking appliances, deep fat fryers, open fired charcoal or gas grills, grease hoods or ducts, or other cooking appliances) was involved in the ignition are said to be caused by cooking equipment. Food preparation devices that do not involve heating, such as can openers or food processors, are not included here. This category includes equipment that functioned properly and equipment that malfunctioned. Incidents in which food or cooking materials were the material first ignited are included only when cooking equipment was identified; if the equipment involved was undetermined, unreported, not applicable or unclassified, the fire would not be captured here. Prior to Version 5.0, cooking equipment fires were identified by equipment involved 20-29). In Version 5.0, cooking equipment fires are identified by confined cooking fires (incident type 113), or equipment involved 631-647, 652, or code 600 when it had been converted from earlier versions. See also *U.S. Home Cooking Fire Patterns and Trends* from the Fire Analysis and Research Division.

Electrical distribution equipment
Incidents in which some form of electrical distribution or related lighting equipment (fixed wiring, transformers, associated overcurrent or disconnect equipment such as fuses or circuit breakers, meters, meter boxes, power switch gear, switches, receptacles, outlets, light fixtures, ballasts, signs, cords, plugs, lamps, light bulbs or other electrical distribution equipment) was involved in ignition or in which the form of heat was a fluorescent light ballast or an electric lamp or light bulb are captured in this category. Prior to Version 5.0, these were identified by equipment involved 40-49 or form of heat of ignition 28 or 54. In Version 5.0, these are identified by factor contributing to ignition 37 or equipment involved 200-263, except 224, 225, 228 and 229. See also *U.S. Home Product Report (Appliances and Equipment)* from the Fire Analysis and Research Division.

Appliances or air conditioning or refrigeration equipment
Incidents in which the equipment involved was coded as some form of air conditioning or refrigeration equipment (central or local air conditioning or refrigeration equipment, water cooling devices or towers, dehumidifiers, or other air conditioning or refrigeration equipment) or appliances that are not classified elsewhere (televisions, radios, stereos, VCR's, cable boxes, washers, dryers, floor care equipment, hand tools, portable appliances designed to produce heat, portable appliances not designed to produce heat, or other appliances or tools) are captured in this category. Prior to Version 5.0, these were identified by equipment involved 30-39, 50-54, or 56–59. In 5.0, these are identified by equipment involved 111-117, 310-316, 318, 345, 445, 611-623, 651-653, 655, 656, 730-759, 800-871, 874-897 or equipment involved 872 and equipment power is not between 20-39 or equipment involved = 600 and the data was originally collected in the Version 5.0 format and not converted. See also *U.S. Home Product Report (Appliances and Equipment)* from the Fire Analysis and Research Division.

Open flame, ember or torch

Incidents involving torches (coded as equipment involved; or coded as form of heat of ignition: cutting, welding, or other torch operation; or coded under ignition factor: thawing, or cutting or welding too close), candles, matches, lighters, open fires, embers, or rekindles are said to be caused by open flames, embers or torches. Prior to Version 5.0, these were identified by equipment involved 87 or form of heat 41 - 47, 53, or 55; or ignition factor 32 or 35. In Version 5.0, these are identified by equipment involved 331-334 or 873, or factor contributing to ignition 13 or 72, or heat source 43 or 64-67, or equipment involved = 872 and equipment power 20-29. See also *Torch Fires in the United States* and *Candle Fires in U.S. Homes and Other Occupancies* from the Fire Analysis and Research Division.

Other heat, flame or spark
Incidents in which the form of heat of ignition was fireworks or explosives (explosives, blasting agents, fireworks, sparklers, paper caps, party poppers, model rockets, or unknown-type heat from explosives or fireworks); unclassified or unknown-type open flame or spark; or heat or spark from friction, molten hot metal, or unclassified or unknown-type hot object. Prior to Version 5.0, these were identified by form of heat of ignition 40, 49-52, 59, or 60-65. In Version 5.0, these are identified by heat source 40-42, 50-60, 69, and 80-84. See also *Fireworks-Related Injuries, Deaths, and Fires in the U.S.* from the Fire Analysis and Research Division.

Other equipment
Incidents in which the equipment involved in ignition was coded as special equipment, processing equipment, service equipment, vehicles, engines, or unspecified equipment are said to be caused by other equipment. These include the following more specific types of equipment: motors; generators; electronic equipment such as telephones or computers; vending machines; drinking fountains; office machines; biomedical equipment; pumps; compressors; internal combustion engines; conveyors; printing presses; unclassified and unknown-type special equipment; furnaces; ovens; kilns; casting, molding; or forging equipment; heat treating equipment; working or shaping machines; coating machines; painting equipment; chemical process equipment; waste recovery equipment; and unclassified or unknown-type processing equipment. Fires in which the form of heat indicates some type of fuel-powered or electrical equipment, but no type of equipment is specified in equipment involved in ignition, were also captured here prior to Version 5.0. These latter fires include fires contradictorily coded as "no equipment" under equipment involved and "equipment involved" under form of heat. Unfortunately, these fires often dominated the “other equipment” category. Prior to Version 5.0, other equipment fires were identified by equipment involved 55, 60-79, or 96; or form of heat 10-19, 20, 29, 56, or 57. In Version 5.0, these are identified by either incident type 115 (incinerator overload or malfunction) or by equipment involved 224, 225, 228 229, 300, 317, 320-329, 340-344, 346-349, 351-365, 371-377, 400-434, 441-444, 446, 450, 451, 500-599,700, 710-729, or heat source 68, or mobile property 2 or 3 (involved in ignition) and mobile property was not equal to 15-17. See also *U.S. Vehicle Fire Trends and Patterns* from the Fire Analysis and Research Division.

Natural causes

Incidents in which the ignition factor was lightning or the form of heat was a natural source (sun's heat, spontaneous ignition, chemical reaction, lightning discharge, static discharge, or unclassified or unknown-type heat from a natural source) are said to be caused by natural causes. Prior to Version 5.0, these were identified by ignition factor 84 or form of heat 70–79. In Version 5.0, these are identified by cause 4 (act of nature) and either heat source 70-74 or factor contributing 65. It was felt that some of the items listed under "act of nature," such as animals or some weather conditions, could be more accurately described as contributing factors. Due to a conversion glitch, many of the form of heat of ignition codes in the seventies and eighties did not convert into the appropriate specific heat source code. Consequently, lightning and spontaneous ignition or chemical reaction do not appear as any of the leading types of natural causes in the 1999 data.

Exposure
Incidents that are caused by the spread of or from another fire are said to be caused by exposures. These include fires in which the exposure number is greater than 0; the ignition factor is property too close; or the form of heat is heat spreading from another fire via direct flame or convection current; radiated heat; heat from flying brand, ember or spark; conducted heat; or unclassified or unknown-type heat. Prior to Version 5.0, these were identified by exposure number greater than zero, ignition factor 65 or form of heat 80-89. In Version 5.0, these incidents are identified by exposure number greater than zero or factor contributing to ignition 70, 71 or 73-75.

Unknown
All remaining fires are grouped under unknown. In this analysis, fires in which the cause was unknown were allocated proportionally among fires of known cause.

Smoke Alarm and Automatic Suppression System Statistics

Percentages and rates for fires when smoke alarm and automatic suppression systems were present were obtained by examining only those fires for which the status was known and classified.

Methodology for Estimating Alarm Operationality

Estimates of alarm performance in fires may be made using the National Fire Incident Reporting System (NFIRS), managed by the U.S. Fire Administration. Alarm performance in the fires in NFIRS is coded as follows:

1. Alarms operated and were in room of fire origin.
2. Alarms operated and were not in room of fire origin.
3. Alarms did not operate and were in room of fire origin.
4. Alarms did not operate and were not in room of fire origin.
5. Alarms were not required to operate because fire was too small.

6. No alarms were present (coded 8).
7. Alarm performance unclassified (coded 9).
8. Alarm performance unknown (coded 0).

This coding indicates whether alarms operated but not whether they were operational. If the "fire too small" code were used whenever it was appropriate, then one could estimate the percentage of alarms operational as the total of fires coded 1 or 2 divided by the total of fires coded 1, 2, 3, or 4. It is possible to check whether the "fire too small" code is being used whenever it is appropriate. If so, the estimated percentage of fires for which the alarm activated would be the same for small and large fires, because all characterizations of alarms having operated or not operated would be limited to fires deemed large enough to activate an operational alarm. This is not what the data show, however. In NFPA's analysis of 1980-83 NFIRS data on dwelling fires, we found that the estimated percentage of alarms operational was 10-15 percentage points lower for fires with extent of flame either unknown or confined to object of origin than for larger fires. There was also a much smaller three-percentage-point difference between the estimates for fires with extent of flame beyond object of origin but confined to room of origin versus fires with extent of flame beyond the room of origin.

After some additional exploratory analysis, it was decided that adjustments could and should be made to the data to produce meaningful results. It appeared that the operational status of alarms could best be estimated as the percentage of activations based on only those fires deemed large enough to activate an operational alarm. Since most of the analysis was to be done on home alarms nearly all of which are smoke alarms, it was decided to switch to smoke spread rather than flame spread as a measure of fire size. The fires that seemed large enough to produce activation were assumed to be those fires (a) with known extent of smoke, (b) not coded as too small to activate an alarm, and (c) with smoke extent beyond the area of origin if the alarm was in the room with the fire and beyond the room of origin if the alarm was outside the room of fire origin.

It is worth restating that these procedures were followed because it was assumed that most home fire alarms are in fact smoke alarms. In fact, the database does not permit one to separate smoke alarms from other alarms and limit the analysis to them.