STRUCTURE FIRES IN BARNS

Ben Evarts

June 2012

National Fire Protection Association
Fire Analysis and Research Division

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Abstract

From 2006 to 2010, 830 structure fires in barns (properties defined in NFIRS as: livestock or poultry storage, including barns, stockyards, and animal pens) were reported to U.S. municipal fire departments per year. These fires were responsible for annual losses of one civilian death, ten civilian injuries, and $28 million in direct property damage. Heating equipment was the cause of nearly one-quarter (25%) of these fires, led by heat lamps (15%). *NFPA 150: Standard on Fire and Life Safety in Animal Housing Facilities* (www.nfpa.org/150) covers barns where animals are housed and is invaluable to anyone interested in safety in this type of property.

These estimates are based on data from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual fire department experience survey.

Keywords: fire statistics, barn, livestock, farm

Acknowledgements

The National Fire Protection Association thanks all the fire departments and state fire authorities who participate in the National Fire Incident Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that make this analysis possible. Their contributions allow us to estimate the size of the fire problem.

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

For more information about the National Fire Protection Association, visit www.nfpa.org or call 617-770-3000. To learn more about the One-Stop Data Shop go to www.nfpa.org/osds or call 617-984-7443.

Copies of this analysis are available from:

National Fire Protection Association
One-Stop Data Shop
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www.nfpa.org
E-mail: osds@nfpa.org
Phone: 617-984-7443

NFPA No. USS74

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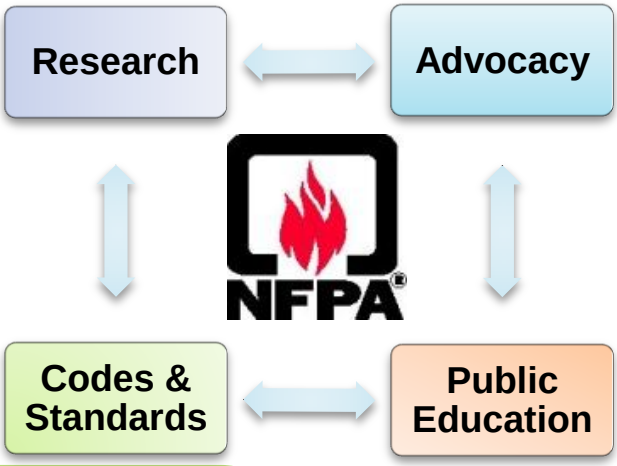
NFPA Fire Safety Resources

NFPA´s wealth of fire-related research includes historical investigations of technically significant fire incidents, fire data analysis, and the Charles S. Morgan Technical Library, one of the most comprehensive fire literature collections in the world. In addition, NFPA´s Fire Protection Research Foundation is a source of independent fire test data. Find out more at:

www.nfpa.org/research

Properly installed and maintained smoke alarms are necessary to provide a warning of fire to the occupants. You can find out more information about smoke alarms here: NFPA Smoke Alarm Information

Home fire sprinkler systems provide even greater protection. These systems respond quickly to reduce the heat, flames, and smoke produced by a fire. More information about home fire sprinklers may be found at www.firesprinklerinitiative.org
Simply put, smoke alarms and fire sprinklers save lives.



NFPA also develops, publishes, and disseminates nearly 300 consensus codes and standards intended to minimize the probability and effects of fire and other hazards. Safety in properties that house animals begins with:

NFPA 150: Standard on Fire and Life Safety in Animal Housing Facilitieswww.nfpa.org/150

For consumers: NFPA provides consumer safety information regarding fire causes, escape planning, fire & safety equipment, and many other topics.

For kids: Sparky.org provides important information for kids delivered via fun games, activities, and cartoons.

For public educators: NFPA offers resources on fire safety education programs, educational messaging, grants & awards, and many other topics.

One-Stop Data Shop
Fire Analysis and Research Division
One Batterymarch Park, Quincy, MA 02169
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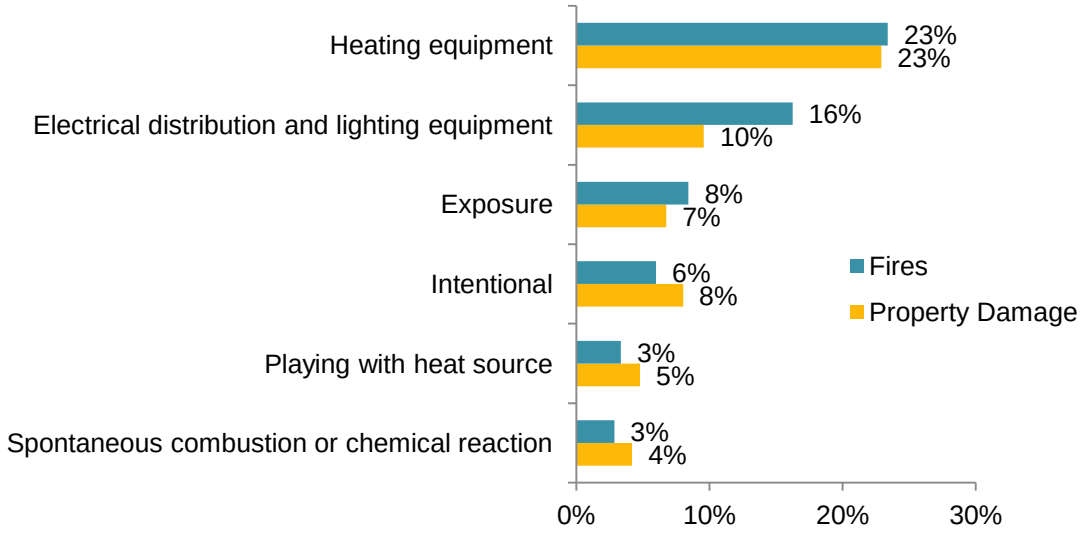
www.nfpa.org

Structure Fires in Barns Fact Sheet

During 2006-2010, an estimated 830 structure fires in barns were reported to U.S. fire departments per year, with associated losses of:

- 1 civilian death,
- 10 civilian injuries, and
- $28 million in property damage annually

Structure Fires in Barns
By Leading Cause 2006-2010 (Top 6 Shown)



- These fires are more common during the colder months of the year (peaking in January) and between noon and 9:00 p.m.
- Heat lamps are the leading equipment involved in the ignition of barn fires, followed by wiring and related equipment, and lamp, light bulb or lighting
- An agricultural crop, such as fruit or vegetable, is the leading item first ignited in these fires (15%), followed by a structural member or framing (13%)

CODES & STANDARDS USEFUL IN PROTECTING BARNS

NFPA 150: Standard on Fire and Life Safety in Animal Housing Facilities www.nfpa.org/150

This standard provides the minimum requirements for the design, construction, fire protection, and classification of animal housing facilities. The document recognizes that animals are sentient beings with a greater value of simple property, and that they lack the ability to self-preserve when housed in buildings.

Additional resources can be found at www.nfpa.org

Structure Fires in Barns

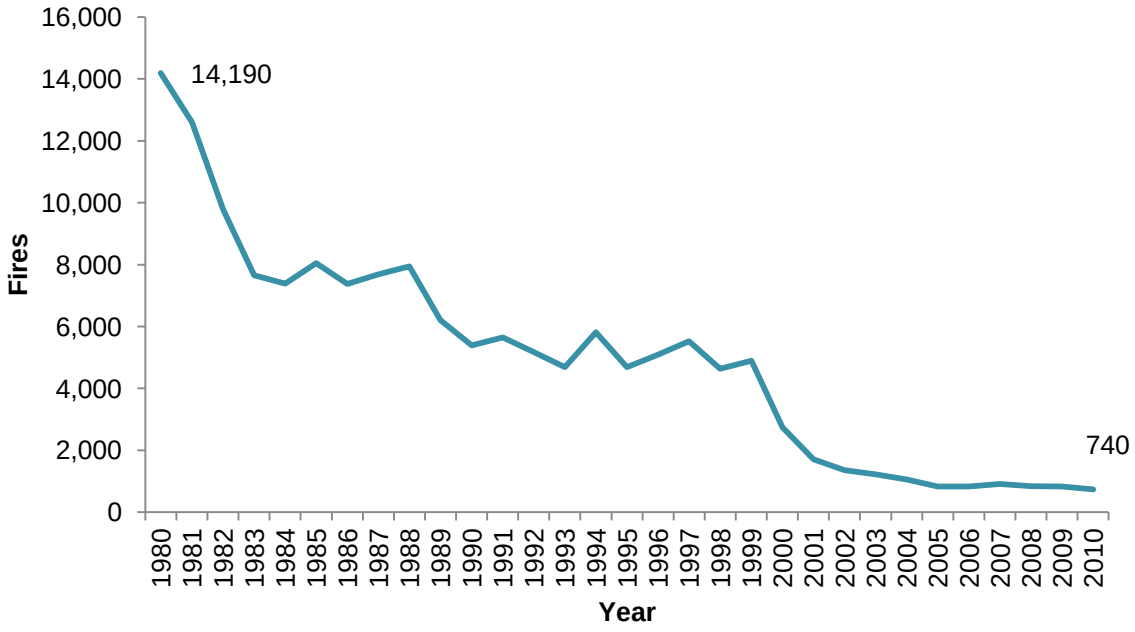
From 2006 to 2010, 830 structure fires in barns (properties defined in NFIRS as: livestock or poultry storage, including barns, stockyards, and animal pens) were reported to U.S. municipal fire departments per year. These fires were responsible for annual losses of one civilian death, ten civilian injuries, and $28 million in direct property damage (animal deaths are not collected in incident reports). *NFPA 150: Standard on Fire and Life Safety in Animal Housing Facilities* (www.nfpa.org/150) covers barns (where animals are housed) and is invaluable to anyone interested in safety in this type of property. In addition to the structure fires, there were an average of 30 vehicle fires and 250 outside or unclassified fires per year at these properties between 2006 and 2010.

Methodology:

The National Fire Incident Reporting System (NFIRS) does not require detail on several common types of fires (confined cooking fires, chimney fires, trash or rubbish fires, etc.) which are coded with specific incident types that indicate the fire was confined to or within the container, chimney, or object of origin. These fires are collectively referred to as "confined fires". Typically, these fires are analyzed separately due to their lack of supporting details, however, because only 3% of structure fires in barns are "confined fires" they are grouped in with all fires for the purposes of this report.

Structure fires in barns have decreased by 95% over the past three decades, from a high of 14,190 in 1980 to 740 in 2010. Much of this decline is associated with changes in categorizing and labeling property uses. Property use code 819, which is used in this analysis, did not exist in previous versions of NFIRS. National estimates from 1980-1998 are calculated using data from NFIRS 4.1 property use codes 815: (barn or stable, including facilities associated with farms, zoos, or wild life preserves, whether for providing restraint or protection for animals or for storage of feed, but excluding silos) and 817: (livestock storage at any point beyond the raising ranch or farm, including rail and truck stockyards and other livestock pens and yards). As you can see in Figure 1 (and Table 1), there was a large drop with the introduction of NFIRS 5.0. However, Figure 1 also indicates that the trend was downward even before the changeover in methodology. It is not clear that any major type of property moved in or out of the categories treated here as barns. The sharp decline may be a side effect of other changes in coding or analysis methods

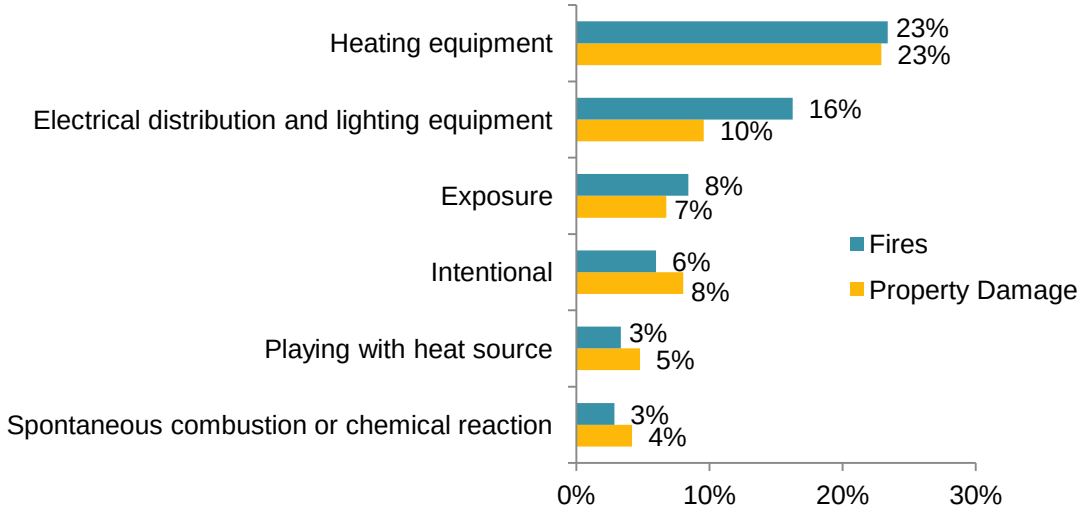
Figure 1.
Structure Fires in Barns, by Year
1980-2010



Structure fires in barns are more common during the colder months, probably due to the prevalence of heating fires (Table 2). Incidents are spaced evenly through the week (Table 3) and are more common between noon and 9:00 p.m. (Table 4).

Heating equipment is involved in nearly one-quarter (23%) of structure fires in barns, and electrical distribution or lighting equipment is involved in 16%. (See Table 5 and Figure 2 below)

Figure 2.
Structure Fires in Barns, by Leading Cause
2006-2010 Annual Averages



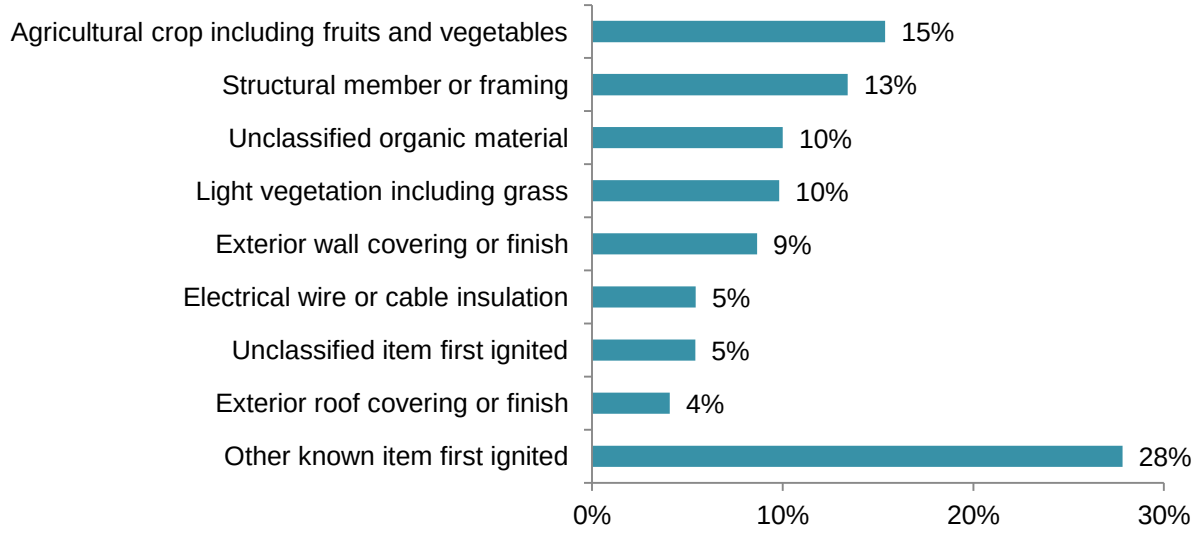
More than four in ten (43%) barn structure fires began without any equipment involved in ignition. The leading equipment involved in ignition in barns was heat lamp, involved in 15% of fires. Seven percent began with wiring and related equipment and 6% with a lamp, bulb, or lighting (See Table 6).

Three-fifths of barn structure fires (61%) were caused unintentionally, and 18% began with the failure of a heat source. Six percent of structure fires in barns were set intentionally (Table 7). An electrical failure or malfunction was a factor in one-quarter (25%) of fires, and a heat source too close to combustibles was a factor in 18% (Table 8).

Arcing was the leading heat source of structure fires in barns (17%), and radiated or conducted heat from operating equipment was the heat source in 16% (Table 9). Nearly one-quarter (23%) of fires originated in an unclassified storage area, and 12% began in an unclassified structural area (Table 10).

Agricultural crops (15%), unclassified organic materials (10%), and light vegetation including grass (10%) were the items first ignited in a combined 35% of fire incidents in barns (see Table 11 and Figure 3).

Figure 3.
Structure Fires in Barns, by Item First Ignited
2006-2010 Annual Averages



Seventy percent of structure fires in barns spread beyond the floor of origin (Table 12). This is likely because of the large open spaces, as well as the lack of detection systems. Only 2% of structure fires in barns reported the presence of automatic detection equipment (Table 13).

Hay or straw was stored on-site in more than one-third (36%) of structure fires in barns. Livestock was present in 22%, (and pets in 2%). This shows that barns are used for a wide variety of purposes, and addressing fire safety in these occupancies can (and should) take on many forms.

ADDITIONAL RESOURCES

Farm Fire Safety: Rutgers Cooperative Extension published an article about fire prevention and safety around the farm. It covers material storage, barn construction, electrical systems and devices, and general precautions: http://www.equineguelph.ca/pdf/facts/D000843.PDF

Fire Safety in Horse Stables: Penn State College of Agricultural Sciences Agricultural Research and Cooperative Extension published a document detailing fire issues relating to horse stables, including storage recommendations, fire codes, and stable design. http://pubs.cas.psu.edu/freepubs/pdfs/ub034.pdf

Table 1.
Structure Fires in Barns, by Year
1980-2010

Year	Fires	Civilian Injuries	Direct Property Damage (as Reported)	Direct Property Damage (in Millions) (in 2010 Dollars)
1980	14,190	60	$131	$346
1981	12,600	64	$146	$349
1982	9,780	68	$79	$179
1983	7,650	65	$126	$276
1984	7,390	50	$70	$146
1985	8,050	40	$81	$163
1986	7,370	36	$72	$143
1987	7,680	48	$68	$130
1988	7,940	48	$101	$186
1989	6,210	42	$82	$145
1990	5,390	43	$70	$117
1991	5,650	44	$67	$107
1992	5,170	46	$56	$87
1993	4,690	39	$53	$80
1994	5,810	42	$80	$118
1995	4,690	29	$47	$67
1996	5,090	38	$83	$115
1997	5,520	27	$85	$116
1998	4,640	29	$82	$110
1999	4,890	68	$144	$189
2000	2,740	47	$43	$55
2001	1,710	0	$47	$58
2002	1,360	3	$23	$28
2003	1,220	14	$46	$55
2004	1,060	15	$41	$47
2005	830	7	$19	$22
2006	830	8	$16	$18
2007	910	12	$26	$27
2008	840	9	$39	$40
2009	830	13	$30	$30
2010	740	8	$29	$29

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. These national estimates are projections based on the detailed information collected in Version 5.0 of NFIRS. Fires are rounded to the nearest ten, civilian fire deaths and injuries are rounded to the nearest one, and direct property damage is rounded to the nearest hundred thousand dollars. Inflation adjustments were based on the consumer price index found in the U.S. Census Bureau's Statistical Abstract of the United States: 2012, "Table 724, Purchasing Power of the Dollar."
Source: NFIRS and NFPA Survey

Table 2.
Structure Fires in Barns, by Month
2006-2010 Annual Averages

Month	Fires		Direct Property Damage (in Millions)	
January	100	(12%)	$5	(16%)
February	90	(11%)	$3	(10%)
March	80	(10%)	$3	(9%)
April	80	(10%)	$2	(6%)
May	70	(8%)	$2	(7%)
June	60	(7%)	$3	(9%)
July	60	(7%)	$2	(7%)
August	50	(6%)	$1	(5%)
September	50	(6%)	$2	(8%)
October	50	(6%)	$1	(5%)
November	60	(8%)	$3	(10%)
December	70	(9%)	$2	(6%)
Totals	830	(100%)	$28	(100%)

Table 3.
Structure Fires in Barns, by Day of Week
2006-2010 Annual Averages

Day of Week	Fires		Direct Property Damage (in Millions)	
Sunday	130	(15%)	$3	(12%)
Monday	130	(15%)	$5	(18%)
Tuesday	120	(14%)	$4	(16%)
Wednesday	120	(14%)	$4	(13%)
Thursday	120	(14%)	$3	(11%)
Friday	110	(13%)	$3	(11%)
Saturday	120	(14%)	$5	(19%)
Totals	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding

Table 4.
Structure Fires in Barns, by Alarm Hour
2006-2010 Annual Averages

Alarm	Fires		Direct Property Damage (in Millions)	
Midnight - 3 a.m.	90	(11%)	$4	(14%)
3 - 6 a.m.	90	(10%)	$5	(17%)
6 - 9 a.m.	80	(10%)	$2	(9%)
9 a.m. - noon	90	(11%)	$2	(8%)
Noon - 3 p.m.	120	(15%)	$3	(11%)
3 - 6 p.m.	140	(17%)	$4	(13%)
6 - 9 p.m.	120	(15%)	$3	(9%)
9 p.m. - midnight	100	(12%)	$6	(20%)
Total	830	(100%)	$28	(100%)

Sums may not equal totals due to rounding

Table 5.
Structure Fires in Barns, by Leading Cause
2006-2010 Annual Averages

Leading Cause	Fires		Direct Property Damage (in Millions)	
Heating equipment	190	(23%)	$6	(23%)
Electrical distribution and lighting equipment	130	(16%)	$3	(10%)
Exposure	70	(8%)	$2	(7%)
Intentional	50	(6%)	$2	(8%)
Playing with heat source	30	(3%)	$1	(5%)
Spontaneous combustion or chemical reaction	20	(3%)	$1	(4%)
Shop tools and industrial equipment excluding torches, burners or soldering irons	10	(2%)	$4	(15%)
Torch, burner, or soldering iron	10	(2%)	$0	(1%)

Source: NFIRS and NFPA Survey

Table 6.
Structure Fires in Barns, by Equipment Involved In Ignition
2006-2010 Annual Averages

Equipment Involved	Fires		Direct Property Damage (in Millions)	
No equipment involved in ignition	360	(43%)	$9	(32%)
Heating equipment	190	(23%)	$6	(23%)
Heat lamp	120	(15%)	$2	(8%)
Fixed or portable space heater	30	(4%)	$1	(4%)
Water heater	30	(3%)	$2	(7%)
Heat tape	10	(1%)	$0	(0%)
Other known heating equipment	10	(1%)	$1	(3%)
Electrical distribution or lighting equipment	130	(16%)	$3	(10%)
Wiring and related equipment	60	(7%)	$2	(7%)
Lamp, bulb, or lighting	50	(6%)	$0	(1%)
Cord or plug	10	(2%)	$0	(0%)
Electric fence	10	(1%)	$0	(0%)
Other known electrical distribution or lighting equipment	0	(0%)	$0	(0%)
Lawn mower	20	(2%)	$2	(8%)
Contained trash or rubbish fire	10	(2%)	$0	(0%)
Torch, burner, or soldering iron	10	(2%)	$0	(1%)
Fan	10	(2%)	$0	(0%)
Cooking equipment	10	(1%)	$0	(1%)
Confined cooking fire	10	(1%)	$0	(0%)
Other known cooking equipment	0	(0%)	$0	(1%)
Office equipment, other	10	(1%)	$1	(5%)
Hay processing equipment	10	(1%)	$0	(0%)
Refrigerator, refrigerator/freezer	10	(1%)	$0	(0%)
Unclassified equipment involved in ignition	0	(1%)	$0	(0%)
Clothes dryer	0	(1%)	$1	(4%)
Unclassified portable appliance designed to produce heat	0	(1%)	$0	(0%)
Other known equipment involved in ignition or confined fires	30	(4%)	$5	(16%)
Total	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding

Table 7.
Structure Fires in Barns, by Cause
2006-2010 Annual Averages

Leading Cause	Fires		Direct Property Damage (in Millions)	
Unintentional	510	(61%)	$15	(55%)
Failure of equipment or heat source	150	(18%)	$6	(21%)
Unclassified cause	70	(8%)	$2	(8%)
Act of nature	60	(7%)	$2	(8%)
Intentional	50	(6%)	$2	(8%)
Total	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Note: This table summarizes findings from multiple fields, meaning that the same fire may be listed under multiple causes. See Appendix B for details

Table 8.
Structure Fires in Barns, by Factor Contributing to Ignition
2006-2010 Annual Averages

Factor Contributing	Fires		Direct Property Damage (in Millions)	
Electrical failure or malfunction	210	(25%)	$9	(31%)
Heat source too close to combustibles	150	(18%)	$4	(13%)
Exposure fire	70	(8%)	$2	(7%)
Outside/open fire for debris or waste disposal	50	(6%)	$1	(2%)
Unclassified factor contributed to ignition	40	(5%)	$1	(3%)
Mechanical failure or malfunction	40	(5%)	$3	(12%)
High wind	40	(4%)	$1	(5%)
Unclassified natural condition	30	(4%)	$2	(6%)
Storm	30	(4%)	$1	(4%)
Playing with heat source	30	(3%)	$1	(5%)
Rekindle	20	(3%)	$0	(0%)
Unclassified fire spread or control	20	(2%)	$0	(2%)
Equipment unattended	20	(2%)	$0	(2%)
Abandoned or discarded materials or products	20	(2%)	$0	(1%)
Cutting, welding too close to combustible	20	(2%)	$0	(0%)
Animal	10	(2%)	$1	(2%)
Unclassified misuse of material or product	10	(2%)	$0	(1%)
Other known factor contributing to ignition	60	(8%)	$2	(8%)
Total fires	830	(100%)	$28	(100%)
*Total factors	870	(105%)	$29	(104%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding
*Multiple entries allowed for this field

Table 9.
Structure Fires in Barns, by Heat Source
2006-2010 Annual Averages

Heat source	Fires		Direct Property Damage (in Millions)	
Arcing	140	(17%)	$5	(17%)
Radiated or conducted heat from operating equipment	130	(16%)	$3	(10%)
Unclassified heat source	80	(10%)	$2	(8%)
Unclassified heat from powered equipment	80	(9%)	$4	(13%)
Hot ember or ash	60	(7%)	$1	(3%)
Unclassified hot or smoldering object	50	(6%)	$2	(5%)
Lightning	40	(5%)	$2	(9%)
Spark, ember, or flame from operating equipment	40	(4%)	$3	(12%)
Match	30	(3%)	$1	(3%)
Heat from direct flame or convection currents	20	(3%)	$0	(1%)
Spontaneous combustion or chemical reaction	20	(3%)	$1	(4%)
Flying brand, ember, or spark	20	(3%)	$0	(2%)
Lighter	20	(2%)	$1	(4%)
Unclassified heat spread from another fire	20	(2%)	$0	(1%)
Radiated heat from another fire	10	(2%)	$0	(2%)
Other known heat source	60	(7%)	$2	(7%)
Total	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding

Table 10.
Structure Fires in Barns, by Area of Origin
2006-2010 Annual Averages

Area of Origin	Fires		Direct Property Damage (in Millions)	
Unclassified storage area	190	(23%)	$7	(26%)
Unclassified structural area	100	(12%)	$2	(8%)
Storage room, area, tank, or bin	60	(7%)	$3	(11%)
Exterior wall surface	60	(7%)	$1	(5%)
Unclassified area of origin	60	(7%)	$1	(5%)
Storage of supplies or tools or dead storage	50	(6%)	$2	(5%)
Wall assembly or concealed space	40	(5%)	$1	(3%)
Unclassified outside area	40	(5%)	$1	(2%)
Lawn, field, or open area	30	(4%)	$0	(2%)
Exterior roof surface	30	(4%)	$1	(2%)
Ceiling or floor assembly or concealed space	20	(3%)	$0	(1%)
Vacant structural area	20	(2%)	$0	(1%)
Unclassified function area	20	(2%)	$0	(2%)
Other known area of origin	130	(15%)	$8	(28%)
Total	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding

Table 11.
Structure Fires in Barns, by Item First Ignited
2006-2010 Annual Averages

Item First Ignited	Fires		Direct Property Damage (in Millions)	
Agricultural crop, including fruits and vegetables	130	(15%)	$5	(18%)
Structural member or framing	110	(13%)	$5	(16%)
Unclassified organic materials	80	(10%)	$3	(12%)
Light vegetation, including grass	80	(10%)	$2	(9%)
Exterior wall covering or finish	70	(9%)	$2	(6%)
Electrical wire or cable insulation	50	(5%)	$2	(8%)
Unclassified item first ignited	40	(5%)	$1	(3%)
Exterior roof covering or finish	30	(4%)	$1	(5%)
Interior wall covering. excluding drapes	30	(4%)	$1	(4%)
Unclassified structural component or finish	30	(3%)	$0	(1%)
Multiple items first ignited	20	(2%)	$1	(2%)
Baled goods or material	20	(2%)	$1	(3%)
Dust, fiber, or lint, including sawdust or excelsior	20	(2%)	$0	(0%)
Flammable or combustible liquids or gases, piping or filter	10	(2%)	$0	(2%)
Other known item first ignited	100	(12%)	$3	(11%)
Total	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding

Table 12.
Structure Fires in Barns, by Extent of Flame Damage
2006-2010 Annual Averages

Extent of Flame Damage	Fires		Direct Property Damage (in Millions)	
Confined fire defined by incident type	30	(3%)	$0	(0%)
Confined to object of origin	140	(16%)	$4	(13%)
Confined to room of origin	60	(7%)	$0	(1%)
Confined to floor of origin	30	(3%)	$1	(3%)
Confined to building of origin	440	(53%)	$15	(54%)
Beyond building of origin	140	(17%)	$8	(29%)
Total	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding

Table 13.
Structure Fires in Barns, by Detector Presence
2006-2010 Annual Averages

Detector presence	Fires		Direct Property Damage (in Millions)	
Present	20	(2%)	$1	(3%)
No detectors present	820	(98%)	$27	(97%)
Total	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding

Table 14.
Structure Fires in Barns, by On-Site Materials
2006-2010 Annual Averages

On-Site Materials	Fires		Direct Property Damage (in Millions)	
Hay or straw	300	(36%)	$12	(43%)
Livestock	180	(22%)	$12	(43%)
Lumber or sawn wood	70	(9%)	$1	(4%)
Feed, grain, or seed	50	(6%)	$4	(14%)
Unclassified on-site material	40	(5%)	$1	(3%)
Unclassified agricultural material	40	(5%)	$1	(4%)
Unclassified wood	40	(4%)	$1	(2%)
Unclassified raw material	30	(3%)	$0	(1%)
Unclassified food, beverage, or agricultural material	20	(2%)	$0	(1%)
Unclassified machinery or tool	20	(2%)	$1	(2%)
Auto, truck, bus, or recreational vehicle	20	(2%)	$2	(6%)
Sawdust, or wood chips	20	(2%)	$1	(2%)
Pets	10	(2%)	$0	(1%)
No on-site materials	70	(8%)	$2	(6%)
Other known on-site material	140	(17%)	$6	(23%)
*Total on-site materials	1,040	(125%)	$44	(157%)
Total fires	830	(100%)	$28	(100%)

Source: NFIRS and NFPA Survey
Sums may not equal totals due to rounding
*Multiple entries allowed for this field

Appendix A: How National Estimates Statistics are Calculated

The statistics in this analysis are estimates derived from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual survey of U.S. fire departments. NFIRS is a voluntary system by which participating fire departments report detailed factors about the fires to which they respond. Roughly two-thirds of U.S. fire departments participate, although not all of these departments provide data every year. Fires reported to federal or state fire departments or industrial fire brigades are not included in these estimates.

NFIRS provides the most detailed incident information of any national database not limited to large fires. NFIRS is the only database capable of addressing national patterns for fires of all sizes by specific property use and specific fire cause. NFIRS also captures information on the extent of flame spread, and automatic detection and suppression equipment. For more information about NFIRS visit http://www.nfirs.fema.gov/. Copies of the paper forms may be downloaded from http://www.nfirs.fema.gov/documentation/design/NFIRS_Paper_Forms_2008.pdf.

NFIRS has a wide variety of data elements and code choices. The NFIRS database contains coded information. Many code choices describe several conditions. These cannot be broken down further. For example, area of origin code 83 captures fires starting in vehicle engine areas, running gear areas or wheel areas. It is impossible to tell the portion of each from the coded data.

Methodology may change slightly from year to year.
NFPA is continually examining its methodology to provide the best possible answers to specific questions, methodological and definitional changes can occur. *Earlier editions of the same report may have used different methodologies to produce the same analysis, meaning that the estimates are not directly comparable from year to year.*

NFPA's fire department experience survey provides estimates of the big picture.
Each year, NFPA conducts an annual survey of fire departments which enables us to capture a summary of fire department experience on a larger scale. Surveys are sent to all municipal departments protecting populations of 50,000 or more and a random sample, stratified by community size, of the smaller departments. Typically, a total of roughly 3,000 surveys are returned, representing about one of every ten U.S. municipal fire departments and about one third of the U.S. population.

The survey is stratified by size of population protected to reduce the uncertainty of the final estimate. Small rural communities have fewer people protected per department and are less likely to respond to the survey. A larger number must be surveyed to obtain an adequate sample of those departments. (NFPA also makes follow-up calls to a sample of the smaller fire departments that do not respond, to confirm that those that did respond are truly representative of fire departments their size.) On the other hand, large city departments are so few in number and protect such a large proportion of the total U.S.

population that it makes sense to survey all of them. Most respond, resulting in excellent precision for their part of the final estimate.

The survey includes the following information: (1) the total number of fire incidents, civilian deaths, and civilian injuries, and the total estimated property damage (in dollars), for each of the major property use classes defined in NFIRS; (2) the number of on-duty firefighter injuries, by type of duty and nature of illness; 3) the number and nature of non-fire incidents; and (4) information on the type of community protected (e.g., county versus township versus city) and the size of the population protected, which is used in the statistical formula for projecting national totals from sample results. The results of the survey are published in the annual report *Fire Loss in the United States*. To download a free copy of the report, visit http://www.nfpa.org/assets/files/PDF/OS.fireloss.pdf.

Projecting NFIRS to National Estimates

As noted, NFIRS is a voluntary system. Different states and jurisdictions have different reporting requirements and practices. Participation rates in NFIRS are not necessarily uniform across regions and community sizes, both factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that a second database -- the NFPA survey -- is needed to project NFIRS to national estimates and to project different parts of NFIRS separately. This multiple calibration approach makes use of the annual NFPA survey where its statistical design advantages are strongest.

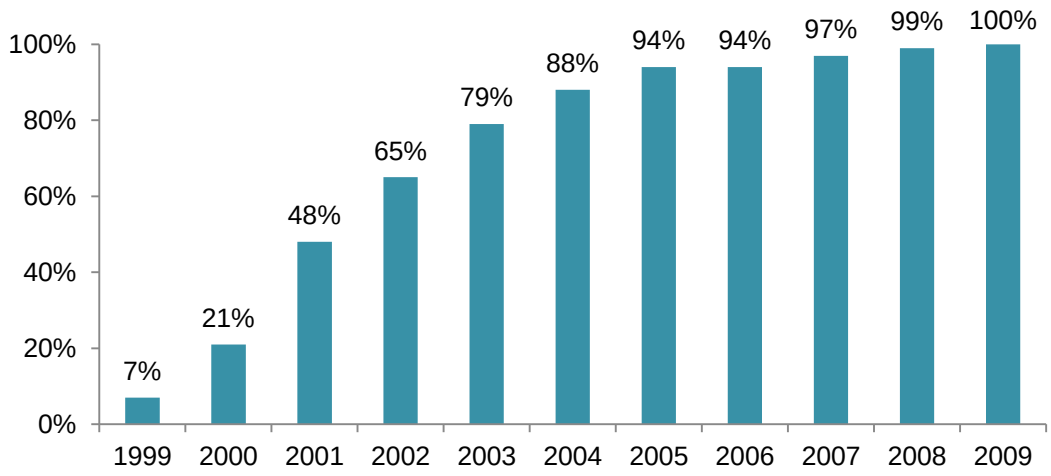
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific fire problems and circumstances are obtained by multiplying the NFIRS data by the scaling ratios. Reports for incidents in which mutual aid was given are excluded from NFPA's analyses.

Analysts at the NFPA, the USFA and the Consumer Product Safety Commission developed the specific basic analytical rules used for this procedure. "The National Estimates Approach to U.S. Fire Statistics," by John R. Hall, Jr. and Beatrice Harwood, provides a more detailed explanation of national estimates. A copy of the article is available online at http://www.nfpa.org/osds or through NFPA's One-Stop Data Shop.

Version 5.0 of NFIRS, first introduced in 1999, used a different coding structure for many data elements, added some property use codes, and dropped others. The essentials of the approach described by Hall and Harwood are still used, but some modifications have been necessary to accommodate the changes in NFIRS 5.0.

Figure A.1 shows the percentage of fires originally collected in the NFIRS 5.0 system. Each year's release version of NFIRS data also includes data collected in older versions of NFIRS that were converted to NFIRS 5.0 codes.

Figure A.1. Fires Originally Collected in NFIRS 5.0 by Year



From 1999 data on, analyses are based on scaling ratios using only data originally collected in NFIRS 5.0:

NFPA survey projections
NFIRS totals (Version 5.0)

For 1999 to 2001, the same rules may be applied, but estimates for these years in this form will be less reliable due to the smaller amount of data originally collected in NFIRS 5.0; they should be viewed with extreme caution.

NFIRS 5.0 introduced six categories of confined structure fires, including:

- cooking fires confined to the cooking vessel,
- confined chimney or flue fires,
- confined incinerator fire,
- confined fuel burner or boiler fire or delayed ignition,
- confined commercial compactor fire, and
- trash or rubbish fires in a structure with no flame damage to the structure or its contents.

Although causal and other detailed information is typically not required for these incidents, it is provided in some cases. Some analyses, particularly those that examine cooking equipment, heating equipment, fires caused by smoking materials, and fires started by playing with fire, may examine the confined fires in greater detail. Because the confined fire incident types describe certain scenarios, the distribution of unknown data differs from that of all fires. Consequently, allocation of unknowns must be done separately.

Some analyses of structure fires show only non-confined fires. In these tables, percentages shown are of non-confined structure fires rather than all structure fires. This approach has the advantage of showing the frequency of specific factors in fire causes, but the disadvantage of possibly overstating the percentage of factors that are seldom seen in the confined fire incident types and of understating the factors specifically associated with the confined fire incident types.

Other analyses include entries for confined fire incident types in the causal tables and show percentages based on total structure fires. In these cases, the confined fire incident type is treated as a general causal factor.

For most fields other than Property Use and Incident Type, NFPA allocates unknown data proportionally among known data. This approach assumes that if the missing data were known, it would be distributed in the same manner as the known data. NFPA makes additional adjustments to several fields. *Casualty and loss projections can be heavily influenced by the inclusion or exclusion of unusually serious fire.*

In the formulas that follow, the term "all fires" refers to all fires in NFIRS on the dimension studied. The percentages of fires with known or unknown data are provided for non-confined fires and associated losses, and for confined fires only.

Cause of Ignition: This field is used chiefly to identify intentional fires. "Unintentional" in this field is a specific entry and does not include other fires that were not intentionally set: failure of equipment or heat source, act of nature, or "other" (unclassified)." The last should be used for exposures but has been used for other situations as well. Fires that were coded as under investigation and those that were coded as undetermined after investigation were treated as unknown.

Factor Contributing to Ignition: In this field, the code "none" is treated as an unknown and allocated proportionally. For Human Factor Contributing to Ignition, NFPA enters a code for "not reported" when no factors are recorded. "Not reported" is treated as an unknown, but the code "none" is treated as a known code and not allocated. Multiple entries are allowed in both of these fields. Percentages are calculated on the total number of fires, not entries, resulting in sums greater than 100%. Although Factor Contributing to Ignition is only required when the cause of ignition was coded as: 2) unintentional, 3) failure of equipment or heat source; or 4) act of nature, data is often present when not required. Consequently, any fire in which no factor contributing to ignition was entered was treated as unknown.

In some analyses, all entries in the category of mechanical failure, malfunction (factor contributing to ignition 20-29) are combined and shown as one entry, "mechanical failure or malfunction." This category includes:

21. Automatic control failure;
22. Manual control failure;
23. Leak or break. Includes leaks or breaks from containers or pipes. Excludes operational deficiencies and spill mishaps;
25. Worn out;
26. Backfire. Excludes fires originating as a result of hot catalytic converters;
27. Improper fuel used; Includes the use of gasoline in a kerosene heater and the like; and
20. Mechanical failure or malfunction, other.

Entries in "electrical failure, malfunction" (factor contributing to ignition 30-39) may also be combined into one entry, "electrical failure or malfunction." This category includes:

31. Water-caused short circuit arc;
32. Short-circuit arc from mechanical damage;
33. Short-circuit arc from defective or worn insulation;

34. Unspecified short circuit arc;
35. Arc from faulty contact or broken connector, including broken power lines and loose connections;
36. Arc or spark from operating equipment, switch, or electric fence;
37. Fluorescent light ballast; and
30. Electrical failure or malfunction, other.

Heat Source. In NFIRS 5.0, one grouping of codes encompasses various types of open flames and smoking materials. In the past, these had been two separate groupings. A new code was added to NFIRS 5.0, which is code 60: "Heat from open flame or smoking material, other." NFPA treats this code as a partial unknown and allocates it proportionally across the codes in the 61-69 range, shown below.

61. Cigarette;
62. Pipe or cigar;
63. Heat from undetermined smoking material;
64. Match;
65. Lighter: cigarette lighter, cigar lighter;
66. Candle;
67 Warning or road flare, fuse;
68. Backfire from internal combustion engine. Excludes flames and sparks from an exhaust system, (11); and
69. Flame/torch used for lighting. Includes gas light and gas-/liquid-fueled lantern.

In addition to the conventional allocation of missing and undetermined fires, NFPA multiplies fires with codes in the 61-69 range by

$$\frac{\text{All fires in range 60-69}}{\text{All fires in range 61-69}}$$

The downside of this approach is that heat sources that are truly a different type of open flame or smoking material are erroneously assigned to other categories. The grouping "smoking materials" includes codes 61-63 (cigarettes, pipes or cigars, and heat from undetermined smoking material, with a proportional share of the code 60s and true unknown data.

Equipment Involved in Ignition (EII). NFIRS 5.0 originally defined EII as the piece of equipment that provided the principal heat source to cause ignition if the equipment malfunctioned or was used improperly. In 2006, the definition was modified to "the piece of equipment that provided the principal heat source to cause ignition." However, much of the data predates the change. Individuals who have already been trained with the older definition may not change their practices. To compensate, NFPA treats fires in which EII = NNN and heat source is not in the range of 40-99 as an additional unknown.

To allocate unknown data for EII, the known data is multiplied by

$$\frac{\text{All fires}}{\text{(All fires – blank – undetermined – [fires in which EII =NNN and heat source <>40-99])}}$$

In addition, the partially unclassified codes for broad equipment groupings (i.e., code 100 - heating, ventilation, and air conditioning, other; code 200 - electrical distribution, lighting and power transfer, other; etc.) were allocated proportionally across the individual code choices in their respective broad groupings (heating, ventilation, and air conditioning; electrical distribution, lighting and power transfer, other; etc.). Equipment that is totally unclassified is not allocated further. This approach has the same downside as the allocation of heat source 60 described above. Equipment that is truly different is erroneously assigned to other categories.

In some analyses, various types of equipment are grouped together.

Code Grouping	EII Code	NFIRS definitions
Central heat	132	Furnace or central heating unit
	133	Boiler (power, process or heating)
Fixed or portable space heater	131	Furnace, local heating unit, built-in
	123	Fireplace with insert or stove
	124	Heating stove
	141	Heater, excluding catalytic and oil-filled
	142	Catalytic heater
	143	Oil-filled heater
Fireplace or chimney	120	Fireplace or chimney
	121	Fireplace, masonry
	122	Fireplace, factory-built
	125	Chimney connector or vent connector
	126	Chimney – brick, stone or masonry
	127	Chimney-metal, including stovepipe or flue
Fixed wiring and related equipment	210	Unclassified electrical wiring
	211	Electrical power or utility line
	212	Electrical service supply wires from utility
	213	Electric meter or meter box
	214	Wiring from meter box to circuit breaker
	215	Panel board, switch board or circuit breaker board
	216	Electrical branch circuit
	217	Outlet or receptacle
	218	Wall switch
	219	Ground fault interrupter
Transformers and power supplies	221	Distribution-type transformer
	222	Overcurrent, disconnect equipment
	223	Low-voltage transformer
	224	Generator
	225	Inverter
	226	Uninterrupted power supply (UPS)
	227	Surge protector
	228	Battery charger or rectifier
	229	Battery (all types)
Lamp, bulb or lighting	230	Unclassified lamp or lighting
	231	Lamp-tabletop, floor or desk
	232	Lantern or flashlight
	233	Incandescent lighting fixture

	234	Fluorescent light fixture or ballast
	235	Halogen light fixture or lamp
	236	Sodium or mercury vapor light fixture or lamp
	237	Work or trouble light
	238	Light bulb
	241	Nightlight
	242	Decorative lights – line voltage
	243	Decorative or landscape lighting – low voltage
	244	Sign
Cord or plug	260	Unclassified cord or plug
	261	Power cord or plug, detachable from appliance
	262	Power cord or plug- permanently attached
	263	Extension cord
Torch, burner or soldering iron	331	Welding torch
	332	Cutting torch
	333	Burner, including Bunsen burners
	334	Soldering equipment
Portable cooking or warming equipment	631	Coffee maker or teapot
	632	Food warmer or hot plate
	633	Kettle
	634	Popcorn popper
	635	Pressure cooker or canner
	636	Slow cooker
	637	Toaster, toaster oven, counter-top broiler
	638	Waffle iron, griddle
	639	Wok, frying pan, skillet
	641	Breadmaking machine

Equipment was not analyzed separately for confined fires. Instead, each confined fire incident type was listed with the equipment or as other known equipment.

Item First Ignited. In most analyses, mattress and pillows (item first ignited 31) and bedding, blankets, sheets, and comforters (item first ignited 32) are combined and shown as "mattresses and bedding." In many analyses, wearing apparel not on a person (code 34) and wearing apparel on a person (code 35) are combined and shown as "clothing." In some analyses, flammable and combustible liquids and gases, piping and filters (item first ignited 60-69) are combined and shown together.

Area of Origin. Two areas of origin: bedroom for more than five people (code 21) and bedroom for less than five people (code 22) are combined and shown as simply "bedroom." Chimney is no longer a valid area of origin code for non-confined fires.

Rounding and percentages. The data shown are estimates and generally rounded. An entry of zero may be a true zero or it may mean that the value rounds to zero. Percentages are calculated from unrounded values. It is quite possible to have a percentage entry of up to 100% even if the rounded number entry is zero. The same rounded value may account for a slightly different percentage share. Because percentages are expressed in integers and not carried out to several decimal places, percentages that appear identical may be associated with slightly different values.

Appendix B: Methodology and Definitions Used in "Leading Cause" Tables

The cause table reflects relevant causal factors that accounted for at least 2% of the fires in a given occupancy. Only those causes that seemed to describe a scenario are included. Because the causal factors are taken from different fields, some double counting is possible. Percentages are calculated against the total number of structure fires, including both confined and non-confined fires. 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 distribution and lighting, clothes dryers and washers, torches). However, the problem may be not with the equipment but with the way it is used. The details in national estimates are derived from the Version 5.0 of the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS 5.0). This methodology is based on the coding system used in Version 5.0 of NFIRS. The *NFIRS 5.0 Reference Guide*, containing all of the codes, can be downloaded from http://www.nfirs.fema.gov/documentation/reference/. Actual estimates are projections based derived from NFPA"s annual fire department experience survey and the procedures below.

Cooking equipment and heating equipment are calculated by summing non-confined fires identified by equipment involved in ignition and relevant confined fires. Confined fires will be shown if they account for at least 1% of the incidents. **Confined cooking fires** (cooking fires involving the contents of a cooking vessel without fire extension beyond the vessel) are identified by NFIRS incident type 113;

Confined heating equipment fires include **confined chimney or flue fires (**incident type 114) and **confined fuel burner or boiler** fires (incident type 116). The latter includes delayed ignitions and incidents where flames caused no damage outside the fire box. The two types of confined heating fires may be combined or listed separately, depending on the numbers involved.

Contained trash or rubbish fires with no flame damage to structure or its contents are identified by incident type 118. No cause can be ascertained for these incidents, but they account for a substantial share of the incidents in some occupancies. When appropriate, these fires are generally shown at the bottom of a cause table.

Confined or contained fires (incident type 113-118) are excluded from the remaining estimates. Unknown data is allocated proportionally among non-confined fires. Reports on specific causal factors may include analysis of confined fires and consequently have higher estimates of specific causes.

Intentional fires are identified by fires with a "1" (intentional) in the field "cause." The estimate includes a proportional share of fires in which the cause was undetermined after investigation, under investigation, or not reported. All fires with intentional causes are included in this category regardless of the age of the person involved. Intentional include those of an incendiary nature and those resulting from a deliberate misuse of the heat source. No age restriction is applied.

Fires caused by **playing with heat source** (typically matches or lighters) are identified by code 19 in the field "factor contributing to ignition." It appears that "none" is often being used in place of "unknown." Fires in which the factor contribution to ignition was undetermined (UU), entered as none (NN) or left blank are considered unknown and allocated proportionally. Because factor contributing to ignition is not required for intentional fires, the share unknown, by these definitions, is somewhat larger than it should be.

The heat source field is used to identify fires started by: **smoking materials** (cigarette, code 61; pipe or cigar, code 62; and heat from undetermined smoking material, code 63); **candles** (code 66), **lightning** (code 73); and **spontaneous combustion or chemical reaction** (code 72). Fires started by heat from unclassified open flame or smoking materials (code 60) are allocated proportionally among the "other open flame or smoking material" codes (codes 61-69) in an allocation of partial unknown data. This includes smoking materials and candles. This approach results in any true unclassified smoking or open flame heat sources such as incense being inappropriately allocated. However, in many fires, this code was used as an unknown.

The equipment involved in ignition field is used to find several cause categories. This category includes equipment that functioned properly and equipment that malfunctioned.

Identified cooking equipment refers to equipment used to cook, heat or warm food (codes 620-649 and 654). Fire in which 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) were 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. A proportional share of fires involving unclassified cooking kitchen and cooking equipment (code 600) are included here.

Identified heating equipment (codes 120-199) includes central heat, portable and fixed heaters (including wood stoves), fireplaces, chimneys, hot water heaters, and heat transfer equipment such as hot air ducts or hot water pipes. Heat pumps are not included. Unclassified heating, ventilation and air condition equipment (code 100) is included here because a larger share of the whole category involved heating rather than air conditioning or ventilation equipment. A proportional share of fires involving unclassified heating, ventilation, and air conditioning equipment (code 100) are included here.

Electrical distribution and lighting equipment (codes 200-299) include: fixed wiring; transformers; associated overcurrent or disconnect equipment such as fuses or circuit breakers; meters; meter boxes; power switch gear; switches, receptacles and outlets; light fixtures, lamps, bulbs or lighting; signs; cords and plugs; generators, transformers, inverters, batteries and battery charges.

Torch, burner or soldering iron (codes 331-334) includes welding torches, cutting torches, Bunsen burners, plumber furnaces, blowtorches, and soldering equipment.

Clothes dryer or washer (codes 811, 813 and 814) includes clothes dryers alone, washer and dryer combinations within one frame, and washing machines for clothes.

Electronic, office or entertainment equipment (codes 700-799) includes: computers and related equipment; calculators and adding machines;, telephones or answering machines; copiers; fax machines; paper shredders; typewriters; postage meters; other office equipment; musical instruments; stereo systems and/or components; televisions and cable TV converter boxes,, cameras, excluding professional television studio cameras, video equipment and other electronic equipment. Older versions of NFIRS had a code for electronic equipment that included radar, X-rays, computers, telephones, and transmitter equipment. Because this code was so broad, it unfortunately converts to equipment involved undetermined.

Shop tools and industrial equipment excluding torches, burners or soldering irons (codes 300-330, 335-399) includes power tools; painting equipment; compressors; atomizing equipment; pumps; wet/dry vacuums; hoists, lifts or cranes; powered jacking equipment; water or gas drilling equipment; unclassified hydraulic equipment; heat-treating equipment; incinerators, industrial furnaces, ovens or kilns; pumps; compressors; internal combustion engines; conveyors; printing presses; casting, molding; or forging equipment; heat treating equipment; tar kettles; working or shaping machines; coating machines; chemical process equipment; waste recovery equipment; power transfer equipment; power takeoff; powered valves; bearings or brakes; picking, carding or weaving machines; testing equipment; gas regulators; separate motors; non-vehicular internal combustion engines; and unclassified shop tools and industrial equipment.

Medical equipment (codes 410-419) includes: dental, medical or other powered bed, chair or wheelchair; dental equipment; dialysis equipment; medical monitoring and imaging equipment; oxygen administration equipment; radiological equipment; medical sterilizers, therapeutic equipment and unclassified medical equipment.

Mobile property (vehicle) describes fires in which some type of mobile property was involved in ignition, regardless of whether the mobile property itself burned. Mobile property includes: highway-type vehicles such as cars, trucks, recreational vehicles, and motorcycles; trains, trolleys and subways; boats and ships; aircraft; industrial, agricultural and construction vehicles; and riding lawn mowers, snow removal vehicles and tractors.

Exposures are fires that are caused by the spread of or from another fire. These fires are identified by factor contributing to ignition 71. This code is automatically applied for all fires with exposure numbers greater than zero. As with playing with fire, Fires in which the factor contribution to ignition was undetermined (UU), entered as none (NN) or left blank are considered unknown and allocated proportionally.

Appendix C: Selected Published Incidents

The following are selected published incidents in barns. Included are short articles from the "Firewatch" or "Bi-monthly" columns in *NFPA Journal* or it predecessor *Fire Journal* and incidents from either the large-loss fires report or catastrophic fires report. If available, investigation reports or NFPA Alert Bulletins are included and provide detailed information about the fires.

It is important to remember that this is anecdotal information. Anecdotes show what can happen; they are not a source to learn about what typically occurs.

NFPA's Fire Incident Data Organization (FIDO) identifies significant fires through a clipping service, the Internet and other sources. Additional information is obtained from the fire service and federal and state agencies. FIDO is the source for articles published in the "Firewatch" column of the *NFPA Journal* and many of the articles in this report.

Fire ruins farm building, Massachusetts

A fire destroyed a barn at a poultry farm, causing a $1 million loss. Workers had left for the day about 90 minutes before the fire was detected.

The two-and-a-half-story, wood-frame building was 200 feet (91 meters) long and 40 feet (12 meters) wide. It had wood-truss floors and a wood-truss roof covered with metal sheathing. There were no sprinklers or fire detection equipment.

Firefighters responding to a 5:38 p.m. 911 call discovered the building fully involved in fire when they arrived three minutes later. Four alarms were sounded, bringing apparatus from several communities to help extinguish the blaze.

Investigators determined that workers using a propane torch on the second floor of the building to kill insects apparently ignited the structural framing. They did not notice any fire or smoke and left for the day later, unaware that a fire was in progress.

On arrival, the incident commander reported that the building was fully involved and ordered a second alarm, requesting water tenders and a n extra engine and ladder. He struck a third alarm within minutes.

The building, valued at $650,000, and its contents, valued at $350,000, were a total loss. No one was injured.

Kenneth J. Tremblay, 2005, "Firewatch", *NFPA Journal*, January/February, 20.

Lightning strike destroys unprotected barn, Ohio

Firefighters facing a fully involved fire spreading from a barn to nearby buildings during a thunderstorm had to use relays to supply water 3,000 feet (914 meters) away from the barn.

The single-story, wood-frame barn, which was 520 feet (158 meters) long and 50 feet (15 meters) wide, had a metal-covered roof and metal walls. It had no fire detection or suppression systems.

A series of thunderstorms was passing through the area at the time of the fire, and at least two lightning strikes hit the farm buildings. Up to seven lightning strikes were documented at or near the property some 30 minutes before the fire alarm was called at 10:49 p.m.

Based on multiple reports of fire, firefighters struck a second and third alarm before they arrived nine minutes later to find one barn completely engulfed in flames, with its roof collapsing. As the

fire threatened other buildings nearby, the incident commander ordered hose lines to protect exposures, and six fire engines were set up to relay water to the fire. As the heavy rain poured down and lightning continued to strike, 16 tankers and 18 fire departments worked together to prevent the fire from spreading further.

The barn, in which the farmer stored farm equipment, straw, hay, and recreational equipment totaling $2.5 million, was valued at $100,000. Both the barn and its contents were destroyed. There were no injuries.

Kenneth J. Tremblay, 2011, "Firewatch," *NFPA Journal*, November/December, 23.