

# **NON-FIRE CARBON MONOXIDE INCIDENTS**

**Ben Evarts**

**March 2012**



**National Fire Protection Association  
Fire Analysis and Research Division**

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## **Abstract**

During 2006-2010, municipal fire departments responded to an annual average of 72,000 carbon monoxide incidents, excluding incidents where nothing was found or fire was present. These incidents were more common during the winter months, and in residential properties. Carbon monoxide calls to fire departments are more common during the early evening hours.

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, carbon monoxide,

## **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](http://www.nfpa.org) or call 617-770-3000. To learn more about the One-Stop Data Shop go to [www.nfpa.org/osds](http://www.nfpa.org/osds) or call 617-984-7443.

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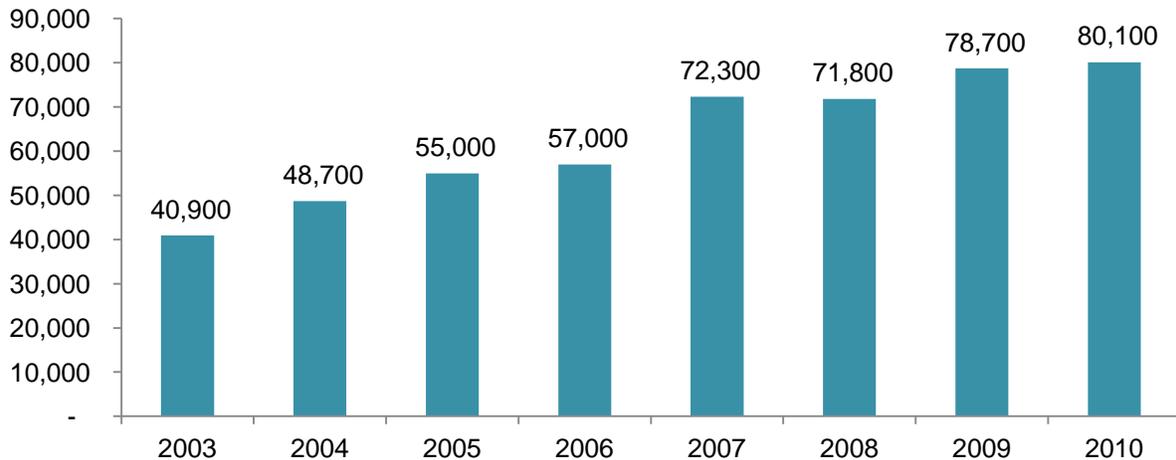
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## Non-Fire Carbon Monoxide Incidents Fact Sheet

During 2006-2010, an estimated 72,000 non-fire carbon monoxide incidents were reported to U.S. fire departments each year: These incidents have been increasing over time.

### Non-Fire Carbon Monoxide Incidents by Year 2003-2010



- These incidents are more common between the months of November and February
- Most incidents (94%) occur in residential properties, with 73% in one- or two-family homes
- Carbon monoxide alarms are more common in the early evening hours, peaking around 8:00 p.m.
- In 2008, there were an estimated 189 carbon monoxide poisoning deaths associated with the use of a consumer product in the U.S.

### **CARBON MONOXIDE**

Often called the silent killer, carbon monoxide is an invisible, odorless, colorless gas created when fuels (such as gasoline, wood, coal, natural gas, propane, oil, and methane) burn incompletely. In the home, heating and cooking equipment that burn fuel are potential sources of carbon monoxide. Vehicles or generators running in an attached garage can also produce dangerous levels of carbon monoxide.

Additional resources can be found at [www.nfpa.org/CO](http://www.nfpa.org/CO)

# NFPA's Fire Safety Resources

NFPA's wealth of fire-related research includes 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:

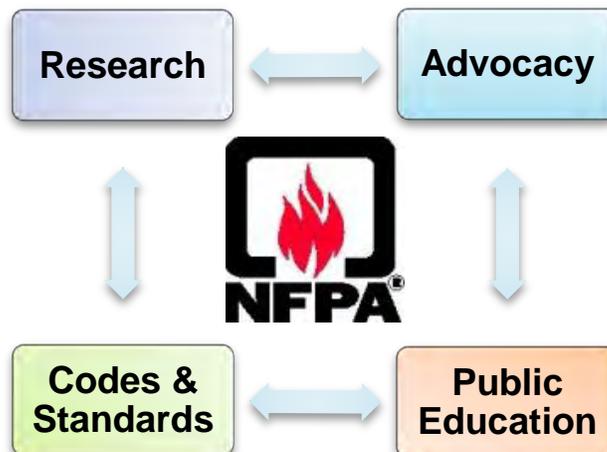
[www.nfpa.org/research](http://www.nfpa.org/research)

Properly installed and maintained smoke alarms are necessary to provide a warning of any fire to all 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 from a fire until help arrives. More information about home fire sprinklers may be found at [www.firesprinklerinitiative.org](http://www.firesprinklerinitiative.org)

Simply put, smoke alarms and fire sprinklers save lives.



NFPA also develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks. Home electrical safety begins with:

[NFPA 720: Standard for the Installation of Carbon Monoxide\(CO\) Detection and Warning Equipment](#)

[NFPA 1: Fire Code](#)

[For consumers:](#) NFPA has consumer safety information regarding causes, escape planning, fire & safety equipment, and many other topics.

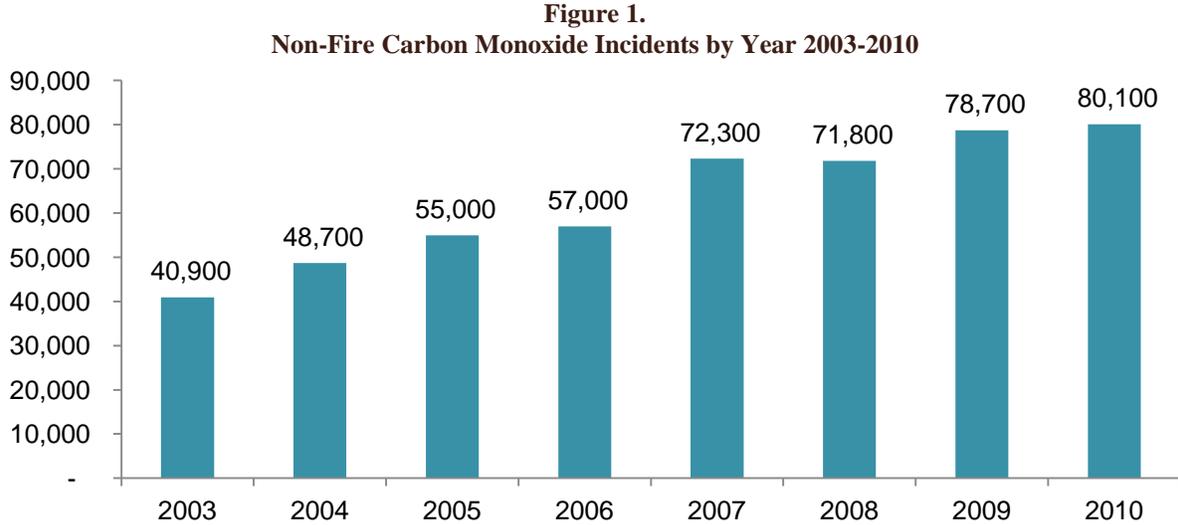
[For kids:](#) Sparky.org has important information for kids delivered via fun games, activities, and cartoons.

[For public educators:](#) Resources on fire safety education programs, educational messaging, grants & awards, and many other topics.

## Non-Fire Carbon Monoxide Incidents

### Non-fire carbon monoxide incidents have increased over the past decade.

Between 2006 and 2010, there were an average of 72,000 non-fire carbon monoxide calls to local fire departments per year. Figure 1 shows that this number has been increasing throughout the last decade.



The vast majority (94%) of these incidents occur in residential properties. Smaller percentages occur in business properties, public assembly properties, and health care facilities. (See Table A)

**Table A.**  
**Non-Fire Carbon Monoxide Incidents, by Property Use: 2006-2010 Annual Averages**

Property Use	Incidents	Percent
Residential	67,980	(94%)
One-or-two-family dwelling	52,780	(73%)
Apartment or multi-family dwelling	12,560	(17%)
Other known residential property types	2,640	(4%)
Mercantile or business	1,250	(2%)
Public assembly	600	(1%)
Health care, or detention or correction	440	(1%)
All other property uses	1,720	(2%)
Total	71,990	(100%)

**Carbon monoxide incidents are more common during the colder months.**

Half (50%) of CO incidents reported to local fire departments occur between the months of November and February, peaking in December (See Figure B below).

**Figure 2.  
Non-Fire Carbon Monoxide Incidents by Month 2006-2010**



**There is no clear pattern in carbon monoxide incidents by day of the week.**

There is some variation by day of the week, but no significant trend is apparent. (See Table B)

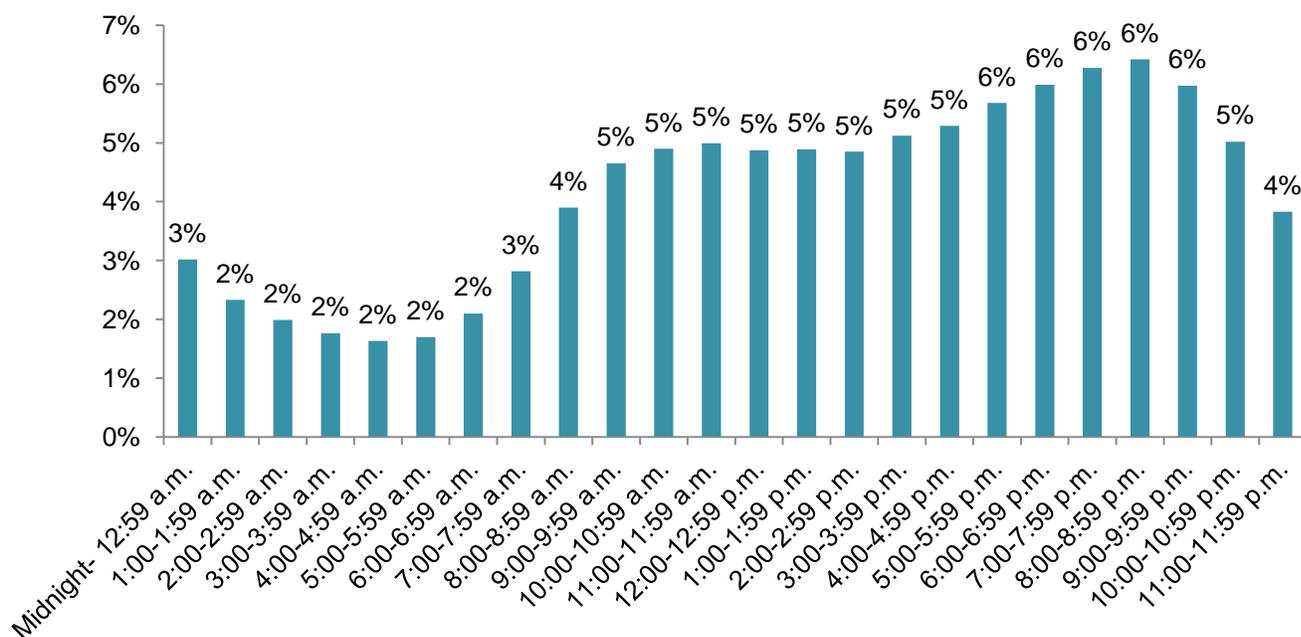
**Table B.  
Non-Fire Carbon Monoxide Incidents by Day of Week 2006-2010**

Day of Week	Incidents	Percent
Sunday	10,600	(15%)
Monday	11,200	(16%)
Tuesday	10,400	(14%)
Wednesday	10,300	(14%)
Thursday	10,200	(14%)
Friday	9,800	(14%)
Saturday	9,500	(13%)
Total	72,000	(100%)

**Carbon monoxide incidents are more likely to be reported during the afternoon and early evening hours.**

Carbon monoxide incidents are more likely during the hours when people are awake and active. They peak in the evening hours, between 5:00 and 9:00 p.m. See Figure C below.

**Figure 3.  
Non-Fire Carbon Monoxide Incidents by Alarm Hour 2006-2010**



**In 2008, 676 people died of unintentional non-fire exposure to gases in the U.S. Most of these deaths are due to carbon monoxide<sup>1</sup>.**

For example, in 1998, the last year when separate results were provided, motor vehicle exhaust, which is always carbon monoxide, accounted for 35% of total unintentional-injury deaths due to poisoning by gases and vapors<sup>2</sup>. Many other incidents involve generators (see below). In addition, 1,141 people died from intentional self-poisoning by exposure to gases and vapors.

**According to the Consumer Product Safety Commission, an estimated 189 people died of unintentional carbon monoxide poisoning caused by consumer products in the United States in 2008.**

Engine-driven tools (mainly generators) were associated with the largest percentage of non-fire CO deaths (49%), followed by heating systems with 35%. There has been an increase in CO

<sup>1</sup> Centers for Disease Control. CDC WONDER Database Query. March 1, 2012. <  
<http://wonder.cdc.gov/controller/datarequest/D67>>

<sup>2</sup> John R. Hall Jr. *Deaths and Injuries Due To Non-Fire Exposure To Gases*. National Fire Protection Association, Quincy, MA, April 2009.

deaths from 1999 to 2009, largely caused by an increase in deaths involving generators<sup>3</sup>. CPSC has additional information about carbon monoxide on its website <http://www.cpsc.gov/cpscpub/pubs/466.html>.

**Codes and standards related to carbon monoxide can help in detection and investigation.**

ASTM E2292 – 04 Standard Practice for Investigation Carbon Monoxide Poisoning Incidents covers guidelines for collecting and preserving information and physical evidence related to incidents involving the poisoning of individuals by carbon monoxide, and can be found online at <http://www.astm.org/Standards/E2292.htm>. NFPA 720: Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment is primarily concerned with life safety, and covers the selection, design, application, installation, location, performance, inspection, testing and maintenance of carbon monoxide detection equipment in buildings [www.nfpa.org/720](http://www.nfpa.org/720).

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<sup>3</sup> Hnatov, Matthew V. United States. Consumer Product Safety Commission. *Non-Fire Carbon Monoxide Deaths Associated with the Use of Consumer Products 2008 Annual Estimates*. Bethesda, MD: , 2011. Web. <<http://www.cpsc.gov/library/foia/foia12/os/co11.pdf>>.

## Appendix A. How National Estimates Statistics are Calculated

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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](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.

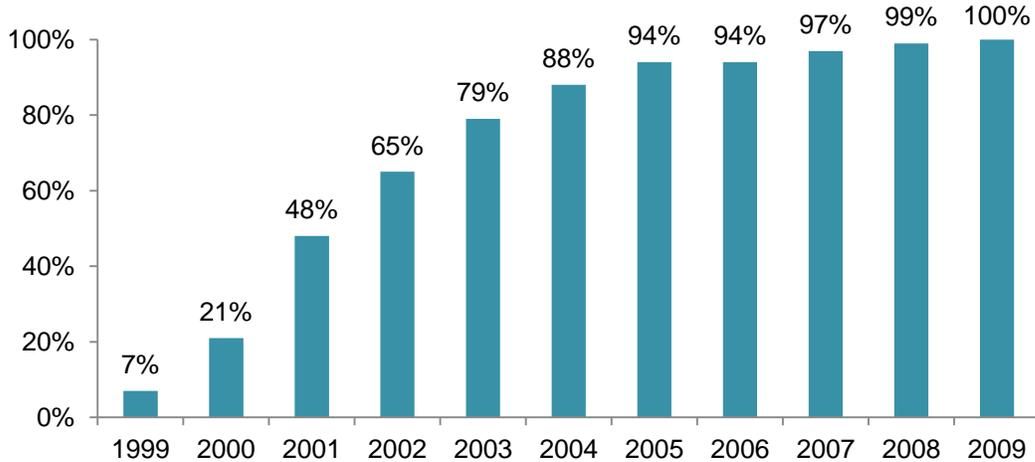
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific 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:

$$\frac{\text{NFPA survey projections}}{\text{NFIRS totals (Version 5.0)}}$$

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

All fires

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(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.

<b>Code Grouping</b>	<b>EII Code</b>	<b>NFIRS definitions</b>
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
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.