Structure Fires Caused by Hot Work

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Key Findings

US fire departments responded to an average of 4,580 structure fires involving hot work per year in 2014–2018. These fires caused an average of 22 civilian deaths, 171 civilian injuries, and $484 million in direct property damage per year.

Of the fires involving hot work, 43 percent occurred in or on homes, including one- or two-family homes and apartments or other multifamily homes, while 57 percent occurred in or on non-home properties.

While welding and cutting torches were the leading types of equipment involved in hot work fires, this varied by occupancy, as follows:

- Welding torches were involved in 40 percent of the non-home hot work fires but only 31 percent of the home fires associated with hot work.
- Cutting torches were involved in one-quarter of the non-home fires (25 percent), twice the percentage of home fires (13 percent).
- Heat-treating equipment was involved in 19 percent of the non-home hot work fires compared to 8 percent of the hot work fires in homes.
- Soldering equipment was involved in more than five times the number of hot work home fires (33 percent) compared to only 6 percent of such fires in non-home properties.

The peak areas for home fires involving hot work were wall assemblies or concealed spaces (16 percent) and bathrooms or lavatories (13 percent). Exterior roof surfaces (12 percent) and processing or manufacturing areas (11 percent) were the leading areas of origin for non-home fires.

Leading items first ignited included the following:

- Structural members or framing in one-quarter of the home fires (24 percent) but only 8 percent of the non-home fires.
- Insulation within structural areas in 20 percent of the home hot work fires but only 9 percent of the non-home fires.
- Flammable or combustible liquids or gases, filters, or piping in 17 percent of the non-home fires but only 5 percent of the home fires.
- Exterior roof coverings or finishes in 10 percent of the non-home fires and 6 percent of the home fires.

From 2001–2018, five firefighters were fatally injured in four unintentional fires started by torches.

Introduction

During the five-year period of 2014–2018, local fire departments responded to an estimated average of 4,580 structure fires per year that involved equipment associated with hot work. These fires caused an average of 22 civilian deaths, 171 civilian injuries, and $484 million in direct property damage per year. These estimates were derived from detailed information collected by the US Fire Administration's National Fire Incident Reporting System (NFIRS) and summary information from NFPA's annual fire experience survey.

In this analysis, hot work fires include fires in which cutting or welding torches, soldering equipment, burners, heat-treating equipment, tar pots or tar kettles and power nail guns, stud drivers, or staplers were the equipment involved in ignition. Any fire in or on a structure is generally considered a structure fire.

Supporting tables with additional information can be found on NFPA's website here.

Descriptions of hot work fires, occupational injuries, and injuries seen in hospital emergency departments (ED) are provided here for illustrative purposes. The occupational injuries and ED injuries were not restricted to structure fires.

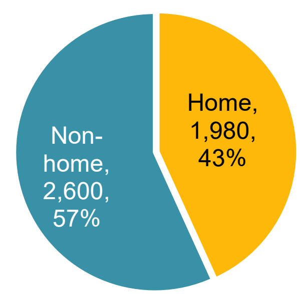
Hot work fires by occupancy

Figure 1 shows that more than two out of every five hot work structure fires occurred in or on home properties. The term *home* encompasses one- or two-family homes, including manufactured housing, and apartments or other multifamily housing. Home hot work fires caused an average of 16 civilian deaths (75 percent), 85 civilian injuries (50 percent), and $106 million in direct property damage (22 percent) per year.

The coded data sources do not indicate who was performing the hot work. As a result, it is impossible to separate the role of crafters, artists, and do-it-yourselfers from professional contractors.

Almost three out of every five hot work fires occurred at non-home properties, including residential properties such as hotels and motels, dormitories, and unclassified residential properties, as well as non-residential properties. These fires caused an average of five civilian deaths (25 percent), 86 civilian injuries (50 percent), and $378 million in direct property damage (78 percent) per year.

Figure 1. Home and non-home hot work structure fires: 2014–2018



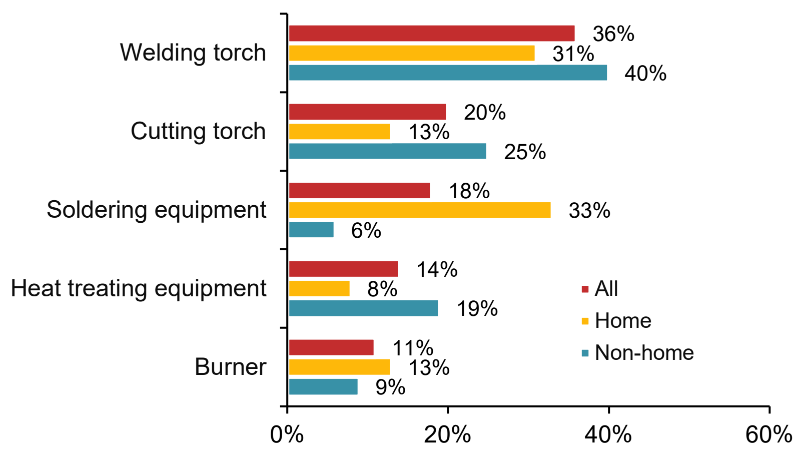
Hot work fires by type of equipment involved

Welding torches ranked first among the types of hot work equipment involved in fires. The estimated average of 1,650 fires per year started by welding torches (36 percent) caused 9 civilian deaths (42 percent), 56 civilian injuries (33 percent), and $157 million in direct property damage (32 percent) annually. Figure 2 shows that the leading types of hot work involved in structure fires varied by occupancy.

For example, a welding arc ignited materials in the ceiling of a Florida concert venue when a worker installed lighting equipment. The property was closed for the night. Although the fire department arrived at the scene shortly after notification by an automatic fire alarm and a 911 call from a passerby, the fire spread rapidly across the ceiling and through the building. The building's sprinkler system was overpowered by the fire, and it was totally destroyed.[1]

Cutting torches were involved in an average of 920 fires (20 percent) per year. These fires caused 30 civilian injuries (18 percent) and $74 million in direct property damage (15 percent) annually. No deaths were reported in these fires.

Figure 2. All home and non-home hot work structure fires by leading equipment involved: 2014–2018



Soldering equipment was involved in an average of 810 fires (13 percent) per year. These fires caused two civilian deaths (8 percent), 27 civilian injuries (16 percent), and $63 million in direct property damage (13 percent) annually.

The leading types of hot work equipment involved in structure fires are different in homes than in non-home properties. Four times as many soldering equipment fires were reported in homes (650 per year) as in non-homes (150 per year). Figure 2 shows the percentage of hot work fires started by the leading types of equipment involved.

Hot work fires by structure status

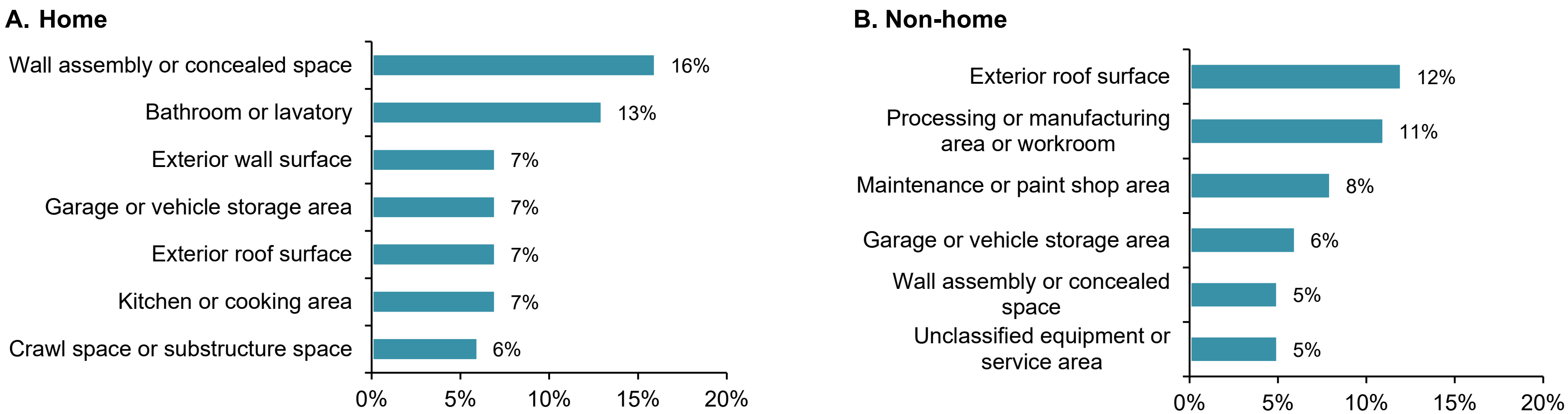
Four out of five structure fires involving hot work (81 percent) occurred in properties that were in normal use. Occupants of a structure may be going about their usual activities while hot work is performed. In addition, 7 percent of the hot work fires occurred in properties that were under construction and 5 percent occurred in structures under major renovation.

Hot work fires by area of origin

While homes and non-homes share some leading areas of origin, Figure 3 shows that there are differences. Exterior roof surfaces (12 percent) and processing or manufacturing areas (11 percent) were the leading areas of origin in non-home incidents.

For example, torch work on the roof of an Ohio restaurant ignited insulation between the new roof and the old one. The property was open while renovations were being done. The fire department encountered a broken hydrant and could not shuttle enough water to get the fire under control. Property damage to the structure and its contents was estimated at $10 million.[2]

Figure 3. Structure fires involving hot work by area of origin: 2014–2018



Hot work fires by item first ignited and factors contributing to ignition

Figure 4 shows that the percentage of hot work fires beginning with structural members or framing was three times as high in home fires as in non-home fires. The percentage of insulation fires was twice as high. The percentage of non-home hot work fires beginning with flammable or combustible liquid or gas was more than three times the percentage of home hot work fires.

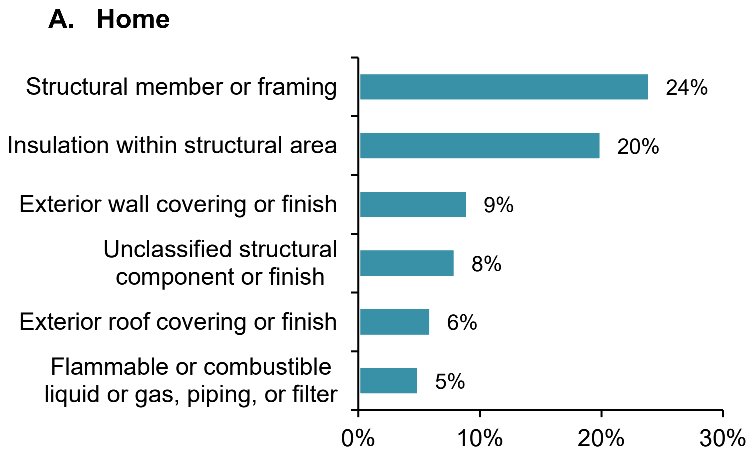
The two leading factors contributing to ignition — heat source too close to combustibles and cutting or welding too close to combustibles — together accounted for roughly two-thirds to three-quarters of the hot work fires. See Figure 5.

Preventing hot work fires

When doing hot work, it is essential to be aware of the environment and materials nearby that could catch fire. NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, provides essential guidance to help prevent these incidents.

The NFPA Hot Work Safety Certificate Training Program was established after a wind-driven 2014 Boston apartment building fire caused the deaths of two firefighters.[3,4] The fire started when molten slag from welding work ignited an attached shed. The welding work was done improperly and without a permit. As a result, the City of Boston passed an ordinance requiring hot work safety certificates for certain workers. NFPA partnered with the Boston Fire Department and Inspectional Services Department to create this training and certificate program.

Figure 4. Structure fires involving hot work by item first ignited: 2014–2018



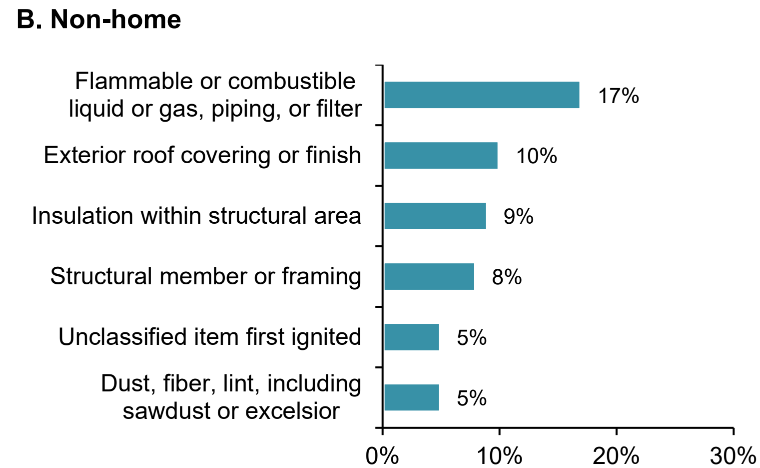
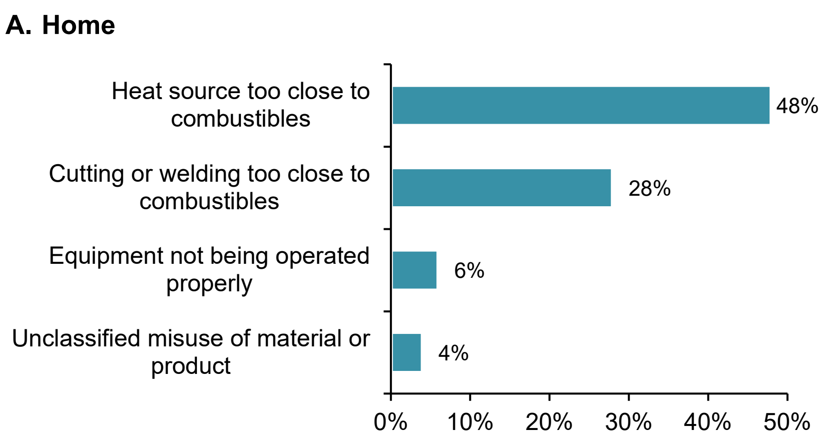
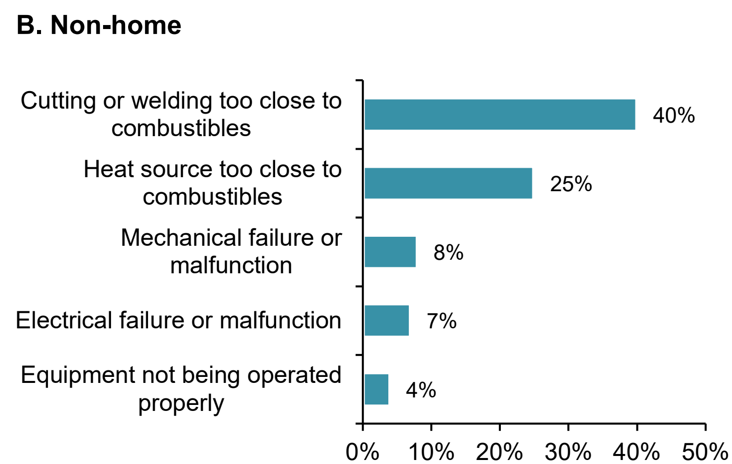


Figure 5. Structure fires involving hot work by factor contributing to ignition: 2014–2018





This training is available online and is mandatory in Massachusetts; it seeks to help those performing hot work on work sites to develop the awareness and understanding needed to do so safely.

The NFPA Hot Work Safety Program offers many additional resources, including a hot work certificate verification database, a template for hot work permits, and a fact sheet and infographic on the subject.

Lessons from hot work incident descriptions

Statistical information can provide context; incident descriptions can fill in additional details. The following three incidents demonstrate the danger of setting down hot torches on or near combustibles:

- At 3:22 a.m., an Illinois restaurant owner called 911 to report a fire in his business. Shortly after, the fire department was notified of an operating sprinkler waterflow alarm. The owner had been using a self-contained torch to repair a faucet in a storage area near the kitchen when a delivery truck arrived. He put the torch on a shelf in the supply room and went outside to receive the delivery. While he was speaking with the driver, an explosion inside the restaurant blew the door open. The owner went inside, used a fire extinguisher in an attempt to control the fire, and then went back outside to call 911. Two sprinklers operated and controlled the fire before the fire department arrived.

  Investigators found that the heat from the torch ignited cardboard boxes nearby. The resulting fire caused a butane canister to explode. They could not tell if the torch had been left on or if residual heat from the torch's tip was the specific heat source. Damage to the building and structure was estimated at $15,000.[5]

- After a butane torch was used in a Nebraska plant that manufactured automobile filters, a worker placed it on a plastic storage shelf. Parts of the torch were still hot. The shelf ignited and melted, triggering the fire alarm and sprinkler system. The employee used a fire extinguisher in an attempt to put out the fire which was extinguished by the facility's sprinkler system before the fire department arrived. The employee was taken to the hospital for treatment for smoke inhalation injuries. The total damage to the structure, which had a combined value with its contents of $150 million, was estimated at $40,000.[6]

- In April 2018, a worker in Georgia was using a torch to cut the lids off of four 55-gallon drums containing the solvent methyl ethyl ketone. Before cutting off the fourth lid, he placed the torch on top of it. The drum exploded. The worker was struck by the drum's top, suffering facial fractures and head trauma.[7]

Workers sometimes try to fight a fire themselves without reporting it first. When fires start in concealed spaces, it is especially hard to ensure that they are fully extinguished. If firefighting attempts are unsuccessful, the consequences of delayed reporting can be devastating.

In one example, a worker was welding around copper pipe in the ceiling of a second-floor mechanical room in an Indiana apartment building when the torch flame ignited insulation. Despite using multiple fire extinguishers, the welder was unsuccessful at extinguishing the fire. He then cut a bigger hole around the pipe and again attempted extinguishment. Because he thought the fire was out, he did not call 911, causing a 45-minute delay in the fire department response. The building was under construction at the time and, consequently, detection and sprinkler systems had not yet been activated. Property loss was estimated at $12 million.[8]

Sometimes slag or embers from hot work can start fires after the work is done. That is why a fire watch is so important. The following examples further illustrate the need for a fire watch:

- In Arizona, 19 apartment buildings under construction were damaged or destroyed in a $17 million fire. Embers from a torch used earlier in the day started a fire on the roof of an electrical closet attached to one of the buildings. The fire department was alerted at 5:54 p.m. Most of the buildings were still in the framing stage; stucco had been applied to two. No smoke detection or automatic suppression system was present and no one was in the buildings when the fire started.[9]

- While workers welded a bracing system in a bathroom of a 22-story Colorado hotel that was under construction, spray-on insulation on an interior wall ignited. The welders were at lunch when the fire was discovered by others a short time later. The other workers called the fire department promptly. The hotel was under construction and the sprinkler system was not yet functional. Firefighters were able to put the fire out quickly, limiting the property loss to $13,000.[10]

CSB guidance on hot work around tanks

The US Chemical Safety and Hazard Investigation Board (CSB) has identified hot work in or around tanks as a particular danger and published a guidance document, "*Seven Key Lessons to Prevent Worker Deaths During Hot Work in and Around Tanks: Effective Hazard Assessment and Use of Combustible Gas Monitoring Will Save Lives*."[11] Their key points are as follows:

1. Use alternatives to hot work whenever possible.
2. Perform a hazard assessment.
3. Monitor the atmosphere with a combustible gas detector before and during hot work even when a flammable atmosphere is not expected.
4. Test the area, including the surrounding tanks and spaces as well as the specific work area. Drain or purge equipment and piping of flammable liquids or gases before hot work starts.
5. Use written permits from qualified, knowledgeable staff that identify the work to be done and the safety requirements.
6. Train thoroughly on hot work, gas detector use, safety equipment, and hazards.
7. Supervise contractors from outside the company and inform them of on-site hazards.

The following two examples further illustrate these points:

- In February 2017, three contract workers were killed and seven injured by an explosion at a Louisiana paper mill during its annual maintenance shutdown. Workers had been welding piping above a "foul condensate" tank that contained an explosive mix of air and turpentine vapor. The tank was blown off its base and over a six-story building before landing almost 375 feet away.[12] For more information, see the CSB report.
- In May 2018, five workers from two companies were involved in an incident at a West Virginia oil and gas company while working on three decommissioned tanks containing sludge from oil remains and gas condensate. Four workers were dealing with a leak along the bottom seam of one tank while another worker began to heat the opposite side of the tank with an acetylene torch. An explosion inside the tank fatally injured one employee. Two others suffered comparatively minor burns.[13]

Fire is not the only hazard associated with hot work

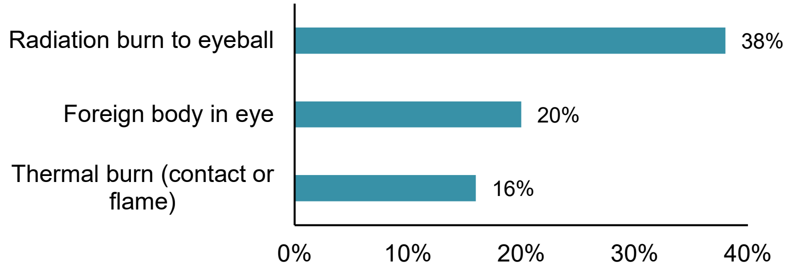
Hot work by definition involves heat, which can itself trigger chemical reactions beyond fire. Welding fumes can cause both immediate and long-term health issues. OSHA® released a fact sheet with additional background and safety advice for such incidents.[14]

For example, in October 2018, a worker in Oklahoma was using a welding torch and solder to repair a food refrigeration case in a grocery store and inhaled residual refrigerant that had oxidized when heated. Afterward, he felt ill and subsequently died from the exposure.[15]

Eye injuries and thermal burns are also common

According to estimates from the Consumer Product Safety Commission (CPSC's) National Electronic Injury Surveillance System (NEISS), an estimated 11,500 people visited hospital emergency departments in 2018 due to injuries associated with welding, soldering, and cutting tools considered consumer products.[16] Note that in most cases, no fire occurred.

Figure 6. Non-occupational injuries associated with cutting, welding, and soldering tools: 2018



Source: CPSC's NEISS

Radiation burns to the eyeball caused 4,300 of these injuries; another 2,300 involved foreign bodies in the eye. These incidents show the importance of wearing eye protection while engaged in hot work. Although NEISS focuses on consumer injuries, the information it provides is relevant for anyone who does hot work. The following examples from the NEISS show the importance of wearing eye protection:

- A 25-year-old man who was welding without eye protection suffered radiation burns to his eyes.
- A 35-year-old woman had assisted someone who was welding and later woke with "burning, itching, eye pain, and photophobia." She was diagnosed with welder's keratitis.
- Welding debris caused a corneal abrasion in a 69-year-old man.
- A 32-year-old man went to the ED after suffering flash burns while welding the night before.
- A 43-year-old man burned his eyes while welding without wearing eye protection.
- A 55-year-old man had a piece of metal in his eye. He believed that this occurred while soldering the night before.
- Foreign material fell into the eye of a 51-year-old man who was welding under a car.

CPSC estimates that another 1,800 (16 percent) of the injuries associated with welding, soldering, and cutting tools were thermal burns. Some of these were due to contact with hot metal or a blow torch; others involved actual fires.

- A 25-year-old man was welding at home when sparks ignited his jacket, causing second-degree burns to his forearm.
- A 76-year-old man was welding when a spark ignited his pants causing burns to his lower leg.
- A 49-year-old man burned his hand on hot metal while welding.
- An 18-year-old man picked up a piece of bare metal while welding barehanded and burned his hand.

The American Welding Society provides safety and health fact sheets addressing a wide variety of safety concerns, including eye and face protection and other types of personal protective equipment, occupational exposure limits, and safety requirements for specific types of welding.

Methodology

For the purposes of this analysis, a fire was said to have involved hot work if any of the following NFIRS "equipment involved in ignition" codes were used on the fire incident report:

- 318 — Power nail gun, stud driver, or stapler
- 331 — Welding torch
- 332 — Cutting torch
- 333 — Burner
- 334 — Soldering equipment
- 351 — Heat treating equipment
- 354 —Tar pot or tar kettle

Note that the definitions used in this report are those used by NFIRS and do not necessarily correspond with those used in NFPA's codes and standards.

This analysis excludes structure fires with "confined structure fire" incident types. These include confined cooking fires, confined chimney or flue fires, confined trash fires, confined fuel burner or boiler fires, confined commercial compactor fires, and confined incinerator fires (NFIRS incident types 113–118). For this analysis, structure fires were identified by NFIRS incident type 110–123, excluding incident types 113–118.)

The fire statistics in this analysis are national estimates of fires reported to US municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire.

Except for property use and incident type, fires with unknown or unreported data were allocated proportionally in calculations of national estimates. Property loss has not been adjusted for inflation. Fires are rounded to the nearest ten, civilian deaths and injuries are rounded to the nearest one, and property damage is rounded to the nearest million dollars. Sums may not equal totals due to rounding errors.

For more information, see *How NFPA's National Estimates Are Calculated for Fires.*

Acknowledgements

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NFPA No. PKG27

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