Structure Fires Caused by Hot Work

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**Key Findings**

US fire departments responded to an average of 4,630 structure fires involving hot work per year in 2013-2017. These fires caused an average of 15 civilian deaths, 198 civilian injuries and $355 million in direct property damage per year.

Forty-three percent of the fires involving hot work in 2013-2017 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.

The leading types of hot work equipment involved in fires were:

- **Welding torches** – involved in 39 percent of non-home hot work fires but only 32 percent of such home fires
- **Cutting torches** – involved in a larger percentage (27 percent) of non-home fires but only 14 percent of the home fires
- **Heat treating equipment** – involved in 17 percent of the non-home hot work fires but only 8 percent of the home incidents
- **Soldering equipment** – involved in one-third (32 percent) of the hot work home fires but 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 peak areas for non-home fires.

Leading items of origin include the following:

- Structural members or framing in one-quarter (24 percent) of the home fires but only 8 percent of the non-home fires
- Insulation within structural areas in 21 percent of home hot work fires but only 9 percent of the non-home fires
- Flammable or combustible liquids or gases, filters, or piping in 16 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 2013-2017, local fire departments responded to an estimated average of 4,630 structure fires per year that involved equipment associated with hot work. These fires caused an average of 15 civilian deaths, 198 civilian injuries, and $355 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 the summary information from NFPA’s annual fire experience survey. Sums may not equal totals due to rounding errors.

Hot work fires in this analysis 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 at hospital emergency departments (ED) are provided for illustrative purposes. The occupational injuries and ED injuries were not restricted to structure fires.

**Firefighter fatalities caused by hot work fires**

From 2001 through 2018, a total of five firefighters were fatally injured in four fires started by torches.1 One was killed in a partial collapse of an apartment building that was undergoing renovations. Another was caught between a manlift and an upper floor at a silo fire while he checked a nearby silo for fire extension. He died as a result of positional asphyxia. Two firefighters were killed in a wind-driven fire in an apartment building that started when molten slag from welding work ignited an attached shed. The welding work was done improperly and without a permit. The fifth firefighter fell down an elevator shaft at a fire that started when slag from welding ignited cork insulation in a vacant warehouse.

Note that these statistics are actual *counts* of firefighter fatalities over the 18 years, not estimated annual averages.

**Hot work fires by occupancy**

Figure 1 shows that more than two 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 eight (57 percent) civilian deaths, 83 (42 percent) civilian injuries, and $100 million (28 percent) in direct property damage per year. The coded data sources do not indicate who was doing the hot work. Consequently, it is impossible to separate out the role of crafters, artists, and do-it-yourselfers from professional contractors.

![Figure 1. Home and non-home hot work structure fires 2013-2017](image)

Almost three 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 six (43 percent) civilian deaths, 115 (58 percent) civilian injuries, and $255 million (72 percent) in direct property damage per year.
Hot work fires by type of equipment involved

Welding torches ranked first among the types of hot work equipment involved in fires. The 1,670 (36 percent) fires per year started by welding torches caused 10 (66 percent) civilian deaths, 75 (38 percent) civilian injuries, and $132 million (37 percent) in direct property damage annually.

- A welding arc ignited materials in the ceiling of a Florida concert venue as 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. The building was totally destroyed.2

Cutting torches were involved in an average of 1,000 (22 percent) fires per year. These fires caused 31 (16 percent) civilian injuries, and $72 million (20 percent) in direct property damage annually. No deaths were reported in these fires.

Soldering equipment was involved in an average of 810 (17 percent) fires per year. These fires caused two (11 percent) civilian deaths, 29 (15 percent) civilian injuries, and $58 million (16 percent) in direct property damage annually.

The leading types of hot work equipment involved in structure fires are different in homes than in non-home properties.

Four out of five structure fires involving hot work occurred in properties that were in normal use. Seven percent occurred in properties that were under construction, and 6 percent occurred in structures under major renovations.

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. Figure 3 shows that exterior roof surfaces (12 percent) and processing or manufacturing areas (11 percent) were peak areas for non-home incidents.

- Torch work on the roof of an Ohio restaurant ignited insulation between a new roof and the old one. The property was open while renovations were done. The fire department encountered a broken hydrant and could not shuttle enough water for fire control. Property damage to the structure and its contents was estimated at $10 million.3
Figure 3.
Structure fires involving hot work, by area of origin
2013-2017

A. Home
- Wall assembly or concealed space: 16%
- Bathroom or lavatory: 13%
- Kitchen or cooking area: 8%
- Exterior roof surface: 7%
- Garage or vehicle storage area: 7%
- Exterior wall surface: 7%
- Crawl space or substructure space: 6%

B. Non-home
- Exterior roof surface: 12%
- Processing or manufacturing area or workroom: 11%
- Maintenance or paint shop area: 8%
- Garage or vehicle storage area: 6%
- Wall assembly or concealed space: 5%
- Unclassified equipment or service area: 5%

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. Flammable or combustible liquid or gas fires were more common in non-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 account for 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 prevent these incidents.

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

In addition, NFPA’s Hot Work Safety Certificate Training Programs will help those performing hot work on worksites to develop the awareness and understanding needed to do so safely. This training is available online and is mandatory in Massachusetts.
Figure 4.
Structure fires involving hot work, by item first ignited
2013-2017

A. Home
- Structural member or framing: 24%
- Insulation within structural area: 21%
- Exterior wall covering or finish: 9%
- Unclassified structural component or finish: 7%
- Exterior roof covering or finish: 6%
- Flammable or combustible liquid or gas, piping, or filter: 5%

B. Non-home
- Flammable or combustible liquid or gas, filter, or piping: 16%
- Exterior roof covering or finish: 10%
- Insulation within structural area: 9%
- Structural member or framing: 8%
- Dust, fiber or lint, including sawdust or excelsior: 5%
- Unclassified item first ignited: 5%

Figure 5.
Structure fires involving hot work, by factor contributing to ignition
2013-2017

A. Home
- Heat source too close to combustibles: 47%
- Cutting or welding too close to combustibles: 30%
- Equipment not being operated properly: 6%
- Unclassified misuse of material or product: 4%

B. Non-home
- Cutting or welding too close to combustibles: 42%
- Heat source too close to combustibles: 25%
- Mechanical failure or malfunction: 8%
- Electrical failure or malfunction: 6%
Lessons from hot work incident descriptions

Statistical information provides a context. Incident descriptions can fill in additional details. The three incidents below show the danger of setting down hot torches on or near combustibles.

- At 3:22 am, 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, went back outside, and called 911. Two sprinklers operated and controlled the fire by the time 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 heat from the torch’s tip was the specific heat source. Damage to the building and structure was estimated at $15,000.4

- After a butane torch was used in a Nebraska plant that manufactured automobile filters, it was placed 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 torch wielder 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 worker was taken to the hospital for treatment of smoke inhalation injuries. Total damage was estimated at $40,000 in a facility with a combined structure and contents value of $150 million.5

- In April 2018, a worker in Georgia had been using a torch to cut the lids off of four 55-gallon drums containing the solvent methyl ethyl ketone. Before cutting the fourth, he placed his torch on top of it. The drum exploded. The worker was struck by the drum’s top, suffering facial fractures and head trauma.6

  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.

- A worker was welding around copper pipe in the ceiling of a second-floor mechanical room of 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. This caused a 45-minute delay. The building was under construction at the time. Consequently, detection and sprinkler systems had not yet been activated. Property loss was estimated at $12 million.7

  Sometimes slag or embers from hot work start fires after the work is done. That is why a fire watch is so important.

- Nineteen Arizona 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 pm. Most of the buildings were still in the framing stage; stucco had been applied to two. No smoke detection or automatic suppression was present, and no one was present when the fire started.8
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. 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 property loss to $13,000.9

Hot work by definition involves heat, which can itself trigger chemical reactions beyond fire.

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. Afterwards, he felt ill and subsequently died from the exposure.10

CSB guidance on hot work around tanks

The 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 summarized below.

1. Use alternatives to hot work whenever possible.
2. Analyze the hazards with 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 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 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.

Two examples illustrate these points.

In February, 2017, three contact workers were killed by an explosion and seven injured 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 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

Hot work injuries seen at hospital emergency departments

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 because of injuries associated with welding, soldering, and cutting tools considered consumer products in 2018.14 Note that in many cases, no fire occurred.
Radiation burns to the eyeball caused 4,300 (38%) of these injuries. Another 2,300 (20%) of the injuries 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 is relevant to anyone who does hot work. The following examples from the NEISS narratives 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 female was assisting 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%) 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.

**Methodology**

For 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; or
- 354 – Tar pot or tar kettle

Note that 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 the 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 type 113-118). Structure fires for this analysis were identified by NFIRS incident type 110-123, excluding incident types 113-118.)

Except for firefighter fatalities, 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 details on how specific estimates are calculated, see *How NFPA’s National Estimates Are Calculated for Home Structure Fires*.

Firefighter fatalities are not estimates or annual averages. Rather they are based on actual counts of deaths over the time period.

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1 Rita Fahy. E-mail correspondence, Subject: “Firefighter fatalities in hot work fires,” July 24, 2019.
8 Badger, 2017, 96.

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To learn more about research at NFPA visit nfpa.org/research.
E-mail: research@nfpa.org.
NFPA No. PKG27-REV

12 Stephen G. Badger, “Catastrophic Multiple-Death Fires in 2017,” NFPA, Quincy, MA.