Fires in Structures under Construction or Renovation

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Key findings

Local fire departments responded to an estimated average of 3,840 fires in structures under construction and 2,580 fires in structures under major renovation per year in 2013 through 2017. The fires in structures under construction caused an average of four civilian deaths, 49 civilian injuries, and $304 million in direct property damage annually, while those in structures under major renovation caused averages of eight civilian deaths, 52 civilian injuries, and $104 million in direct property damage annually.

Structures under construction

- The estimated number of fires in structures under construction has increased since 2014 after declining between 2008 and 2010.
- Three of every four fires in structures under construction involved residential properties.
- Cooking equipment is the leading cause of fires on construction sites. These fires tend to be minor.
- Fires that were intentionally set caused one in 10 fires, but one-third (32 percent) of direct property damage.
- Fires in structures under construction were highest in the cold weather months of November, December, January, and March.
- Fires in structures under construction were most common in the afternoon and early evening, but fires that occurred between midnight and 4 a.m., accounted for almost one-third of direct property damage.
- The leading factors contributing to the ignition of fires in structures under construction included electrical failures or malfunctions, abandoned or discarded materials or products, and heat sources too close to combustible materials.

Structures under major renovation

- 2008 was the peak year for fires in structures under renovation, and the trends since 2009 have been fairly flat. There was a sizable increase from 2016 to 2017; 2017 accounted for the second largest number of fires in the past decade.
- The leading cause of fires in structures under major renovation was electrical distribution and lighting equipment, accounting for nearly one-quarter of fires.
- A structural member or framing was the leading item first ignited in structures under major renovation, accounting for one-fifth of direct property damage.
- The leading factors contributing to the ignition of fires in structures under major renovation included electrical failures or malfunctions and heat sources too close to combustible materials.
- Arcing was the leading heat source in these fires, followed by a spark, ember, or flame from operating equipment, radiated or conducted heat from operating equipment, and unclassified heat from powered equipment.
Part 1. Fires in structures under construction
From 2013 to 2017, local fire departments responded to an estimated average of 3,840 fires in structures under construction per year. These fires caused an average of four civilian deaths, 49 civilian injuries, and $304 million in direct property damage annually. Only 1 percent of all reported structure fires were in structures under construction.

While large fires typically make the news, many of the fires in structures under construction were much smaller. As shown in the supporting tables, approximately one-third (32 percent) of these fires were confined fires. The presence of workers at construction sites who can detect and extinguish fires before they have an opportunity to spread may explain why many of these fires were confined fires.

The vast majority of fires in structures under construction involved residential properties, which accounted for three-quarters of these fires, as well as the largest shares of deaths injuries and direct property damage (Table A). Another 7 percent of fires involved mercantile or business properties, followed by fires in outside or special properties, which accounted for 5 percent of fires, but 13 percent of the direct property damage.

Table A. Fires in Structures under Construction by Property Use 2013-2017 Annual Averages

<table>
<thead>
<tr>
<th>Property Use</th>
<th>Fires</th>
<th>Civilian Deaths</th>
<th>Civilian Injuries</th>
<th>Direct Property Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>76%</td>
<td>59%</td>
<td>73%</td>
<td>76%</td>
</tr>
<tr>
<td>Mercantile or business</td>
<td>7%</td>
<td>16%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>Outside or special property</td>
<td>5%</td>
<td>7%</td>
<td>4%</td>
<td>13%</td>
</tr>
<tr>
<td>Storage</td>
<td>4%</td>
<td>4%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Assembly</td>
<td>3%</td>
<td>0%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>Educational</td>
<td>2%</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Recent trends in fires in structures under construction
Figure 3 shows the estimated number of fires in structures under construction over the ten-year period from 2008 to 2017. As indicated, the trend line is relatively flat but shows that the number of these fires increased since 2014 after declining between 2008 and 2010.

Figure 2. Fires in Structures under Construction, 2008–2017

Large-loss fire, apartment under construction, $12,000,000 in dollar loss
Date: January 2007
Time: 1:57 p.m.

Property Characteristics and Operating Status:
This four-story, 39-unit apartment building was comprised of unprotected wood-frame construction and was under construction. The ground floor area was not reported. Workers were on the job site at the time.

Fire Protection Systems:
There was no detection system present. A sprinkler system was being installed at the time, but was not yet operable. The type and coverage of the system were not reported.

Fire Development:
Hot tar from a tar kettle on the roof ignited the roofing materials.

Leading causes of fire in structures under construction

Some of the causes of fires in properties under construction are consistent with all structure fires. Figure 3 shows that cooking equipment is the leading cause of fires on construction sites. When cooking fires occur on these properties, they are usually minor; nevertheless, they accounted for approximately one-third of injuries. While cooking materials were the most common item first ignited, electrical distribution and lighting equipment accounted for 16 percent of fires, but two-fifths (41 percent) of the direct property damage in these fires. Another 15 percent of fires were caused by heating equipment. Fires that were intentionally set caused one in 10 (11 percent) fires, but one-third (32 percent) of direct property damage. Fires caused by a torch, burner, or soldering iron caused 7 percent of fires and 14 percent of direct property damage.

Timing of fires in structures under construction

Figure 4 shows that fires in structures under construction were somewhat higher in the cold weather months of November, December, January, and March, potentially due to the use of heating devices for warmth or for heating food. It is important at construction sites—where combustible and flammable materials are present—that equipment be used for its intended purpose. It is also important that temporary heaters are selected and used with fire safety in mind. Care is needed to ensure that temporary heaters are properly set up and that areas around them are kept clear of combustible materials.

The peak periods for fires in structures under construction were the hours between noon and 4 p.m. and between 4 p.m. and 8 p.m. (Figure 5). Although just 12 percent of fires occurred between midnight and 4 a.m., these fires accounted for 31 percent of direct property damage.
No one is likely to be on site when fires ignite during the very early morning hours, which allows them to spread before they are detected.

**Figure 5. Fires in Structures under Construction by Time of Day 2013–2017 Annual Averages**

Leading items first ignited in structure fires under construction

Cooking materials were the item most often first ignited in structures under construction, but approximately one-third of fires involved the ignition of structural elements, including structural member or framing, exterior wall covering or finish, insulation within structural areas, unclassified structural components, and exterior roof coverings or finishes, as indicated in Figure 6. Roughly one in 10 fires involved the ignition of waste materials at the construction site, including rubbish, trash, waste, or oily rags.

**Figure 6. Leading Items First Ignited in Structure Fires under Construction, 2013–2017 Annual Averages**

Items first ignited and direct property damage

While fires in which a structural member or framing were first ignited accounted for two-fifths of property losses in structures under construction, fires that began with other structural elements together accounted for nearly one-fifth of losses, including exterior wall covering or finish, unclassified structural component or finish, insulation within a structural area, and exterior roof covering or finish. Fires in which rubbish, trash, or waste was first ignited accounted for 16 percent of direct property damage. See Figure 7.
Figure 7. Leading Items First Ignited in Structure Fires under Construction by Direct Property Damage, 2013–2017 Annual Averages

**Equipment involved in ignition**
Fires in structures under construction most often involved cooking equipment, electrical distribution and lighting equipment, and heating equipment, with electrical distribution and lighting equipment accounting for a disproportionately large share of direct property damage and cooking equipment for the largest share of injuries (Table B). Temporary electrical wiring or lighting can emit heat or sparks if not properly installed or maintained and should be regularly reviewed by qualified personnel to ensure safety. Confined commercial compactors were involved in 10 percent of fires, but were not associated with any losses, while torches burners, or soldering irons were involved in seven percent of fires, but these fires accounted for fourteen percent of direct property damage. Hot work activities pose a variety of combustion hazards and should be carried out under stringent permitting system. For more information on hot work safety, see nfpa.org/Training-and-Events/By-topic/Hot-Work.

Table B. Fires in Structures under Construction, by Equipment Involved in Ignition, 2013–2017 Annual Averages

<table>
<thead>
<tr>
<th>Equipment Involved</th>
<th>Fires</th>
<th>Civilian Injuries</th>
<th>Direct Property Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking equipment</td>
<td>22%</td>
<td>34%</td>
<td>2%</td>
</tr>
<tr>
<td>Electrical distribution and lighting equipment</td>
<td>16%</td>
<td>16%</td>
<td>41%</td>
</tr>
<tr>
<td>Wiring and related equipment</td>
<td>11%</td>
<td>8%</td>
<td>7%</td>
</tr>
<tr>
<td>Lamp, bulb, or lighting</td>
<td>3%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>Heating equipment</td>
<td>15%</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>Fixed or portable space heater</td>
<td>5%</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>Confined commercial compactor fire</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Torch, burner or soldering iron</td>
<td>7%</td>
<td>2%</td>
<td>14%</td>
</tr>
</tbody>
</table>

**Factor contributing to ignition**
The leading factors contributing to the ignition of fires in structures under construction included electrical failures or malfunctions, abandoned or discarded materials or products, and heat sources too close to combustible materials, as shown in Figure 8. Other factors contributing to construction fires included cutting or welding too close to combustible materials, unclassified misuse of materials or products, unattended equipment, and failure to clean. Housekeeping practices at construction sites can ensure that waste and trash materials are stored away from ignition sources and structures. Additional good worksite practice should provide for regular maintenance of equipment and establish fire safety procedures for the storage and handling of powered equipment.
Heat source
The leading heat sources for fires in structures under construction involved either heat or sparks, embers or flame from operating equipment, which together accounted for nearly two of five fires, followed by arcing (Figure 9). Taken together, some kind of operating equipment acted as the heat source in almost one-half of these fires. Unclassified hot or smoldering objects provided the heat source in seven percent of fires, but accounted for one-fifth of direct property damage, potentially because these fires had the potential to go undetected before ignition. Hot embers or ash also provided the heat source in seven percent of fires, but accounted for little property damage. Four percent of fires involved spontaneous combustion or chemical reaction, underscoring the importance of proper disposal and storage of material, such as greasy rags or other combustible materials.
Part 2. Fires in structures under major renovation
In the 2013 through 2017 period, local fire departments responded to an estimated average of 2,580 fires in structures under major renovation per year. These fires caused an average of eight civilian deaths, 52 civilian injuries, and $104 million in direct property damage annually. Only 1 percent of all reported structure fires were in structures under major renovation. While large fires typically make the news, for many of the fires in structures under major renovation, almost one-fifth (19 percent) were confined fires, as shown in the supporting tables report.

Recent trends in fires in structures under major renovation
After a sharp drop from 2008 to 2009, these fires fluctuated between 2,300 to 2,800 per year. Although there was a large increase in fires from 2016 to 2017, the 2017 estimate was still below that in 2008. See Figure 10.

Figure 10. Fires in Structures under Major Renovation, 2008–2017

Leading causes in structure fires under major renovation
The leading cause of fires in structures under major renovation in 2013 through 2017 was electrical distribution and lighting equipment; it accounted for nearly one-quarter of fires and the resulting direct property damage, as well as three in 10 injuries (Figure 11). Fifteen percent of fires were caused by heating equipment, but accounted for 21 percent of injuries. Fires that were intentionally set caused 12 percent of home fires. One in 10 fires were caused by cooking equipment, a significantly lower share than was the case with structures under construction. Fires that were caused by a torch, burner, or soldering iron accounted for one in 10 fires, but over one-fifth of direct property damage, while smoking materials were found to cause just 3 percent of fires, but 8 percent of injuries.

Figure 11. Fires in Structures under Major Renovation by Leading Cause, 2013–2017 Annual Averages
Timing of fires in structures under major renovation

As shown in Figure 12, there is little month to month variation in fires in structures under renovation. Although fires peaked in March and were somewhat higher in December and January, the share of cold weather fires is not as prevalent as that seen with structures under construction; this is potentially because there is less need for temporary heating equipment or other mechanized equipment in renovation projects. Civilian injuries were highest in January (11 percent) and February (15 percent), but this was not the case for other cold weather months, so it is unclear if this was just an anomaly in the data.

Figure 12. Fires in Structures under Major Renovation by Month
2013–2017 Annual Averages

As with structures under construction, the peak periods for fires in structures under major renovation were the hours between noon and 4 p.m. (21 percent of total) and between 4 p.m. and 8 p.m. (22 percent of total). There were also fewer fires between midnight and 4 a.m., but these fires caused disproportionate shares of direct property damage, as indicated in Figure 13.

Figure 13. Fires in Structures under Major Renovation by Time of Day, 2013–2017 Annual Averages

Leading items first ignited in structure fires under major renovation

Structural elements accounted for over one-third of items first ignited in structures under major renovation, including structural members or framing, exterior wall coverings or finishes, insulation within structural areas, and unclassified structural components. See Figure 14. Flammable or combustible liquids or gases were first ignited in 6 percent of fires, but these fires accounted for over one-third (35 percent) of injuries.

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Equipment involved in ignition

Electrical distribution and lighting equipment, principally wiring and related equipment, was involved in almost one-quarter of fires in structures undergoing major renovation and accounted for thirty percent of injuries, as well as one-quarter of direct property damage (Table 6, supporting tables). Heating equipment was involved in another 15 percent of fires. Most heating equipment injuries involved space heaters. Cooking equipment was involved in 10 percent of fires, substantially lower than was the case in structures under construction (22 percent). A torch, burner, or soldering iron was involved in 9 percent of fires, but these fires contributed to over one-fifth of the direct property damage caused by fires in structures under construction. No equipment was involved in one-fifth of fires.

Factor contributing to ignition

The leading factors contributing to the ignition of fires in structures under major renovation included electrical failures or malfunctions (20 percent) and heat sources too close to combustible materials (16 percent). The latter accounted for over one-quarter of injuries, as indicated in Figure 15. Abandoned or discarded materials or products were a factor in 10 percent of fires, underscoring again the importance of housekeeping efforts and proper storage of materials at work sites that could pose fire hazards. Cutting or welding too close to combustible materials accounted for 9 percent of fires, but 16 percent of direct property damage.
**Heat source**
Consistent with the involvement of electrical distribution and lighting equipment in structures under major renovation fires, arcing was the leading heat source in these fires, followed by a spark, ember, or flame from operating equipment, radiated or conducted heat from operating equipment, and unclassified heat from powered equipment. However, other leading heat sources indicate that fires at construction sites can be ignited by a variety of heat sources beside equipment, including hot or smoldering objects, hot embers or ash, spontaneous combustion or chemical reaction, and smoking materials, as shown in Figure 16.

**Hot slag starts fire in retail store**
A large retail store undergoing renovation lost $500,000 worth of its contents when hot slag from a welding operation on the roof dripped into the building and ignited combustibles below.

The single-story structure was 200 feet (61 meters) long and 300 feet (91 meters) wide. A wet-pipe sprinkler system had been installed.

The fire department received a call about the water flow alarm at 8:14 a.m. When they arrived four minutes later, they used a thermal imaging camera to find the fire, which sprinklers had confined to several boxes stored on the top shelf in a rear storage area.

Investigators discovered that the construction crew had earlier spotted a fire on the roof and extinguished it with snow. They were unaware until the sprinklers activated and alarm sounded that hot slag had started a fire beneath their work area.

Damage to the building was minimal. There were no injuries.


**Discussion**
On average, firefighters responded to just over 10 fires in structures under construction and seven fires in structures undergoing major renovation each day between 2013 and 2017. Fires at such construction sites are a longstanding problem, but their major causes are generally well-established—a good indication that they can be prevented through greater attention to fire hazards.
Consider that the most common causes of construction and renovation fires in the most recent five-year period, as well as historically, involve electrical distribution and lighting equipment, heating equipment, cooking equipment, a torch, burner, or soldering iron, or an intentional cause. For each of these, safety protocols are available to reduce the risk of fire.

These include:

- Ensuring that temporary electrical service lighting follows installation requirements set forth in the National Electrical Code®, that electrical equipment is maintained and regularly inspected, that use of extension wiring is kept to a minimum, and that machinery and equipment do not overload available circuits.
- Prohibiting the use of temporary cooking equipment (such as hot plates or grills) or the use of improvised heating devices for warming food at the construction site.
- Ensuring that unauthorized temporary heaters are restricted from the worksite, that heaters permitted on the worksite are placed at safe distances from combustible and flammable materials and used in conformity with manufacture instructions, and that heaters are regularly checked to ensure that they are being safely operated and do not constitute a hazard (such as being overturned).
- Requiring a permit system for hot work activities and enforcing a thirty-minute (or longer) cool-down interval following use of torches, burners, or soldering irons.
- Reducing the risk of arson by safeguarding construction sites with fencing or other controls, such as lighting or after-hours security personnel, as needed.

Guidance for preventing fires at structures under construction or undergoing renovation is available in NFPA 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations.

Acknowledgments

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