



**RESEARCH**

# US Experience with Sprinklers

Marty Ahrens  
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## KEY FINDINGS

### Sprinklers in Reported Structure Fires: All Occupancies

From 2015 to 2019, local fire departments responded to an estimated average of 51,000 structure fires per year (10 percent) in which sprinklers were present. These fires caused an average of 36 civilian deaths (1 percent) and \$1 billion in direct property damage (9 percent) annually.

Sprinklers reduce the impact of fires. Compared to reported fires in properties with no automatic extinguishing systems (AES), when sprinklers were present, the civilian fire death and injury rates per fire were 89 percent and 27 percent lower, respectively. The rate of firefighter injuries per fire was 60 percent lower.

Fire spread was confined to the object or room of origin in 95 percent of reported structure fires in which sprinkler systems were present compared to 71 percent in properties with no AES.

Sprinklers have proven to be reliable in reported structure fires considered large enough to activate them. From 2015 to 2019, sprinklers operated in 92 percent of such fires and were effective at controlling the fire in 96 percent of the incidents in which they operated. Overall, sprinkler systems operated and were effective in 88 percent of the fires considered large enough to activate them.

The most common reason that sprinklers failed to operate was the system being shut off at some point before the fire.

One sprinkler is usually enough to control a fire. In 77 percent of the structure fires where sprinklers operated, only one operated. In 97 percent, five or fewer operated. In 99 percent, 10 or fewer operated.

### Sprinklers in Reported Home Fires

Sprinklers were present in an estimated average of 23,600 of the reported home<sup>1</sup> structure fires per year in 2015–2019, resulting in an average of 23 civilian deaths, 555 civilian injuries, and \$194 million in direct property damage annually.

The 7 percent of reported home structure fires that occurred in properties with sprinklers accounted for 1 percent of home fire deaths, 5 percent of home fire injuries, and 3 percent of home property loss.

Sprinklers operated in 95 percent of the home fires in which the systems were present and the fires were considered large enough to activate them. They were effective at controlling the fire in 97 percent of the fires in which they operated. Taken together, sprinklers operated effectively in 92 percent of the fires large enough to trigger them.

In 89 percent of the home fires with operating sprinklers, only one operated. In 99.5 percent, five or fewer operated.

Sprinklers save lives and reduce injuries and property loss. From 2015 to 2019, the civilian death and injury rates per reported home fire were 88 and 28 percent lower, respectively, and average property loss per home fire was 62 percent lower in reported home fires in which sprinklers were present compared to fires in homes with no AES.

The rate of firefighter injuries per home fire in which sprinklers were present was 78 percent lower than in homes with no AES.

In reported home fires in which sprinklers were present, the fire was confined to the object or room of origin 97 percent of the time compared to 74 percent in homes with no AES.

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<sup>1</sup> The term *home* includes one- and two-family homes, including manufactured housing and apartments or other multifamily homes.

## INTRODUCTION

This report provides a statistical overview of sprinkler presence and performance in reported fires. This information is essential for understanding the prevalence, impact, reliability, and effectiveness of these systems and increasing their positive impact. Because the majority of fire deaths are caused by home fires, additional details are provided on sprinklers in fires in these properties.

Estimates were derived from the details collected by the US Fire Administration's (USFA's) [National Fire Incident Reporting System \(NFIRS\)](#) and NFPA's annual fire department experience survey.

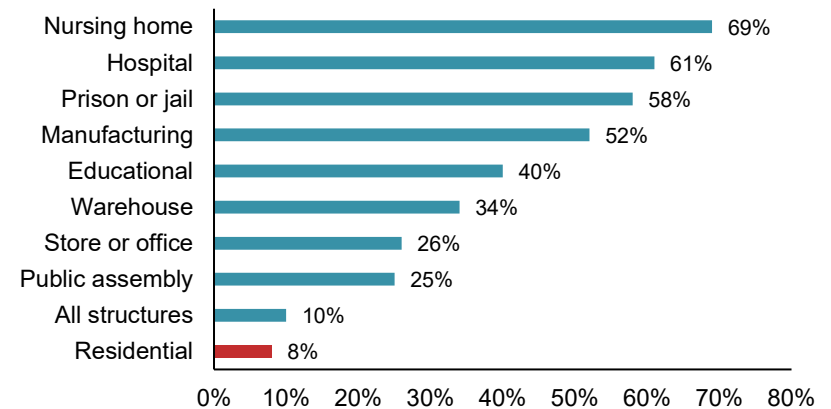
Unless otherwise specified, estimates and rates in this report exclude fires in properties under construction. In addition, the casualty and loss estimates can be heavily influenced by the inclusion or exclusion of one unusually serious fire.

More detailed information is available in the [supporting tables](#).

## Sprinkler Presence and Type

Some type of sprinkler was present in an estimated average of 51,000 (10 percent) of the reported structure fires during 2015–2019. Sprinkler presence varied widely by occupancy. Figure 1 shows the percentage of fires by occupancy in which any type of sprinkler was present. Sprinklers were most likely to be found in institutional occupancies, such as nursing homes, hospitals, and prisons or jails. Although the majority of the structure fires and associated civilian fire deaths, injuries, and direct property damage occurred in residential properties, particularly homes, only 8 percent of the reported residential fires occurred in properties with sprinklers. High-rise buildings are more tightly regulated and much more likely to have sprinklers than shorter structures.<sup>1</sup>

Figure 1. Presence of sprinklers in US structure fires by occupancy: 2015–2019



Some properties have both sprinkler and non-sprinkler AES. This is particularly likely in commercial kitchens. In such cases, only the AES type in the fire area would be recorded. This could result in underestimates of the presence of sprinklers in some occupancies.

Table A summarizes information about the various types of automatic extinguishing systems (AES) present in all the reported structure fires *except those in buildings under construction*. Figure 2 shows that wet pipe systems were in use at almost nine out of every 10 reported fires in which sprinklers were present.

Figure 2. Types of sprinklers present at US structure fires: 2015–2019

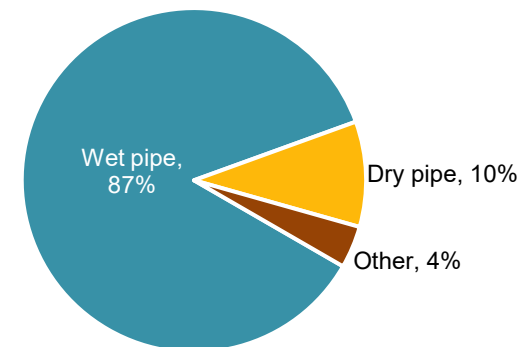
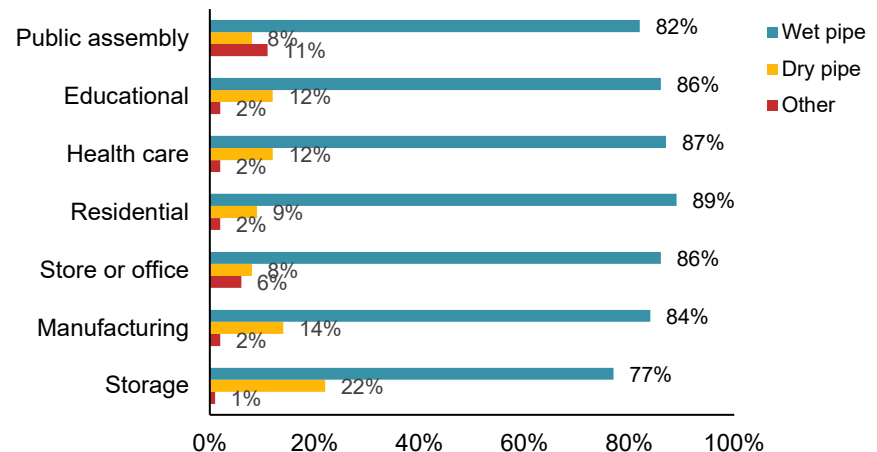


Table A. Summary of AES presence and type in reported structure fires: 2015–2019 annual averages

AES Presence and Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
<b>AES present</b>	<b>61,100</b>	<b>(13%)</b>	<b>37</b>	<b>(1%)</b>	<b>1,130</b>	<b>(9%)</b>	<b>\$1,086</b>	<b>(10%)</b>
Sprinkler system present	51,000	(10%)	36	(1%)	1,020	(8%)	\$1,008	(9%)
<i>Wet pipe sprinkler system</i>	44,200	(9%)	33	(1%)	919	(7%)	\$908	(9%)
<i>Dry pipe sprinkler system</i>	5,000	(1%)	2	(0%)	87	(1%)	\$88	(1%)
<i>Other type of sprinkler system</i>	1,800	(0%)	1	(0%)	14	(0%)	\$12	(0%)
Non-sprinkler AES present	10,100	(2%)	1	(0%)	111	(1%)	\$78	(1%)
<b>Partial AES system of any type present</b>	<b>2,500</b>	<b>(1%)</b>	<b>6</b>	<b>(0%)</b>	<b>54</b>	<b>(0%)</b>	<b>\$109</b>	<b>(1%)</b>
<b>AES of any type not in fire area and did not operate</b>	<b>1,700</b>	<b>(0%)</b>	<b>2</b>	<b>(0%)</b>	<b>55</b>	<b>(0%)</b>	<b>\$56</b>	<b>(1%)</b>
<b>No AES present</b>	<b>423,200</b>	<b>(87%)</b>	<b>2,816</b>	<b>(98%)</b>	<b>11,609</b>	<b>(90%)</b>	<b>\$9,387</b>	<b>(88%)</b>
<b>Total</b>	<b>488,500</b>	<b>(100%)</b>	<b>2,862</b>	<b>(100%)</b>	<b>12,848</b>	<b>(100%)</b>	<b>\$10,637</b>	<b>(100%)</b>

Figure 3 shows that dry pipe sprinkler systems were more common in storage occupancies. Table 2 in the [supporting tables](#) shows that other types of sprinkler systems were seen most frequently in eating and drinking establishments and grocery or convenience stores. It is possible that some of these other types were miscodes of systems designed specifically for cooking equipment.

Figure 3. Sprinkler system type by occupancy: 2015–2019



## Fires in Properties with Sprinklers vs. with No AES

Figure 4 shows that the death rate per 1,000 reported fires was 89 percent lower in properties with sprinklers than in properties with no AES. These rates are based strictly on the reported presence or absence of this equipment; whether or not the system operated was not considered. Civilian deaths in sprinklered properties are discussed in greater detail later in this report.

**Figure 4. Civilian death rates per 1,000 reported fires in properties with sprinklers and with no AES 2015–2019**

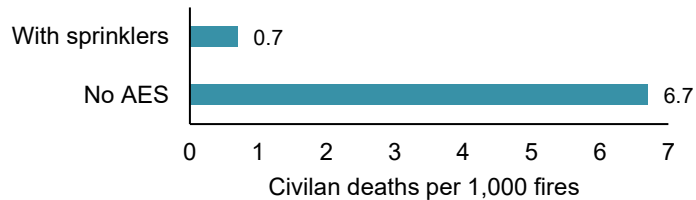


Figure 5 shows that the civilian injury rate per 1,000 reported fires was 27 percent lower in properties with sprinklers than in properties with no AES. Many of the injuries occurred in fires that were too small to activate the sprinklers. In others, someone was injured while trying to fight the fire in the initial moments before the sprinklers operated.

**Figure 5. Civilian injury rates per 1,000 reported fires in properties with sprinklers vs. with no AES: 2015–2019**

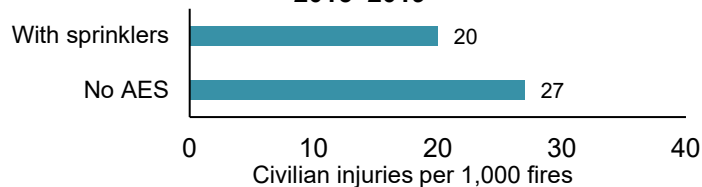
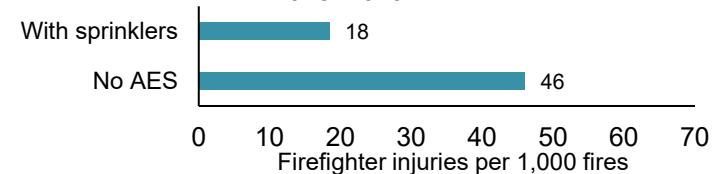


Figure 6 shows that the rate of firefighter injuries per 1,000 fires was 60 percent lower in structure fires with sprinklers compared to fires in properties without AES protection. Sprinklers begin to control a fire when

they activate, making the situation less dangerous for responding firefighters.

**Figure 6. Firefighter injury rates per 1,000 fires in properties with sprinklers vs. with no AES: 2015–2019**

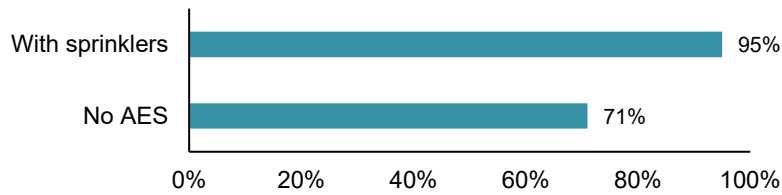


Reductions in the average dollar loss per fire when sprinklers were present varied greatly by occupancy. Table 4 in the [supporting tables](#) shows that compared to properties with no AES, the average overall loss was 11 percent lower in fires where sprinklers were present. The percentage reductions were highest in health care occupancies (73 percent), stores or offices (70 percent), public assembly occupancies (63 percent), and homes (62 percent).

The average loss per fire was higher in sprinklered warehouses and manufacturing properties than in those with no AES. Warehouse contents or expensive machinery may be rendered worthless by smoke alone. A very small fire can damage expensive manufacturing equipment. In the rare cases in which a sprinkler system fails to operate or operates ineffectively, the monetary loss can be exceedingly high, increasing the average loss for the occupancy type. For example, the average loss in sprinklered manufacturing properties was inflated by a \$1.1 billion loss caused by a November 2019 Texas petrochemical plant explosion and the resulting multi-day fire and additional explosions.<sup>2</sup> The plant's wet pipe sprinkler system did not operate.

Sprinklers limit fire spread. Figure 7 shows a 24 percent increase in fires that were confined to the object or room of origin when sprinklers were present compared to fires with no AES.

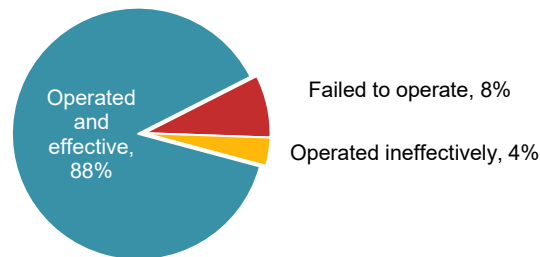
**Figure 7. Percent of fires confined to object or room of origin in properties with sprinklers vs. with no AES: 2015–2019**



### Sprinkler Operation, Effectiveness, and Issues

From 2015 to 2019, sprinklers operated in 92 percent of the fires in which they were present and the fire was considered large enough to activate them.<sup>i</sup> They were effective at controlling the fire in 96 percent of the fires in which they operated. Taken together, sprinklers operated effectively in 88 percent of the fires large enough to trigger them. (See Figure 8.) Details on sprinkler operation and effectiveness in different occupancies and for wet and dry pipe systems are provided in Table 6 of the [supporting tables](#).

**Figure 8. Sprinkler operation and effectiveness: 2015–2019**

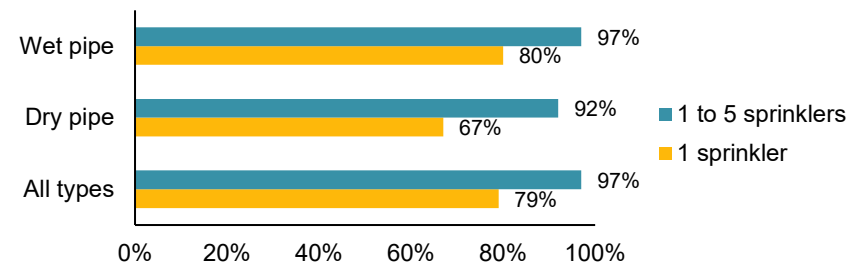


<sup>i</sup> These calculations exclude fires with confined structure fire incident types (NFIRS incident types 113–118). Among confined fires in which sprinklers were present, the fire was too small to activate the sprinklers 71 percent of the time, the sprinklers operated and were effective 14 percent of the time, and the sprinklers failed to operate 4 percent of the time. Since these fires are, by definition, confined, it is likely that a substantial share of the fires in which the sprinklers were said to fail, were, in fact, too small to cause the sprinkler to operate. The 41 percent of non-confined fires (NFIRS incident types 110–123, except for 113–118) that were too small to activate the sprinklers and the less than 1 percent of the non-confined structure fires in which sprinkler operation was unclassified were also excluded.

<sup>ii</sup> Fires with NFIRS confined fire incident types were included in these calculations.

Sprinkler systems are designed to operate only where fire is present. Just one sprinkler activated in more than three-quarters (77 percent) of the fires in which sprinklers of any type operated and four out of five (80 percent) fires with operating wet pipe sprinkler systems. Figure 9 shows that in 97 percent of the fires in which sprinklers operated, five or fewer were activated. This was true for 92 percent of the dry pipe sprinkler systems.<sup>ii</sup> In 99 percent of the fires with operating sprinklers of any type, 10 or fewer sprinklers operated.

**Figure 9. When sprinklers operated, percentage of fires in which one or one to five sprinklers operated by type of sprinkler system: 2015–2019**



The following incident descriptions illustrate the effectiveness of sprinklers:

- Around 2:30 a.m., an alarm monitoring company alerted the local fire department to a system activation at a department store in a North Dakota mall.<sup>3</sup> Arriving firefighters initially saw no signs of fire or operating sprinklers. A store representative led them to a separate area where water was coming from under a closed office door. An electronic device left to charge overnight had overheated and started a small fire on the desk that spread to a chair. A single sprinkler extinguished the fire.

- An intentional fire set along an exterior wall of a California nonprofit organization’s storage facility spread inside.<sup>4</sup> The fire department was notified around 4:20 a.m. Two sprinklers controlled the inside fire and firefighters completed extinguishment. In the report, the investigator noted that the building would likely have been a total loss without the working sprinklers.
- A sprinkler at an Illinois fitness center controlled a dryer fire.<sup>5</sup> Responding firefighters used a pump can to extinguish the remaining fire inside the dryer. The maintenance worker who discovered the fire had attempted to put the fire out with an extinguisher. He was transported to the hospital for treatment of moderate smoke inhalation.

In 98 percent of the fires in which one sprinkler operated, it was effective. Figure 10 shows that sprinklers were somewhat less likely to have operated effectively when more sprinklers operated.

**Figure 10. Percentage of fires in which sprinklers were effective by number that operated: 2015–2019**

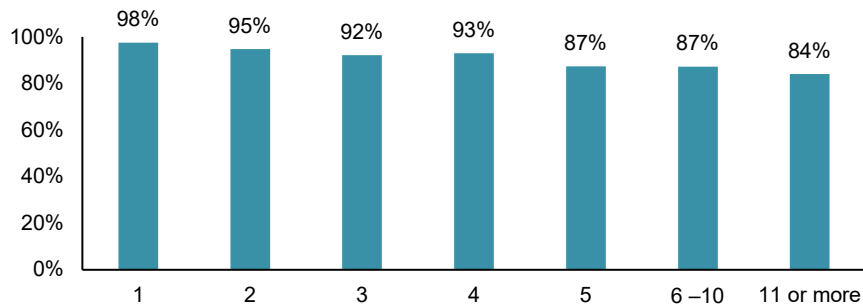


Figure 11 shows that in nearly three out of every five incidents in which sprinklers failed to operate, the system had been shut off.

- An October 2018 West Virginia warehouse fire in which the sprinklers had been shut off caused \$10 million in property damage.<sup>6</sup> The warehouse contained plastic goods and recycled plastic.

**Figure 11. Reasons for sprinkler failure: 2015–2019**

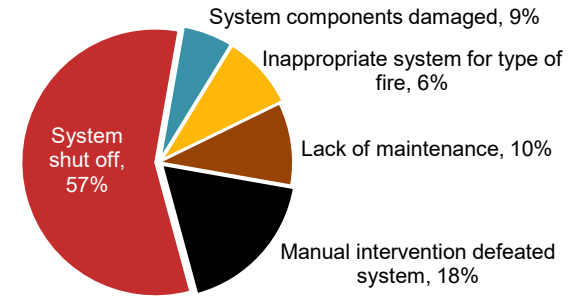
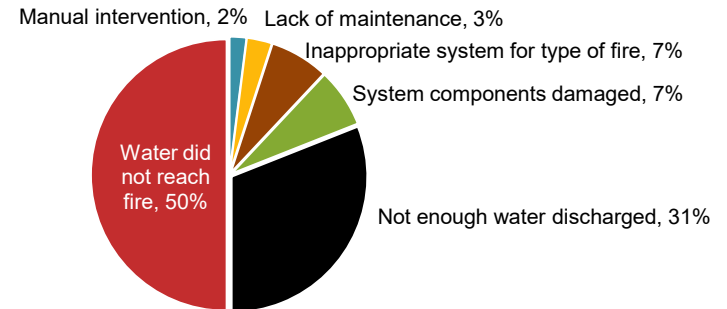


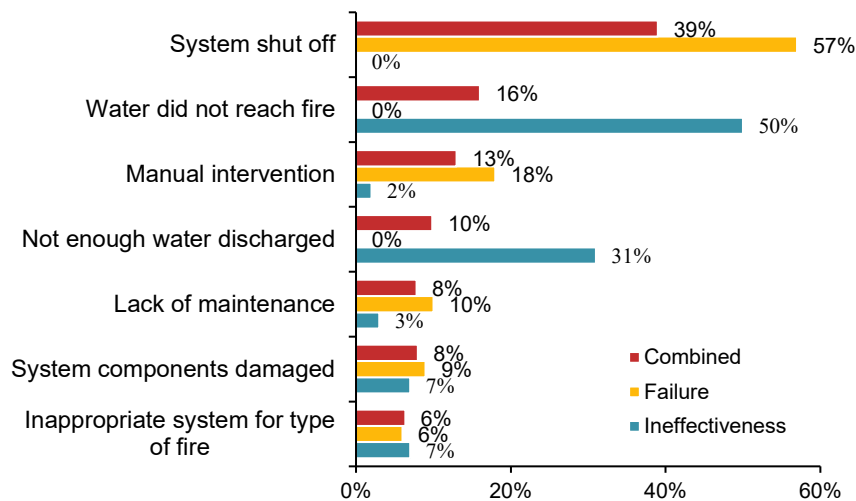
Figure 12 shows that in eight out of every 10 fires in which sprinkler systems operated ineffectively, the problem involved getting water to the fire. In half of the fires in which sprinklers were ineffective, the water did not reach the fire. In nearly one-third of the fires, not enough water was discharged.

**Figure 12. Reasons for sprinkler ineffectiveness: 2015–2019**



In 2015–2019, reported sprinkler failures (750 per year) were more than twice as common as reported fires in which sprinklers were ineffective (340 per year). Figure 13 shows the breakdown of each cause of failure or ineffectiveness individually and combined. For example, manual intervention was blamed for 13 percent of the total situations in which sprinklers were either ineffective or failed to operate at all. As noted earlier, manual intervention was blamed for 18 percent of the fires in which sprinklers failed to operate and 2 percent of the fires in which they were ineffective.

**Figure 13. Reasons for combined sprinkler failure and ineffectiveness: 2015–2019**



The categories in Figures 11–13 are based on NFIRS and sometimes overlap.

Long, Wu, and Blum explored the root causes of unsatisfactory sprinkler performance, dividing them into the following broad categories:<sup>7</sup>

- “Failure to maintain operational status of the system.” Regular inspection, testing, and maintenance are essential to ensure sprinkler operability. Water being shut off before or during a fire is included in this category.

- “Failure to assure adequacy of the system and/or for the complete coverage of current hazard.” Problems with the initial plans, installation errors, and changes to the structure or its contents could be captured here.
- “Defects affecting, but not involving, the sprinkler system.” This includes water supply problems and building construction issues.
- “Inadequate performance by the sprinkler itself.” Sprinkler systems have numerous components. A failure of one component can impact the larger system.
- All other situations, including fires that started on the structure’s exterior, delays in notifying the fire department, etc.

### Civilian Deaths in Sprinklered Properties

While sprinklers were present in 10 percent of all the properties in which fires occurred in 2015–2019, only 1 percent of all the fire deaths occurred in these properties. Fires in sprinklered properties killed an average of 36 people per year in 2015–2019. Fires in properties that were not under construction and had no automatic extinguishing systems caused an average of 2,816 civilian deaths per year.

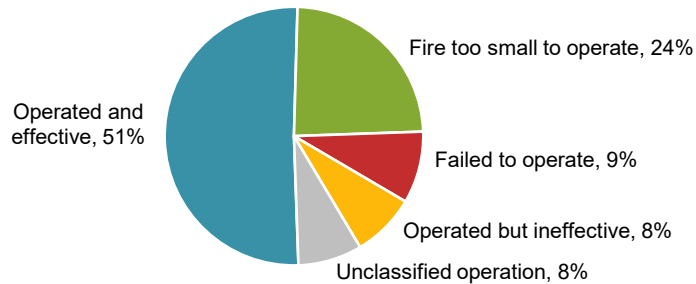
In fires that were large enough to activate sprinklers, 21, or 87 percent, of the fatalities per year resulted from fires in which the sprinklers operated. Of those who died in fires with operating sprinklers, 18, or 86 percent, died in fires in which the sprinklers operated effectively. Taken together, 18, or three-quarters (75 percent), of the 24 victims of fires large enough to activate sprinklers per year were fatally injured in fires in which the sprinklers operated and were effective.

Figure 14 shows that nine, or one-quarter, of the 36 victims per year of fires in sprinklered properties were fatally injured in fires that never became large enough to activate the sprinklers. In other cases, the sprinklers extinguished the fire. Victims in fires with sprinklers were typically fatally injured before the sprinklers activated. In both situations, the victims were usually intimate with the ignition. In some cases, the victim had been smoking in bed or while using medical oxygen. The



victim's clothing may have caught fire while the victim was cooking or smoking.

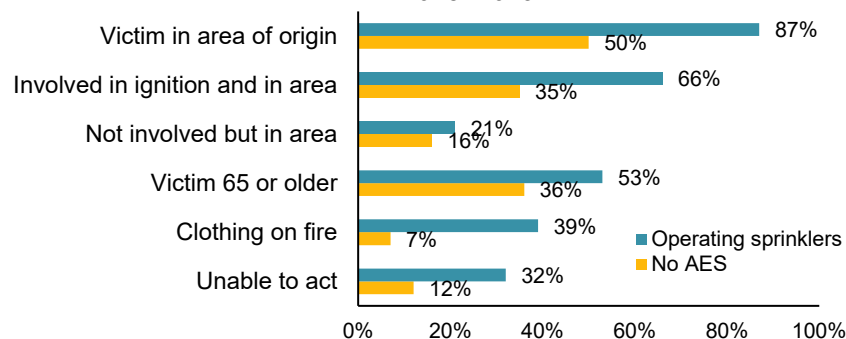
**Figure 14. Civilian fire deaths by sprinkler performance: 2015–2019**



- In 2015, a resident of a 7-story North Carolina apartment building was fatally injured when he lit a cigarette while using medical oxygen. The living room sprinkler extinguished his burning clothes and chair.<sup>8</sup>

Compared to victims of fires in which no AES was present, people who died in fires in which sprinklers operated were more likely to have been in the area of origin, been at least 65 or older, been wearing clothing that caught fire, or been unable to act, and even more likely to have been involved in the ignition and in the area. Figure 15 shows this contrast. Note that many of these differences are also evident among victims of fires with and without working smoke alarms.<sup>9</sup>

**Figure 15. Victim characteristics in fires with operating sprinklers vs. with no AES: 2015–2019**



There are limits to even the best fire protection. When someone is directly involved in the ignition of a fire or their clothing is burning, they may be fatally injured before the sprinkler system operates. If someone is physically incapable of getting themselves to safety, even a fire controlled by sprinklers can still cause harm.

Three-quarters (76 percent) of the fire deaths in sprinklered properties resulted from fires that were confined to the object or room of origin. This was true for only 18 percent of the deaths from fires in which no AES was present. When present, sprinklers keep the fire from spreading and threatening those in other areas. A fire that is confined to the room of origin is much less dangerous to those outside the room.

Multiple death fires are rare when sprinklers are present. However, as mentioned earlier, exterior fires can challenge sprinkler protection. In addition, explosions can damage a sprinkler system, rendering it ineffective or non-functional.

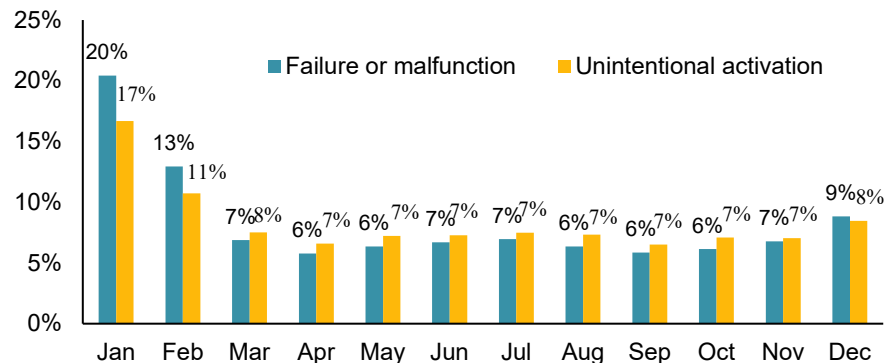
Two fires in 2015–2019 in which sprinklers were present resulted in four deaths each.

- Around 2:00 a.m. one morning in March 2017, a fire department was alerted to a fire at a Maryland assisted living facility of unprotected wood-frame construction.<sup>10</sup> One employee and six adult residents were in the structure at the time of the fire. All the residents required assistance to evacuate. A discarded cigarette had ignited leaves and grass outside the building. The flames spread to the exterior wall, porch, and into the confined ceiling space. Both detection and activation of the residential wet pipe sprinkler system were delayed because the fire was in the concealed space. Once activated, the sprinkler system controlled the fire. In addition to the four fatalities, three civilians were also injured.
- Around 9:30 p.m. on a May 2019 evening, an Illinois fire department was notified of an explosion and fire at a silicone manufacturing plant.<sup>11</sup> The plant was operating at the time. The explosion damaged both the detection and sprinkler systems, so they did not operate.

## Unwanted Activations

Fire departments responded to an estimated average of 26,000 sprinkler activations caused by a system failure or malfunction per year and 29,700 unintentional sprinkler activations per year in 2015–2019. According to the *NFIRS 5.0 Complete Reference Guide*,<sup>12</sup> false alarms due to sprinkler failures or malfunctions include “any failure of sprinkler equipment that leads to sprinkler activation with no fire present.” This category “excludes unintentional operating caused by damage to the sprinkler system.” Unintentional activations also include “testing the sprinkler system without fire department notification.” The winter months of December, January, and February account for only one-quarter of the year yet Figure 16 shows that 42 percent of the sprinkler system failures or malfunctions occurred in these three months, as did 36 percent of the unintentional activations. This suggests that cold weather and frozen pipes played a role.

**Figure 16. Unwanted sprinkler activations by type and month: 2015–2019**



Not all activations result in water flow outside the system. For example, water may flow in the pipes of a dry pipe system. This could alert a monitoring company and trigger a fire department response.

In their 2012 article on investigating inadvertent fire sprinkler discharges,<sup>13</sup> Blum, Long, and Dillon referred to Russ Fleming’s 2000 description of the six primary reasons for non-fire discharges from

sprinklers: overheating, freezing, mechanical damage, corrosion, deliberate sabotage, and mechanical defects.

Overheating can be caused by nearby equipment that may have been added after a sprinkler system was installed. While overheating typically affects the sprinkler and not the piping, freezing can impact the pipes. Mechanical damage can occur when a sprinkler is bumped by something such as a ladder, forklift, or tossed objects. Deliberate sabotage includes vandalism and disabling sprinklers to increase fire damage. While rare, manufacturing defects can also occur.

In a 2017 article, Huet, Martorano, and Ames described experiments involving intentional damage simulating random microscopic flaws to more than 100 glass bulb sprinklers. These were then exposed to a constant load in a test frame.<sup>14</sup> Forty-four of the sprinklers failed within 36 days, while the remaining 58 lasted more than two years. They concluded that unwanted activations due to damaged sprinkler bulbs tended to occur within days or weeks of the damage. Such damage, if undetected, could explain unwanted activations with no identifiable cause.

## Sprinklers in Home Fires

### Sprinkler Presence and Type

During 2015–2019, some type of fire sprinkler was present in an estimated average of 23,600 reported home structure fires (7 percent) per year. Properties under construction were excluded from these estimates. Table B summarizes information about automatic extinguishing systems (AES), including sprinklers, in all reported home structure fires except those under construction. According to the 2011 American Housing Survey, buildings with more housing units were more likely to have sprinklers. Figure 17 shows that 5 percent of housing units that are occupied year-round had sprinklers, ranging from a low of 1 percent in manufactured homes to a high of 31 percent in buildings with at least 50 units.<sup>15</sup>

**Figure 17. Percentage of occupied units with sprinklers per the 2011 American Housing Survey**

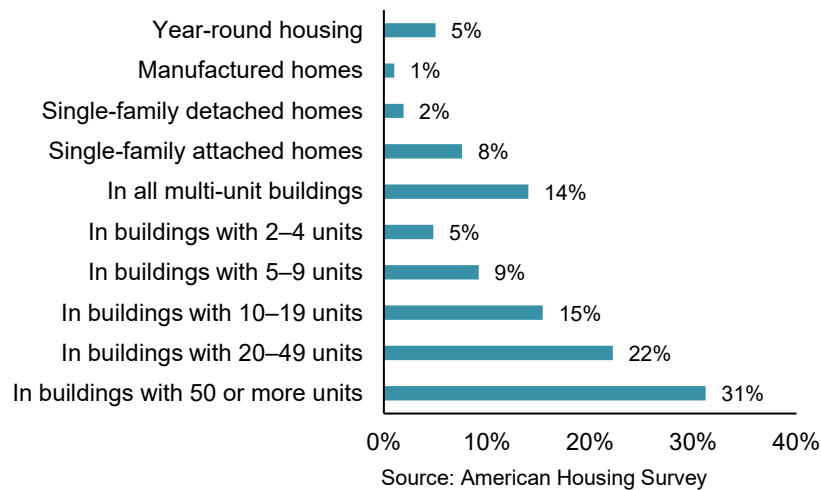
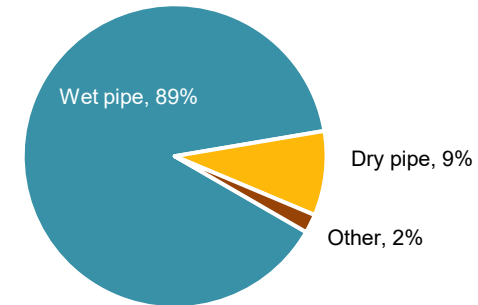


Figure 18 shows that wet pipe sprinkler systems were present in nine out of every 10 reported home fires with sprinklers.

**Figure 18. Types of sprinkler systems present at home structure fires: 2015–2019**



**Table B. Summary of AES presence and type in reported home structure fires, excluding properties under construction: 2015–2019 annual averages**

AES Presence and Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)
<b>AES present</b>	<b>25,000</b>	<b>(7%)</b>	<b>24</b>	<b>(1%)</b>	<b>593</b>	<b>(5%)</b>	<b>\$197</b>	<b>(3%)</b>
Sprinklers present	23,600	(7%)	23	(1%)	555	(5%)	\$194	(3%)
<i>Wet pipe sprinkler system</i>	21,000	(6%)	22	(1%)	477	(4%)	\$185	(3%)
<i>Dry pipe sprinkler system</i>	2,100	(1%)	1	(0%)	69	(1%)	\$8	(0%)
<i>Other type of sprinkler system</i>	500	(0%)	0	(0%)	9	(0%)	\$1	(0%)
Non-sprinkler AES present	1,400	(0%)	1	(0%)	38	(0%)	\$3	(0%)
Partial system AES present	900	(0%)	5	(0%)	40	(0%)	\$25	(0%)
AES not in fire area and did not operate	500	(0%)	0	(0%)	28	(0%)	\$24	(0%)
<b>None present</b>	<b>318,500</b>	<b>(92%)</b>	<b>2,587</b>	<b>(99%)</b>	<b>10,408</b>	<b>(94%)</b>	<b>\$6,907</b>	<b>(97%)</b>
<b>Total</b>	<b>344,900</b>	<b>(100%)</b>	<b>2,616</b>	<b>(100%)</b>	<b>11,036</b>	<b>(100%)</b>	<b>\$7,153</b>	<b>(100%)</b>

## Fires in Homes with Sprinklers vs. with No AES

Figure 19 shows that the civilian death rate per 1,000 reported fires was 88 percent lower in homes with sprinklers than in homes with no AES during 2015–2019. These rates are based only on the reported presence or absence of an AES; operation was not considered.

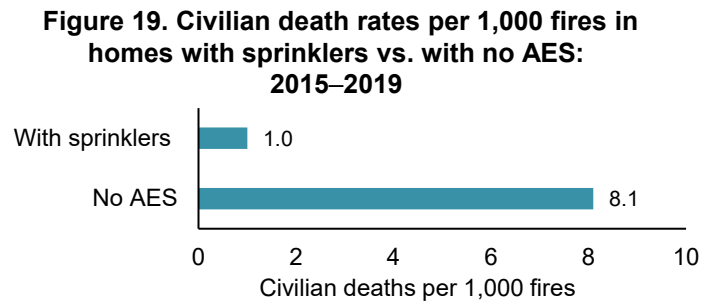


Figure 20 shows that the civilian injury rate per 1,000 reported fires was 28 percent lower in homes with sprinklers than in homes with no AES. In many cases, the injuries occurred in fires that were too small to activate the sprinkler system. In others, someone was injured while trying to fight the fire in the initial moments before the sprinklers operated. A 2012 Fire Protection Research Foundation study found that sprinkler presence was associated with a 53 percent reduction in the medical cost of civilian injuries per 100 home fires.<sup>16</sup>

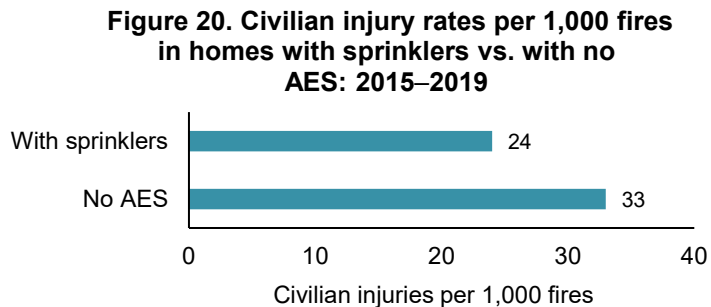
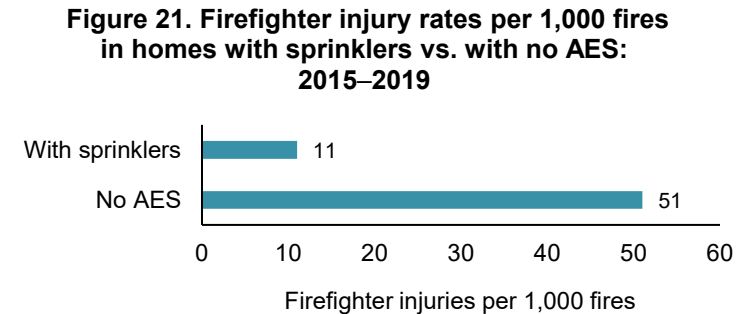


Figure 21 shows that the average firefighter fireground injury rate per 1,000 reported home fires was 78 percent lower when sprinklers were present than in fires with no AES.



When sprinklers were present in reported home fires, the average property loss per fire was 62 percent lower than the average in homes with no AES. See Figure 22.

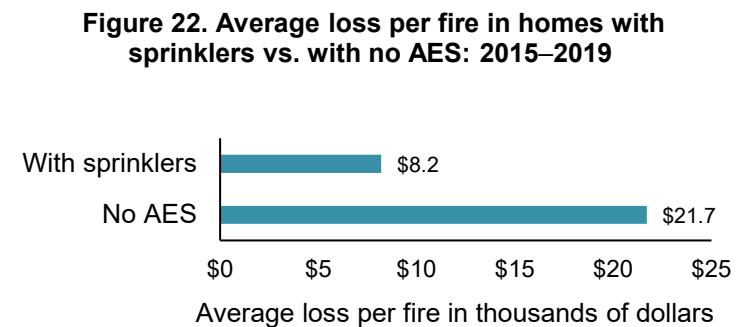
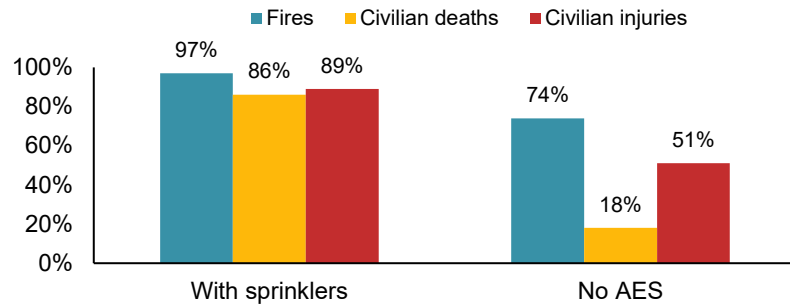


Figure 23 shows that when sprinklers were present, almost all of the fires were confined to the object or room of origin. The majority of civilian deaths and injuries resulting from fires in homes with sprinklers were caused by these fires. In home fires that lacked AES, only three-quarters of the fires were confined to the object or room of origin. Only one in five deaths and half of the injuries in home fires with no AES present resulted from such fires.

**Figure 23. Percent of home fires, injuries, and casualties resulting from fires confined to object or room of origin: 2015–2019**



In rare cases, sprinklers may contain or even extinguish fires that cause fatal injuries. These injuries can occur *before* the fire’s heat reaches a sprinkler. In some situations, the victim might be unable to move out of harm’s way.

- An alarm monitoring company notified a fire department of a fire in a 12-story New York apartment building. By the time firefighters arrived, a wet pipe sprinkler system had operated and extinguished most of the fire in a third-floor apartment. A bed in the living room had been ignited by smoking materials. A male resident with a mobility impairment was severely burned and died at the hospital.<sup>17</sup>

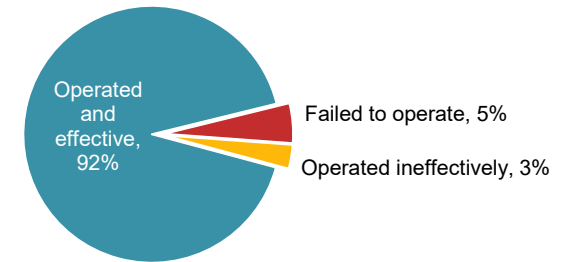
### Sprinkler Operation, Effectiveness, and Issues in Home Fires

Figure 24 shows that sprinklers operated in 95 percent of the home fires in which sprinklers were present and the fires were considered large enough to activate them.<sup>i</sup> They were effective at controlling the fire in 97 percent of the fires in which they operated. Taken together, sprinklers

<sup>i</sup> These calculations exclude fires with confined structure fire incident types (NFIRS incident types 113–118). Among confined fires in which sprinklers were present, the fire was too small to activate the sprinklers 69 percent of the time, the sprinklers operated and were effective in 27 percent of total fires with sprinklers (and in 99 percent of the fires in which sprinklers operated), and the sprinklers failed to operate 3 percent of the time. Since these fires are, by definition, confined, it is likely that a substantial share of the fires in which the sprinklers were said to fail, were, in fact, too small to cause the sprinkler to operate. The 34 percent of non-confined fires (NFIRS incident types 110–123, except for 113–118) that were too small to activate the sprinklers and the 1 percent of non-confined structure fires in which sprinkler operation was unclassified were also excluded.

operated effectively in 92 percent of the fires large enough to trigger them.

**Figure 24. Sprinkler operation and effectiveness in home fires: 2015–2019**



Sprinklers protect occupants and property in many circumstances. Sometimes, no one is home or everyone has safely evacuated. Operating sprinklers can also protect a building and its occupants from incendiary fires. Fires that start on the exterior of a building can be particularly challenging, as they can enter into concealed spaces and spread before smoke alarms sound to alert occupants. Sprinkler protection for balconies can limit the damage from these fires. The following are several examples of such scenarios:

- One sprinkler operated to extinguish a grease fire that spread to the overhead cabinets in the kitchen of a second-floor Arizona apartment. The resident had gone outside while cooking and learned of the fire when an outdoor sprinkler alarm sounded. Another building resident called 911 to report the sprinkler activation and burning odor.<sup>18</sup>
- A dry pipe sprinkler system extinguished a fire in a second-floor unit in a three-story university apartment building in Colorado. A candle had been left burning unattended when the occupant left the unit. A

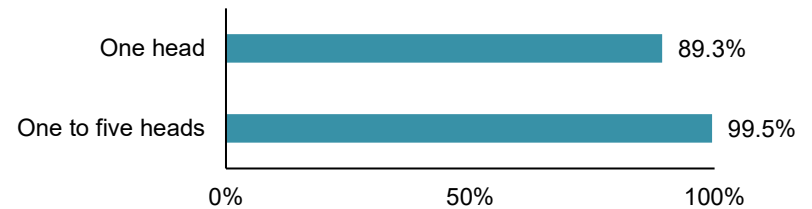
drape on an open window ignited when it was blown over the candle. The fire spread to the window blinds and papers on the desk before it was extinguished.<sup>19</sup>

- While firefighters were responding to a late afternoon fire alarm with smoke reported on the second floor of a four-story Oregon apartment building, they were informed that residents on the second and fourth floors had mobility impairments and would need help to evacuate. After they arrived, they found that the sprinkler system had extinguished an incendiary fire in a second-floor laundry room.<sup>20</sup>
- A 24-unit Texas apartment building was protected by a wet pipe sprinkler system installed under the provisions of NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*. Discarded smoking materials ignited a plastic container on a third-floor balcony. The fire spread to an outdoor couch and upward and sideways on the balcony until a sidewall sprinkler activated and contained the fire. Firefighters completed extinguishment when they arrived. The exterior fire did not activate smoke alarms inside the building.<sup>21</sup>

As in structure fires overall, when home sprinklers failed to operate, it was usually because the system had been shut off. This was true in a 2015 California single-family home fire that killed a young woman. The property's sprinkler system, installed to the requirements of NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, had been shut off at some point before the fire.<sup>22</sup>

Figure 25 shows that in nearly all the home fires in which operating sprinklers were present, five or fewer individual sprinklers operated.

**Figure 25. Percent of home fires with operating sprinklers in which one or one to five operated: 2015–2019**



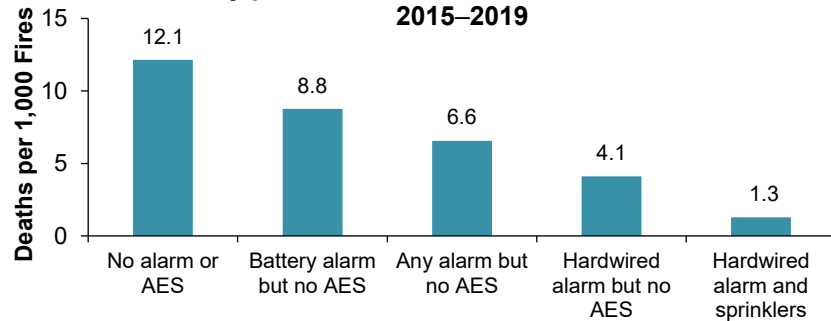
### Impact of Smoke Alarm and Sprinkler Presence on Death Rates per 1,000 Home Fires

The lowest home fire death rate per 1,000 reported fires was found in homes with sprinkler systems and hardwired smoke alarms.<sup>1</sup> Figure 26 shows that compared to reported home fires (*including* properties under construction) in which no smoke alarms or AES was present, the death rate per 1,000 reported fires was:

- 28 percent lower when battery-powered smoke alarms were present, but AES protection was not
- 46 percent lower when smoke alarms with any power source were present but AES protection was not
- 66 percent lower when hardwired smoke alarms were present but AES protection was not
- 89 percent lower when sprinklers and hardwired smoke alarms were present

<sup>1</sup> In this analysis, the term *smoke alarm* also includes smoke detectors that are part of a system.

**Figure 26. Average fire death rate per 1,000 reported home structure fires by presence of smoke alarms and AES: 2015–2019**



Note that these rates are based on the *presence* of various types of fire protection; operation was not considered. Minor fires in homes with monitored smoke alarms are more likely to result in a fire department response than comparable fires in homes with unmonitored smoke alarms. Smoke alarms in monitored systems are generally hardwired.

### Unwanted Activations

Fire departments responded to an estimated average of 4,700 non-fire activations of home fire sprinklers per year caused by a system failure or malfunction and 5,400 unintentional sprinkler activations per year in 2015–2019. According to the *NFIRS 5.0 Complete Reference Guide*<sup>23</sup>, sprinkler failures or malfunctions include “any failure of sprinkler equipment that leads to sprinkler activation with no fire present.” The category “excludes unintentional operating caused by damage to the sprinkler system,” which should be considered unintentional activations. Unintentional activations include “testing the sprinkler system without fire department notification.”

Forty-eight percent of the home sprinkler activations resulting from system failures or malfunctions and 38 percent of the unintentional home sprinkler activations occurred in the winter months of December, January, and February.

## Conclusions and Further Reading

Sprinklers are a very reliable and effective part of fire protection. Their impact is most visible in the reduction of civilian fire deaths per 1,000 reported fires when sprinklers are present compared to fires without AES. Notable reductions can also be seen in the injury rates, in most occupancies, in the average loss per fire. Increasing the use of sprinklers can reduce loss of life and property damage caused by fire.

NFPA standards provide essential guidance on the installation, inspection, testing, maintenance, and integration of sprinklers with other systems, as well as for evaluating needs when an occupancy changes use or contents. See the following standards for more information:

- NFPA 13, *Standard for the Installation of Sprinkler Systems*
- NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*
- NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. See NFPA 25 for minimum inspection, testing, and maintenance requirements for sprinkler systems.
- NFPA 4, *Standard for the Integrated Fire Protection and Life Safety Systems Testing*. See NFPA 4 for test protocols to ensure that the fire protection and life safety systems will function correctly together.
- NFPA 1, *Fire Code*. NFPA 1 includes evaluation requirements for assessing the adequacy of existing sprinkler systems if the use or contents of a space have changed.

Resources to help reduce the home fire death toll by increasing the number of new one- and two-family homes protected by sprinklers are available from the [NFPA Fire Sprinkler Initiative](#).

## Methodology

The statistics in this analysis are estimates derived from the US Fire Administration's (USFA's) [National Fire Incident Reporting System](#) (NFIRS) and the National Fire Protection Association (NFPA) annual survey of US fire departments. Fires reported to federal or state fire departments or industrial fire brigades are not included in these estimates. Unless otherwise specified, properties under construction were excluded from the analysis.

The NFPA fire department experience survey provides estimates of the big picture. NFIRS is a voluntary system through which participating fire departments report detailed factors about the fires to which they respond.

To compensate for fires reported to local fire departments but not captured in NFIRS, scaling ratios are calculated and then applied to the NFIRS database using the formula below:

$$\frac{\text{NFPA's fire experience survey projections}}{\text{NFIRS totals}}$$

NFPA also allocates unknown data proportionally to compensate for fires for which information was undetermined or not reported.

Fires in which partial sprinkler systems were present and fires in which sprinklers were present but failed to operate because they were not in the fire area were excluded from the estimates of presence and operation.

Fires with one of the six NFIRS confined fire incident types were included in estimates of sprinkler presence, fire spread, and sprinklers operating, but not of operation or effectiveness in general. Information on methodology is provided in more detail at the end of this report.

Confined structure fires in NFIRS 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). Losses are generally minimal in these fires, which, by definition, are assumed to have been limited to the object of origin. Although detailed data about detection is not required for these fires, it is sometimes available.

Raw NFIRS data for 2015–2019, excluding properties under construction, contained a total of 7,737 confined structure fires (1 percent of total confined fires) in which some type of AES was present and 34,919 confined structure fires (4 percent of total confined fires) in which none was present. AES presence was undetermined or left blank for 95 percent of the confined structure fires. A total of 4,355 confined fires with AES present indicated wet pipe, dry pipe, or other sprinklers were present. The AES type was undetermined or not reported in 2,338 confined fires with AES present. Sprinkler operation when present was known in a total of 92 percent (3,793) of the confined fires in which sprinklers were present. Sprinkler operation for confined fires was used to calculate the number of sprinklers that operated in fires in which sprinklers operated but not for overall estimates of operation or effectiveness.

The raw NFIRS data for 2015–2019 contained a total of 53,859 non-confined structure fires (NFIRS incident type 110–123, excluding incident types 113–118) in which AES presence was known. A total of 103 civilian deaths; 2,137 civilian injuries; and \$3.8 billion in direct property damage were associated with these fires. AES presence was known for 97 percent of the non-confined fires, 90 percent of the deaths, 95 percent of the injuries, and 99 percent of the direct property damage. The AES type was known in 67 percent of the non-confined fires, 80 percent of the deaths, 81 percent of the injuries, and 84 percent of the associated property loss when AES was present.

When sprinklers were present in non-confined structure fires, sprinkler operation was known for a five-year raw total of 27,151 fires associated with 57 deaths; 1,426 injuries; and \$2.6 billion in direct property damage. When present, sprinkler operation was known for 84 percent of the non-confined fires, 72 percent of the deaths, 89 percent of the injuries, and 89 percent of the direct property damage. (“Operation of AES, other” was considered unknown.).

When AES was coded as present, but failed to operate, and the reason given was “fire not in the area protected,” NFPA recoded the AES presence to



“Not in fire area; did not operate.” These incidents and incidents coded to indicate the presence of partial systems were excluded from further analysis.

Property damage has not been adjusted for inflation. In most cases, fires are rounded to the nearest ten, civilian deaths and injuries are rounded to the nearest one, and direct property damage is rounded to the nearest million dollars. Less rounding is used when the numbers are smaller.

For more information on the methodology used for this report see, *How NFPA’s National Estimates Are Calculated for Home Structure Fires*.

## Acknowledgments

The National Fire Protection Association thanks all the fire departments and state fire authorities who participate in the National Fire Incident

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

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<sup>9</sup> M. Ahrens. *Smoke Alarms in US Home Fires*. (Quincy, MA: National Fire Protection Association, 2021). [nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Detection-and-signaling/ossmekealarms.pdf](https://nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Detection-and-signaling/ossmekealarms.pdf)

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