NFPA RESEARCH

US Experience with Sprinklers

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October 2021

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[i] 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.

[i] 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.

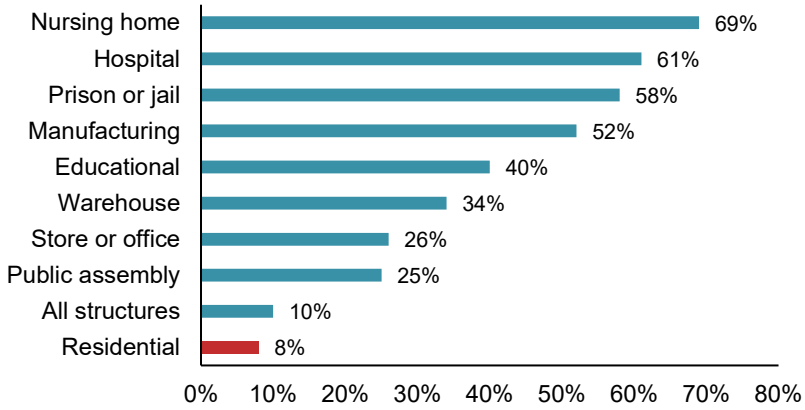
Estimates were derived from the details collected by the US Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and NFPA's annual fire department experience survey. Unless otherwise specified, estimates and rates in this report exclude fires in properties under construction. 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.[1]

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

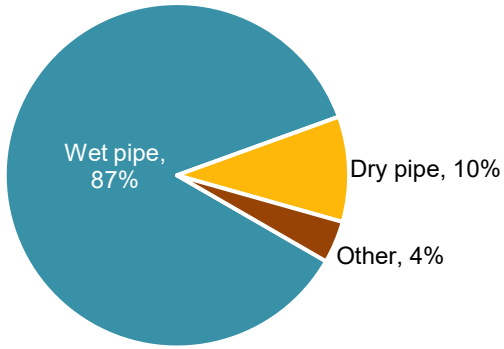
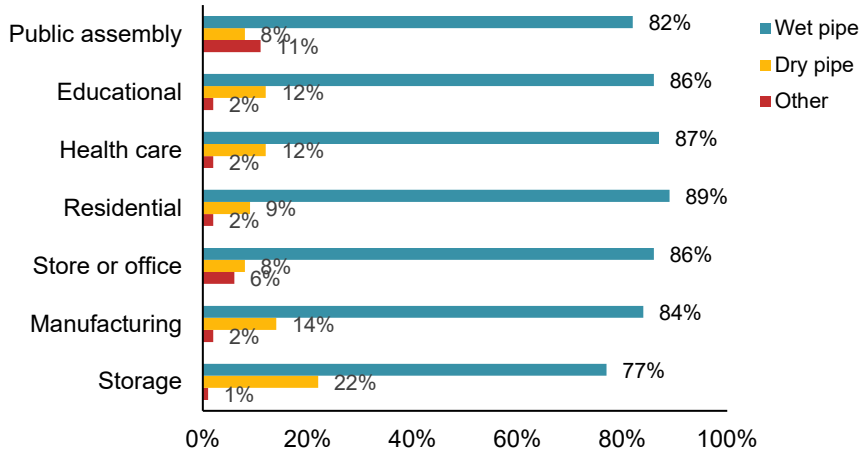


Table A. Summary of AES presence and type in reported structure fires: 2015–2019 annual averages

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

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

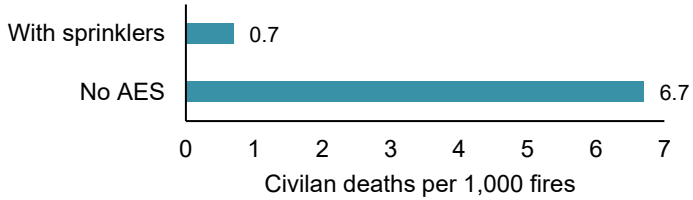


Figure 5 shows that the civilian injury rate per 1,000 reported fires was 27 percent lower in properties with sprinklers than in properties with no AES. Many of the injuries occurred in fires that were too small to activate the sprinklers. In others, someone was injured while trying to fight the fire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

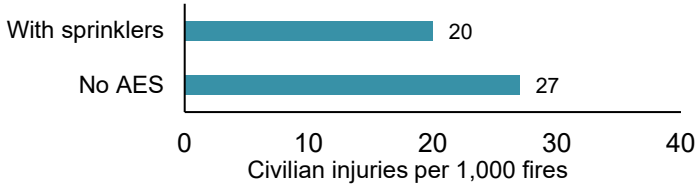
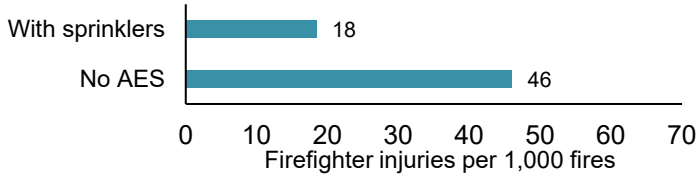


Figure 6 shows that the rate of firefighter injuries per 1,000 fires was 60 percent lower in structure fires with sprinklers compared to fires in properties without AES protection. Sprinklers begin to control a fire when they activate, making the situation less dangerous for responding firefighters.

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

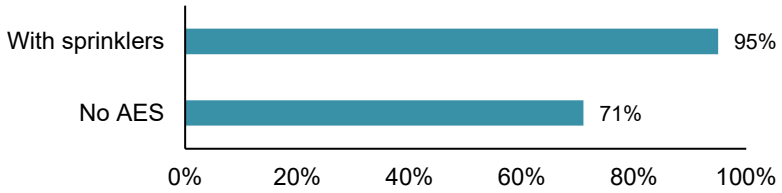


Reductions in the average dollar loss per fire when sprinklers were present varied greatly by occupancy. Table 4 in the supporting tables shows that compared to properties with no AES, the average overall loss was 11 percent lower in fires where sprinklers were present. The percentage reductions were 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.[2] 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.

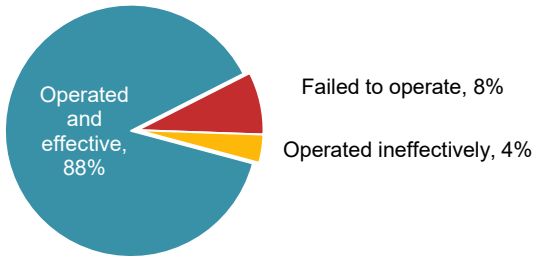
Figure 7. Percent of fires confined to object or room of origin in properties with sprinklers vs. with no AES: 2015–2019



Sprinkler Operation, Effectiveness, and Issues

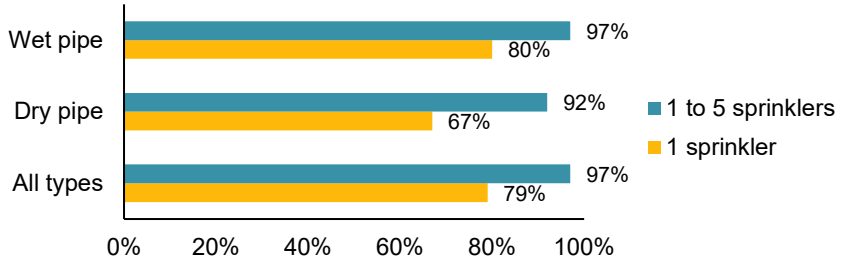
From 2015 to 2019, sprinklers operated in 92 percent of the fires in which they were present and the fire was considered large enough to activate them.[i] They were effective at controlling the fire in 96 percent of the fires in which they operated. Taken together, sprinklers operated effectively in 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



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.[ii] 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. [3] 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.

[i] 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.

[ii] Fires with NFIRS confined fire incident types were included in these calculations.

- An intentional fire set along an exterior wall of a California nonprofit organization's storage facility spread inside.[4] 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. [5] 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

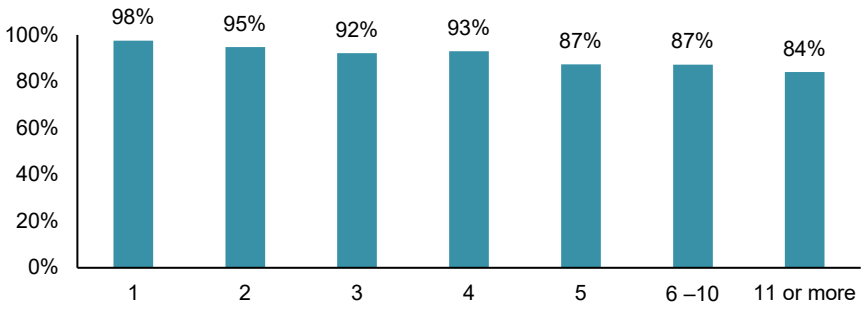


Figure 11 shows that in nearly three out of every five incidents in which sprinklers failed to operate, the system had been shut off.

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

Figure 11. Reasons for sprinkler failure: 2015–2019

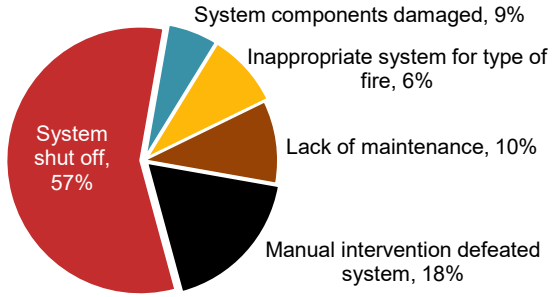
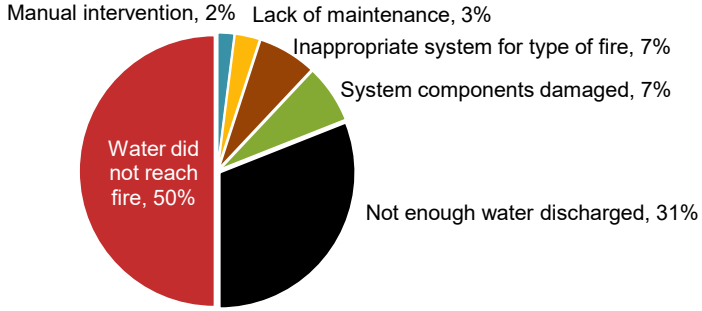


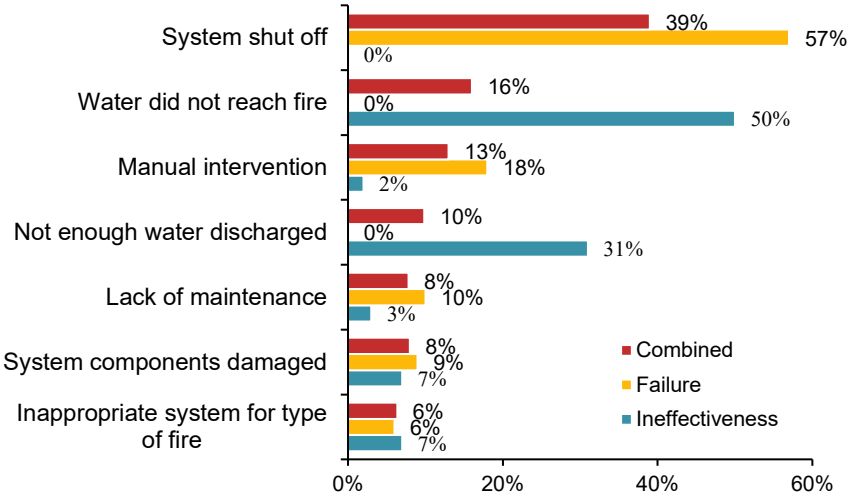
Figure 12 shows that in eight out of every 10 fires in which sprinkler systems operated ineffectively, the problem involved getting water to the fire. In half of the fires in which sprinklers were ineffective, the water did not reach the fire. In nearly one-third of the fires, not enough water was discharged.

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:[7]

- "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

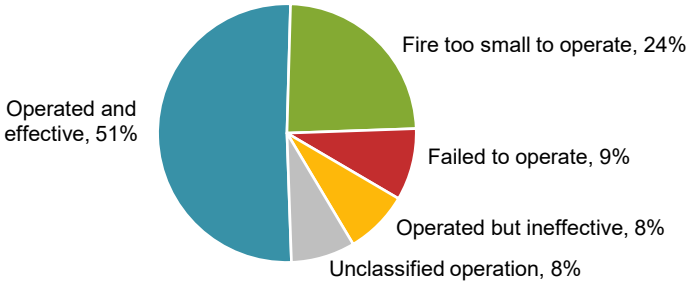
While sprinklers were present in 10 percent of all the properties in which fires occurred in 2015–2019, only 1 percent of all the fire deaths occurred in these properties. Fires in sprinklered properties killed an average of 36 people per year in 2015–2019. Fires in properties that were not under construction 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.

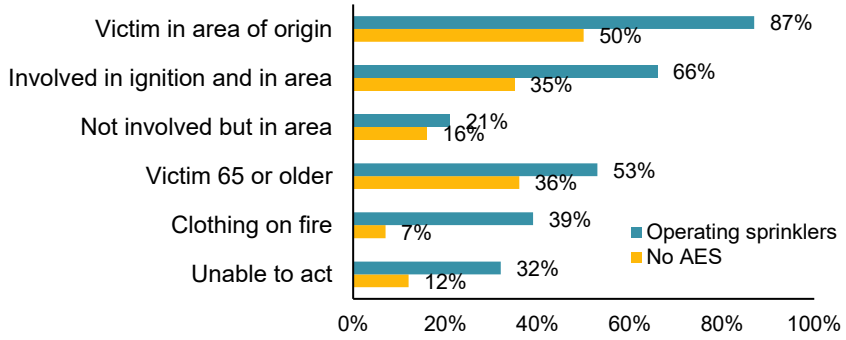
Figure 14. Civilian fire deaths by sprinkler performance: 2015–2019



- 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.[8]

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.[9]

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 themself 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.

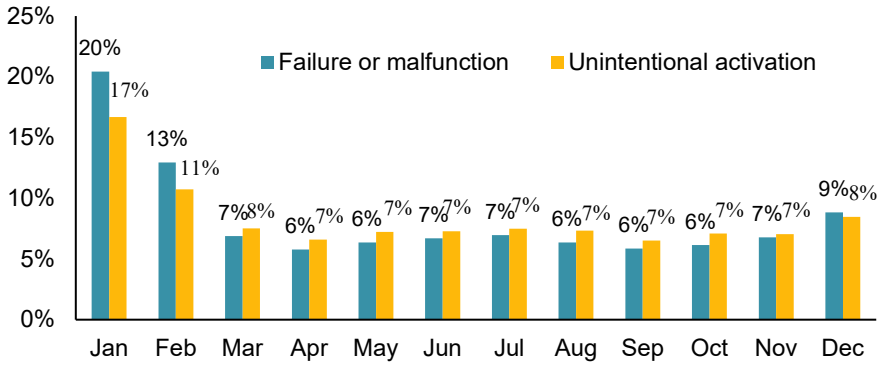
Two fires in 2015–2019 in which sprinklers were present resulted in four deaths each.

- 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.[10] 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.[11] 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,*[12] 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,[13] 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.

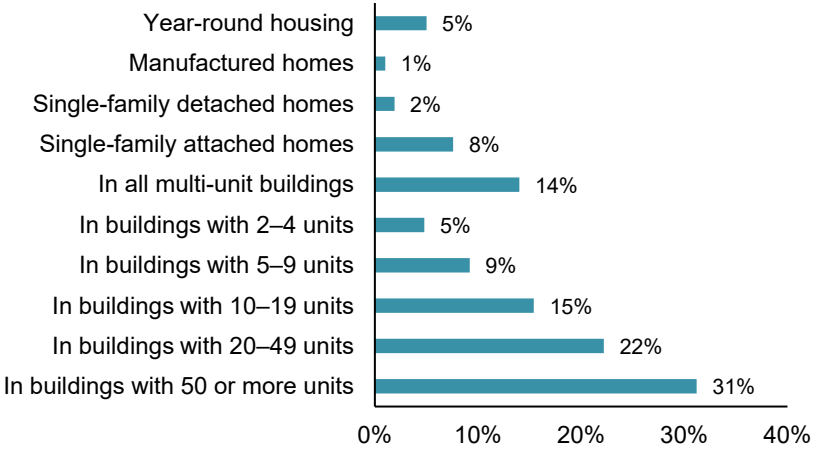
In a 2017 article, Huet, Martorano, and Ames described experiments involving intentional damage simulating random microscopic flaws to more than 100 glass bulb sprinklers. These were then exposed to a constant load in a test frame.[14] Forty-four of the sprinklers failed within 36 days, while the remaining 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.[15]

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



Source: 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

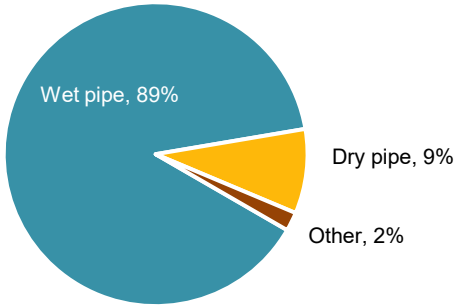


Table B. Summary of AES presence and type in reported home structure fires, excluding properties under construction: 2015–2019 annual averages

AES Presence and Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
AES present	**25,000**	**(7%)**	**24**	**(1%)**	**593**	**(5%)**	**$197**	**(3%)**
Sprinklers present	23,600	(7%)	23	(1%)	555	(5%)	$194	(3%)
Wet pipe sprinkler system	*21,000*	*(6%)*	*22*	*(1%)*	*477*	*(4%)*	*$185*	*(3%)*
Dry pipe sprinkler system	*2,100*	*(1%)*	*1*	*(0%)*	*69*	*(1%)*	*$8*	*(0%)*
Other type of sprinkler system	*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%)
None present	**318,500**	**(92%)**	**2,587**	**(99%)**	**10,408**	**(94%)**	**$6,907**	**(97%)**
Total	**344,900**	**(100%)**	**2,616**	**(100%)**	**11,036**	**(100%)**	**$7,153**	**(100%)**

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 19. Civilian death rates per 1,000 fires in homes with sprinklers vs. with no AES: 2015–2019

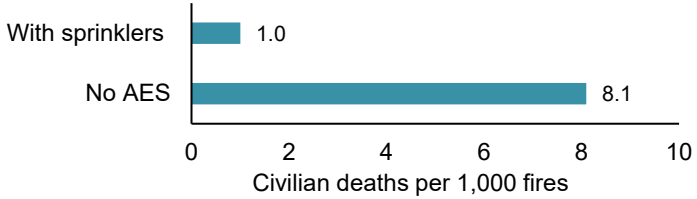


Figure 20 shows that the civilian injury rate per 1,000 reported fires was 28 percent lower in homes with sprinklers than in homes with no AES. In many cases, the injuries occurred in fires that were too small to activate the sprinkler system. In others, someone was injured while trying to fight the 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.[16]

Figure 20. Civilian injury rates per 1,000 fires in homes with sprinklers vs. with no AES: 2015–2019

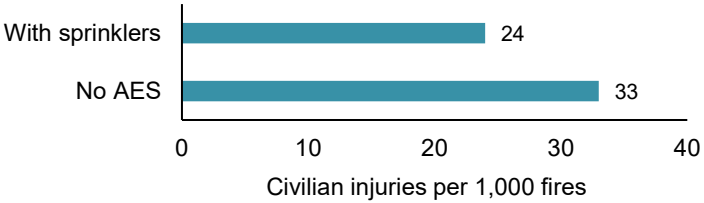
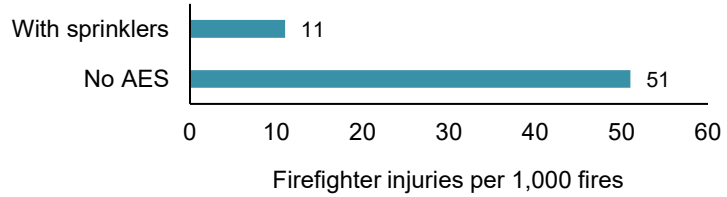


Figure 21 shows that the average firefighter fireground injury rate per 1,000 reported home fires was 78 percent lower when sprinklers were present than in fires with no AES.

Figure 21. Firefighter injury rates per 1,000 fires in homes with sprinklers vs. with no AES: 2015–2019



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 22. Average loss per fire in homes with sprinklers vs. with no AES: 2015–2019

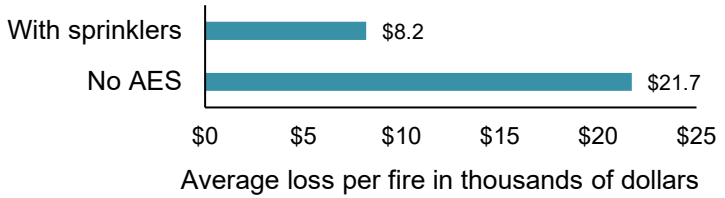
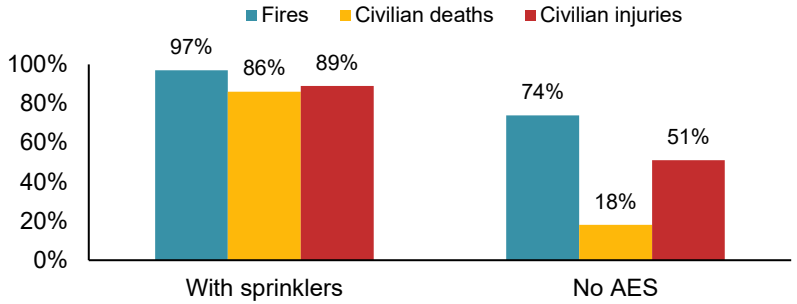


Figure 23 shows that when sprinklers were present, almost all of the fires were confined to the object or room of origin. The majority of civilian deaths and injuries resulting from fires in homes with sprinklers were caused by these fires. In home fires that lacked AES, only three-quarters of the fires 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



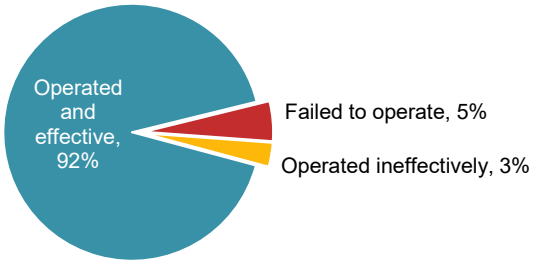
In rare cases, sprinklers may contain or even extinguish fires that cause fatal injuries. These injuries can occur *before* the fire's heat reaches a sprinkler. In some situations, the victim might be unable to move out of harm's way.

- 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.[17]

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.[i] 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.

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.[18]
- 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

[i] 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.

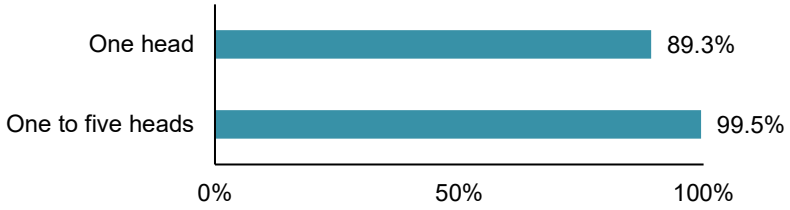
drape on an open window ignited when it was blown over the candle. The fire spread to the window blinds and papers on the desk before it was extinguished.[19]

- 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.[20]
- 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.[21]

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.[22]

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



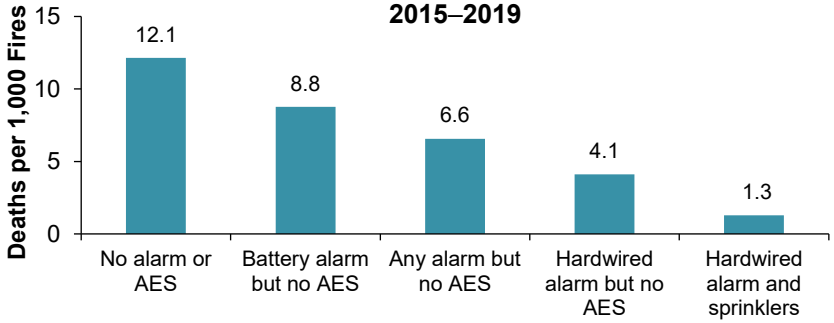
Impact of Smoke Alarm and Sprinkler Presence on Death Rates per 1,000 Home Fires

The lowest home fire death rate per 1,000 reported fires was found in homes with sprinkler systems and hardwired smoke alarms.[i] 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

[i] 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*[23], 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 undermined 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 Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that makes this analysis possible. Their contributions allow us to estimate the size of the fire problem.

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

Thanks also to Ben Evarts for providing the estimates of unwanted activations.

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NFPA No. USS14-REV

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RESEARCH

US Experience with Sprinklers

Supporting Tables

October 2021

Marty Ahrens

US Experience with Sprinklers: Supporting Tables

The tables in this document are a companion to the report of the same name. The table topics are listed below.

Most of the national estimates of fires and losses in this analysis are presented as 2015–2019 annual averages. Estimates were derived from the US Fire Administration's National Fire Incident Reporting System (NFIRS) and NFPA's annual fire department experience survey and include proportional shares of unknown or missing data. Fires are rounded to the nearest 10, deaths and injuries to the nearest one, and property loss to the nearest million dollars. Property loss was not adjusted for inflation. Percentages were calculated on unrounded estimates. Sums may not equal totals due to rounding errors. Estimates include proportional shares of fires with unknown data. For more information on how these estimates were calculated, please see the full report and *How NFPA's National Estimates Are Calculated for Fires.*

Acknowledgments

The National Fire Protection Association thanks all the fire departments and state fire authorities who participate in the National Fire Incident Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that makes this analysis possible. Their contributions allow us to estimate the size of the fire problem.

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

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NFPA No. USS14-ST

Table 1. Presence of Sprinklers in Structure Fires by Property Use (Excluding Properties Under Construction)

Property Use	Number of Structure Fires with Equipment Present and Percentage of Total Structure Fires by Property Use							
	Any Automatic Extinguishing System (AES)						Any Sprinkler	
	1980–1984		1994–1998		2015–2019		2015–2019	
All public assembly	4,280	(13%)	4,380	(26%)	7,900	(49%)	4,120	(25%)
Variable-use amusement place	120	(8%)	140	(16%)	240	(21%)	210	(19%)
Place of worship or funeral property	50	(2%)	90	(5%)	330	(19%)	290	(16%)
Library or museum	80	(14%)	110	(28%)	190	(30%)	180	(28%)
Eating or drinking establishment	3,310	(16%)	3,240	(29%)	5,740	(62%)	2,300	(25%)
Passenger terminal	70	(20%)	60	(35%)	300	(40%)	250	(33%)
Educational property	1,620	(13%)	1,820	(24%)	2,000	(43%)	1,860	(40%)
Health care property*	6,920	(47%)	4,400	(68%)	3,820	(65%)	3,420	(58%)
Nursing home	2,250	(61%)	2,060	(76%)	2,170	(76%)	1,980	(69%)
Hospital	3,370	(47%)	1,650	(74%)	830	(80%)	640	(61%)
Prison or jail	370	(10%)	430	(19%)	300	(61%)	280	(58%)
All residential	7,090	(1%)	11,110	(3%)	32,370	(9%)	30,390	(8%)
Home (including apartment)	5,120	(1%)	8,440	(2%)	24,970	(7%)	23,570	(7%)
Hotel or motel	1,590	(15%)	1,690	(35%)	2,190	(56%)	2,090	(54%)
Dormitory or barracks	430	(16%)	620	(29%)	2,300	(60%)	2,130	(56%)
Rooming or boarding home	70	(4%)	230	(17%)	900	(31%)	860	(29%)
Residential board and care home or assisted living facility	Not available		Not available		860	(46%)	820	(43%)
Store or office	5,510	(13%)	5,230	(21%)	6,500	(34%)	4,940	(26%)
Grocery or convenience store	1,160	(15%)	1,190	(27%)	2,360	(53%)	1,250	(28%)
Laundry, dry cleaning, or other professional service	330	(8%)	310	(13%)	330	(19%)	330	(18%)
Department store	1,340	(44%)	1,100	(52%)	580	(51%)	520	(47%)
Office	1,240	(12%)	1,470	(25%)	1,000	(32%)	940	(30%)
Manufacturing facility	11,910	(44%)	6,400	(50%)	3,050	(58%)	2,720	(52%)
All storage	1,430	(2%)	1,090	(3%)	830	(4%)	810	(4%)
Warehouse (excluding cold storage)	1,060	(13%)	740	(22%)	500	(35%)	500	(34%)
All structures**	38,620	(4%)	37,100	(7%)	61,40	(13%)	51,000	(10%)

* Health care property includes other facilities not listed separately. In 1980–1984 and 1994–1998, this category excludes doctors' offices and elder care facilities without nursing staff (which are assumed to be residential board and care facilities). In 2015–2019, health care property includes nursing homes, hospitals, clinics, doctor's offices, substance abuse recovery centers or developmental disability facilities.
** Includes properties not listed separately above.

Note: Post-1998 estimates are based only on fires reported in Version 5.0 of NFIRS and include fires reported as confined fires. After 1998, buildings under construction are excluded. Sprinkler statistics exclude partial systems and installations with no sprinklers in the fire area.

Table 2. Type of Sprinkler System Reported in Structure Fires Where Equipment Was Present in Fire Area by Property Use (Excluding Properties Under Construction): 2015–2019 Annual Averages

Property Use	Fires per year with any type of sprinkler	Wet pipe sprinklers		Dry pipe sprinklers		Other sprinklers*	
All public assembly	4,120	3,330	(82%)	330	(8%)	470	(11%)
Variable-use amusement place	210	180	(85%)	30	(14%)	0	(1%)
Place of worship or funeral property	290	220	(75%)	50	(16%)	20	(9%)
Library or museum	180	170	(97%)	0	(2%)	0	(1%)
Eating or drinking establishment	2,300	1,740	(76%)	160	(7%)	400	(17%)
Passenger terminal	250	240	(98%)	0	(1%)	0	(0%)
Educational property	1,860	1,590	(86%)	230	(12%)	30	(2%)
Health care property**	3,420	2,960	(87%)	390	(12%)	70	(2%)
Nursing home	1,980	1,730	(88%)	210	(11%)	40	(2%)
Hospital	640	570	(89%)	60	(9%)	10	(1%)
Prison or jail	280	250	(91%)	20	(8%)	0	(1%)
All residential	30,390	27,030	(89%)	2,770	(9%)	590	(2%)
Home (including apartment)	23,570	20,960	(89%)	2,130	(9%)	480	(2%)
Dormitory or barracks	2,130	1,830	(86%)	260	(12%)	30	(2%)
Hotel or motel	2,090	1,850	(88%)	190	(9%)	50	(2%)
Rooming or boarding house	860	800	(94%)	50	(6%)	0	(0%)
Residential board and care or assisted living facility	820	730	(89%)	70	(9%)	20	(2%)
Store or office	4,940	4,270	(86%)	380	(8%)	290	(6%)
Grocery or convenience store	1,250	980	(78%)	100	(8%)	180	(14%)
Laundry, dry cleaning, or other professional service	330	300	(91%)	20	(5%)	10	(4%)
Department store	520	460	(88%)	50	(10%)	10	(2%)
Office	940	820	(87%)	80	(8%)	40	(5%)
Manufacturing facility	2,720	2,290	(84%)	370	(14%)	60	(2%)
All storage	810	620	(77%)	180	(22%)	10	(1%)
Warehouse (excluding cold storage)	500	410	(81%)	90	(18%)	0	(1%)
All structures ***	51,000	44,160	(87%)	5,040	(10%)	1,810	(4%)

* Includes deluge and pre-action sprinkler systems and may include sprinklers of an unknown or unreported type.
** Nursing homes, hospitals, clinics, doctor's offices, substance abuse recovery centers or developmental disability facilities.
*** Includes properties not listed separately above.

Note: Row totals are shown in the left-most column of percentages and sums may not equal totals due to rounding errors. In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the location where the fire started. This field was not required if the fire did not begin within the designed range of the system. Buildings under construction and partial systems were excluded.

Source: NFIRS and NFPA fire experience survey.

Table 3. Estimated Reduction in Civilian Deaths per Thousand Fires Associated with All Types of and Wet Pipe Sprinklers by Property Use (Excluding Properties Under Construction): 2015–2019 Annual Averages

Property Use	Without AES	With sprinklers of any type	Percent reduction from no AES	With wet pipe sprinklers	Percent reduction from no AES
All public assembly	1.9	0.1	97%	0.1	96%
Health care*	1.2	0.8	33%	0.5	58%
Residential	8.0	0.9	89%	1.0	88%
Home (including apartment)	8.1	1.0	88%	1.0	87%
Dormitory or barracks	1.0	0.2	84%	0.2	81%
Hotel or motel	8.6	0.2	98%	0.2	98%
Rooming or boarding house	6.5	3.3	49%	3.5	46%
Residential board and care or assisted living facility	3.2	1.4	57%	1.5	52%
Store or office	1.2	0.5	57%	0.4	64%
Manufacturing facility	1.0	0.6	34%	0.7	22%
Warehouse (excluding cold storage)	2.1	0.0	100%	0.0	100%
All structures**	6.7	0.7	89%	0.7	89%

* Includes nursing homes, hospitals, clinics, doctor's offices, substance abuse recovery centers or developmental disability facilities.
** Includes properties not listed separately above.

Note: These are national estimates of structure fires reported to US municipal fire departments based on fires reported in NFIRS and so exclude fires reported only to federal or state agencies or industrial fire brigades.

Source: NFIRS and NFPA fire experience survey.

Table 4. Estimated Reduction in Average Direct Property Loss per Fire Associated with Any Type of and Wet Pipe Sprinklers by Property Use (Excluding Properties Under Construction): 2015–2019 Annual Averages

Property Use	Loss without AES	Loss with sprinklers of any type	Percent reduction	Loss with wet pipe sprinkler system	Percent reduction from no AES
All public assembly	$31,500	$11,600	63%	$12,000	62%
Health care*	$13,900	$3,800	73%	$4,000	71%
Residential	$21,200	$8,500	60%	$9,000	57%
Home (including apartment)	$21,700	$8,200	62%	$8,800	59%
Dormitory or barracks	$3,700	$1,500	58%	$1,700	53%
Hotel or motel	$29,800	$22,400	28%	$22,700	24%
Rooming or boarding house	$7,700	$3,600	52%	$3,700	51%
Residential board and care or assisted living facility	$4,600	$6,700	-44%	$7,300	-58%
Store or office	$59,400	$17,600	70%	$17,900	70%
Manufacturing facility	$141,000	$170,300	No reduction	$192,100	No reduction
Warehouse (excluding cold storage)	$112,300	$144,000	No reduction	$149,400	No reduction
All structures	$22,200	$19,800	11%	$20,600	7%

* Includes nursing homes, hospitals, clinics, doctor's offices, substance abuse recovery centers or developmental disability facilities.
** Includes properties not listed separately above.

Note: These are national estimates of structure fires reported to US municipal fire departments based on fires reported in NFIRS and so exclude fires reported only to federal or state agencies or industrial fire brigades.

Source: NFIRS and NFPA fire experience survey.

Table 5. Percentage of Fires with Fire Spread Confined to Room of Origin in Fires with Sprinklers Present vs. No Automatic Extinguishing System: 2015–2019 Annual Averages

Property Use	Percentage of fires confined to room of origin excluding structures under construction and sprinklers not in fire area: With no AES	With sprinklers of any type	Difference (in percentage points)
Public assembly	77%	93%	16%
Religious property	73%	94%	22%
Library or museum	83%	96%	13%
Eating or drinking establishment	72%	91%	19%
Educational	89%	97%	8%
Health care property*	92%	98%	6%
Residential	74%	97%	23%
Home (including apartment)	74%	97%	23%
Dormitory or barracks	97%	99%	3%
Hotel or motel	84%	96%	13%
Store or office	67%	92%	24%
Grocery or convenience store	72%	94%	22%
Department store	65%	90%	25%
Office building	75%	93%	19%
Manufacturing facility	64%	84%	21%
Storage	25%	80%	55%
Warehouse (excluding cold storage)	52%	79%	27%
All structures**	71%	95%	24%

* Includes nursing homes, hospitals, clinics, doctor's offices, substance abuse recovery centers or developmental disability facilities.
** Includes properties not listed separately above.

Note: All fires with one of the six NFIRS confined structure fire incident types were considered confined to the object of origin by definition. Fires that were confined to the room of origin include fires confined to the object of origin. In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the location where the fire started. This field is not required if the fire did not begin within the designed range of the system.

Source: NFIRS and NFPA fire experience survey.

Table 6. Sprinkler Reliability and Effectiveness When Fire Was Coded as Not Confined, Was Large Enough to Activate Sprinkler, and Sprinkler Was Present in Area of Fire by Property Use: 2015–2019 Annual Averages

A. All Sprinklers

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate or unclassified operation	Fires coded as confined fires	Number of qualifying fires per year	Percent where equipment operated (A)	Percent effective of those that operated (B)	Percent where equipment operated effectively (A x B)
All public assembly	4,120	720	2,580	820	89%	92%	82%
Eating or drinking establishment	2,300	410	1,360	530	88%	91%	80%
Educational property	1,860	420	1,220	220	84%	97%	82%
Health care property*	3,420	650	2,390	380	86%	98%	84%
All residential	30,390	2,600	23,310	4,480	94%	97%	91%
Home (including apartment)	23,570	1,890	18,030	3,650	95%	97%	92%
Hotel or motel	2,090	400	1,280	410	91%	97%	88%
Store or office	4,940	1,150	2,450	1,340	90%	96%	86%
Grocery or convenience store	1,250	280	730	240	85%	94%	80%
Department store	520	180	220	120	89%	97%	86%
Office	940	210	510	220	88%	97%	85%
Manufacturing facility	2,720	650	900	1,170	91%	94%	86%
All storage	810	140	280	380	86%	95%	84%
Warehouse (excluding cold storage)	500	90	160	250	88%	95%	84%
All structures**	51,000	6,780	34,830	9,390	92%	96%	88%

* Includes nursing homes, hospitals, clinics, doctor's offices, substance abuse recovery centers or developmental disability facilities.
** Includes properties not listed separately above.

Note: In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the location where the fire started. This field is not required if the fire did not begin within the designed range of the system.

Source: NFIRS and NFPA fire experience survey.

Table 6. Sprinkler Reliability and Effectiveness When Fire Was Coded as Not Confined, Was Large Enough to Activate Sprinkler, and Sprinkler Was Present in Area of Fire by Property Use: 2015–2019 Annual Averages, (Continued)

B. Wet Pipe Sprinkler Systems Only

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate or unclassified operation	Fires coded as confined fires	Number of qualifying fires per year	Percent where equipment operated (A)	Percent effective of those that operated (B)	Percent where equipment operated effectively (A x B)
All public assembly	3,330	600	2,030	700	90%	94%	85%
Eating or drinking establishment	1,740	330	980	430	90%	93%	84%
Educational property	1,590	370	1,020	200	85%	97%	83%
Health care property*	2,960	570	2,050	330	88%	97%	85%
All residential	27,030	2,330	20,560	4,150	95%	97%	92%
Home (including apartment)	20,960	1,690	15,870	3,390	95%	97%	92%
Hotel or motel	1,850	350	1,130	370	92%	97%	90%
Store or office	4,270	1,030	2,030	1,210	91%	97%	88%
Grocery or convenience store	980	250	520	210	87%	95%	83%
Department store	460	160	190	110	88%	98%	86%
Office	820	190	440	180	89%	97%	86%
Manufacturing facility	2,290	540	770	980	92%	94%	87%
All storage	620	110	220	300	91%	95%	87%
Warehouse (excluding cold storage)	410	80	120	210	90%	96%	86%
All Structures**	44,160	5,920	29,870	8,370	92%	96%	89%

* Includes nursing homes, hospitals, clinics, doctor's offices, substance abuse recovery centers or developmental disability facilities.
** Includes properties not listed separately above.

Note: In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the location where the fire started. This field is not required if the fire did not begin within the designed range of the system.

Source: NFIRS and NFPA fire experience survey.

Table 6. Sprinkler Reliability and Effectiveness When Fire Was Coded as Not Confined, Was Large Enough to Activate Sprinkler, and Sprinkler Was Present in Area of Fire by Property Use: 2015–2019 Annual Averages, (Continued)

C. Dry Pipe Sprinkler Systems Only

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate or unclassified operation	Fires coded as confined fires	Number of qualifying fires per year	Percent where equipment operated (A)	Percent effective of those that operated (B)	Percent where equipment operated effectively (A x B)
All residential	2,770	230	2,280	260	91%	97%	89%
Homes	2,130	160	1,770	190	92%	98%	90%
Store or office	380	100	190	90	83%	94%	78%
Manufacturing facility	370	100	110	160	89%	93%	83%
All storage	180	30	70	80	79%	94%	74%
All structures*	5,040	690	3,540	800	87%	94%	82%

* Includes properties not listed separately above.

Note: These are percentages of fires reported to US municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the location where the fire started. This field is not required if the fire did not begin within the designed range of the system. Buildings under construction were excluded. Percentages are based on estimated total fires reported in NFIRS with the indicated type of automatic extinguishing system and system performance not coded as fire too small to activate systems. Fires were excluded if the reason for failure or ineffectiveness was "system not present in area of fire." Fires were recoded from "operated but ineffective" to "failed to operate" if the reason for failure or ineffectiveness was "system shut off." Fires were recoded from "failed to operate" to "operated but ineffective" if the reason for failure or ineffectiveness was "not enough agent" or "agent did not reach fire."

Source: NFIRS and NFPA fire experience survey.

Table 7. Number of Sprinklers That Operated in Structure Fires by Type of Sprinkler System (Excluding Properties Under Construction): 2015–2019 Annual Averages

Number of Sprinklers Operating	Percentage of structure fires where that many sprinklers operated		
	Wet Pipe	Dry Pipe	All Sprinklers (Including "other")
1	80%	47%	77%
1 or 2	91%	63%	89%
1 to 3	94%	71%	92%
1 to 4	96%	83%	95%
1 to 5	97%	90%	97%
1 to 10	99%	99%	99%

Note: Percentages are based on structure fires reported in NFIRS to US municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percentages are based on fires where sprinklers were reported as present and operating and there was reported information on the number of sprinklers that operated. Fires were excluded if the reason for failure or ineffectiveness was coded as "system not present in area of fire." Fires were recoded from "operated but ineffective" to "failed to operate" if the reason for failure or ineffectiveness was "system shut off." Fires were recoded from "failed to operate" to "operated but ineffective" if the reason for failure or ineffectiveness was "not enough agent" or "agent did not reach fire." In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the location where the fire started. Buildings under construction were excluded, as were partial systems and fires reported as confined fires.

Source: NFIRS and NFPA fire experience survey.

Table 8. Reasons for Sprinkler Failure or Ineffectiveness in Structure Fires Large Enough to Activate Sprinkler Present in Fire Area (Excluding Fires with Confined Structure Fire Incident Types and Fires in Properties Under Construction): 2015–2019 Annual Averages

A. Reason Sprinkler Failed to Operate

Reason	All sprinklers		Wet pipe		Dry pipe	
System shut off	430	(57%)	340	(56%)	70	(64%)
Manual intervention defeated system	130	(18%)	120	(20%)	10	(8%)
Lack of maintenance	70	(10%)	60	(9%)	10	(12%)
System components damaged	70	(9%)	50	(9%)	10	(12%)
Inappropriate system for type of fire	40	(6%)	40	(6%)	0	(4%)
Total	750	(100%)	610	(100%)	100	(100%)

B. Reason Operating Sprinkler Was Ineffective

Reason	All sprinklers		Wet pipe		Dry pipe	
Water did not reach the fire	170	(50%)	140	(53%)	10	(36%)
Not enough water released	100	(31%)	70	(27%)	20	(50%)
Inappropriate system for type of fire	20	(7%)	20	(8%)	0	(3%)
System components damaged	20	(7%)	20	(8%)	0	(3%)
Lack of maintenance	10	(3%)	0	(1%)	0	(7%)
Manual intervention defeated system	10	(2%)	10	(3%)	0	(0%)
Total	340	(100%)	270	(100%)	40	(100%)

C. Reasons for Sprinkler Failure or Ineffectiveness Combined

Reason	All sprinklers		Wet pipe		Dry pipe	
System shut off	430	(39%)	340	(39%)	70	(47%)
Water did not reach the fire	170	(16%)	140	(16%)	10	(10%)
Manual intervention defeated system	140	(13%)	130	(15%)	10	(6%)
Not enough water released	100	(10%)	70	(8%)	20	(14%)
System components damaged	90	(8%)	80	(9%)	10	(10%)
Lack of maintenance	80	(8%)	60	(7%)	20	(11%)
Inappropriate system for type of fire	70	(6%)	60	(7%)	10	(4%)
Total	1,080	(100%)	880	(100%)	140	(100%)

Note: Buildings under construction were excluded, as were partial systems and fires reported as confined fires. Fires reported with unclassified reasons for failure were treated as cases of unknown reasons for failure.

Source: NFIRS and NFPA fire experience survey.

Table 9. Characteristics of Fatal Victims in Fires with Sprinklers vs. No Automatic Extinguishing Equipment: 2015–2019 Annual Averages

A. Number of Victims by Sprinkler Presence and Performance

Sprinkler/AES Status	Deaths when sprinklers present		Deaths when no AES present	
Total civilian deaths	36	(100%)	2,816	(100%)
Operated and effective	*18*	*(51%)*		
Operated but ineffective	*3*	*(8%)*		
Fire too small to operate	*9*	*(24%)*		
Failed to operate	*3*	*(9%)*		
Unclassified operation	*3*	*(8%)*		

B. Characteristics in Fires with Operating Sprinklers vs. No AES

Fire or Victim Characteristic	Deaths when sprinklers present		Deaths when no AES present	
With operating sprinklers	21	(100%)	2,816	(100%)
Victim in area of origin	18	(87%)	1,319	(50%)
Involved in ignition	*14*	*(66%)*	*976*	*(35%)*
Not involved in ignition	*4*	*(21%)*	*446*	*(16%)*
Victim 65 or older	11	(53%)	1,001	(36%)
Clothing on fire	8	(39%)	193	(7%)
Unable to act	7	(32%)	331	(12%)

Note: Here is an example of how to read this table: Almost nine out of every 10 people (87 percent) who died in fires despite the presence of operating sprinklers were located in the area of fire origin. Being closer to the fire makes it harder to escape. In comparison, only half of the fatal victims (50 percent) in fires in which no automatic extinguishing equipment was present were located in the area of fire origin.

Source: NFIRS and NFPA fire experience survey.