Sprinkler Performance – How are we doing? How can NFPA 13 and 25 help?

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Abstract

Sprinklers are a highly effective and reliable part of a building's fire protection system. In 2010-2014, sprinklers were present in 10 % of reported U.S. fires. When these fires were considered large enough to activate the sprinkler, sprinklers operated 92 % of the time. Sprinklers were effective in controlling the fire in 96 % of the fires in which they operated. National estimates created from the detailed data in the National Fire Incident Reporting System (NFIRS) about automatic extinguishing systems combined with the results of NFPA's annual fire department experience survey provide information about sprinkler prevalence, reliability, effectiveness, and broad categories of performance issues.

In three out of five (59 %) fires in which sprinklers failed to operate, the sprinkler had been shut off. In half of the fires in which operating sprinklers were ineffective, the water did not reach the fire. In an additional 30 %, not enough water was discharged. The provisions in NFPA 13, Standard for the Installation of Sprinkler Systems, and NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems that mitigate these issues are discussed.

Keywords: Fire suppression, sprinklers, fire statistics, sprinkler performance, NFPA 13, NFPA 25

Introduction

Sprinklers play a critical role in fire protection. Information about sprinkler presence and performance in reported fires is essential to understanding the prevalence, impact, reliability and effectiveness of these systems as well as avenues for performance improvement. This paper provides a statistical overview of sprinkler presence and performance in reported fires. These estimates are summarized from NFPA's upcoming report, *U.S. Experience with Sprinklers.* [1]

Two NFPA standards, NFPA 13, *Standard for the Installation of Sprinkler Systems,*[2] and NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* [3] provide guidance about proper installation and ongoing maintenance of these systems. Provisions to prevent the identified problems are highlighted.

Calculating estimates of sprinkler performance

The U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) [4] collects detailed incident-based information about causes and circumstances of fires from local fire departments. Participation in NFIRS voluntary at the federal level. Some states require fire departments to report all incidents or all fires, some have a loss threshold, and in other states, reporting is completely voluntary.

NFPA's annual Fire Experience Survey (FES) collects summary data from a sample of fire departments to calculate estimates of fires and associated losses by broad category. More details can be found in NFPA's report, *U.S. Fire Loss during 2015* and other reports in the series. [5].

To compensate for fires reported to local fire departments but not captured by NFIRS, fire and loss estimates from the FES are divided by comparable totals in NFIRS to develop multipliers. NFIRS data are scaled up by these multipliers. In most cases, unknown data are allocated proportionally. The basic approach was documented in a 1989 *Fire Technology* article by John Hall and Beatrice Harwood. [6]

In the current version of NFIRS details about automatic extinguishing systems are not required for six types of confined structure fires, although such data is sometimes provided. For statistical purposes, these are all assumed to have had fire spread limited to the object of origin. They are included in estimates of sprinkler presence and fire spread, but not of operation.

Estimates of sprinkler presence, performance and effectiveness

During 2010-2014, some type of sprinkler was present in an estimated total of 49,800 (10 %) reported fires. Fig. 1 shows that wet pipe sprinklers were found in 87 %, dry pipe systems in 10 %, and other types of sprinklers in 3 %.

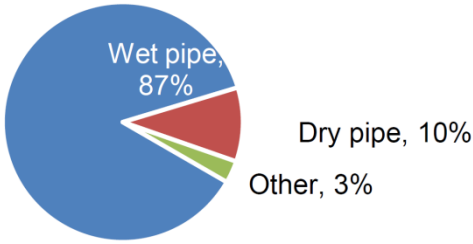

Fig. 1. Types of sprinklers found in U.S. structure fires: 2010-2014.

In reported structure fires with no automatic extinguishing systems (AES) present, the death rate was 6.3 per 1,000 fires. Fig. 2 shows that when sprinklers were present, the death rate of 0.9 deaths per 1,000 fires was 87 % lower.

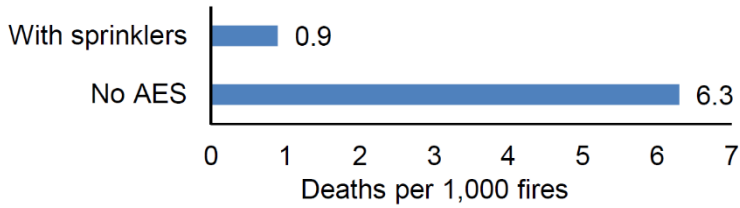

Fig. 2. Death rates per 1,000 fires.

Fig. 3 shows that when sprinklers were present, flame damage was confined to the room of origin in 96% of fires compared to 71 % of fires without AES, a difference of 25 percentage points.

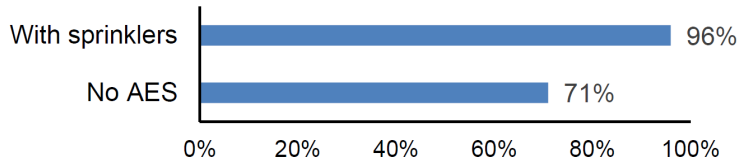

Fig. 3. Percent of fires confined to room of origin: 2010-2014.

Fig. 4 shows that sprinklers operated in 92 % of the fires in which sprinklers were present and the fire was considered large enough to activate them. They were effective at controlling the fire in 96 % of fires in which they operated, Taken together, that means sprinklers operated effectively in 88 % of the fires large enough to trigger them (92 % x 96 %).

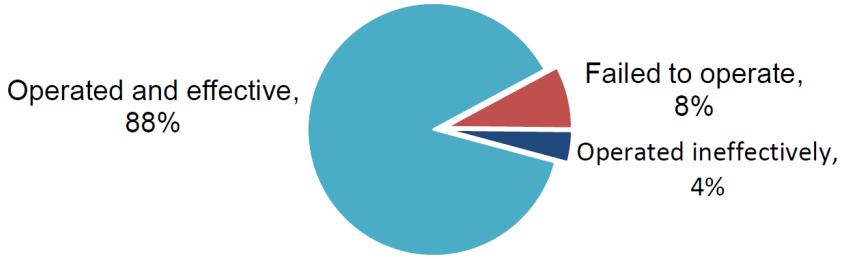

Fig. 4. Sprinkler operation and effectiveness: 2010-2014.

Sprinkler failures

Fig. 5 shows that in three of every five (59 %) incidents in which sprinklers failed to operate, the system had been shut off. Manual intervention defeated the system in 17 % of the incidents. In some cases, someone turned off the system prematurely. This was the cause for a fire at a medical research lab in North Carolina, where building maintenance staff prematurely shut off the sprinkler system before firefighters arrived. [7]

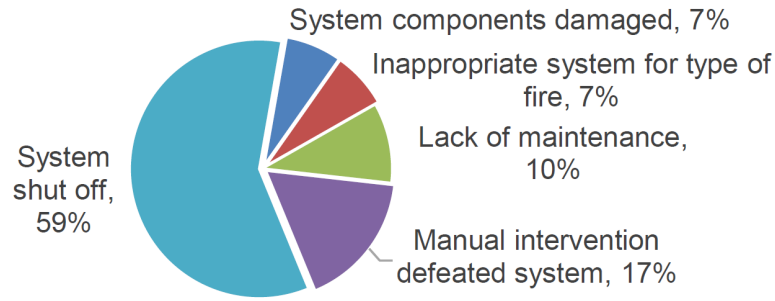

Fig. 5. Reasons for sprinkler failures: 2010-2014.

NFPA 25 provides the minimum requirements for the periodic inspection, testing, and maintenance of water-based fire protection systems, and addresses how to reduce the negative impact of manual intervention. Specifically, requirements for control valves are described in Chapter 13. In addition, an impairment program outlined in Chapter 15 minimizes the length of time a system is out of services, and outlines procedures that ensure systems and valves are properly returned to service upon the completion of all inspection, testing and/or maintenance activities.

Ten percent of the failures were caused by a lack of maintenance. Table 5.1.1.2, Summary of Sprinkler System Inspection, Testing, and Maintenance of NFPA 25 provides the frequency of which sprinkler system components are required to be inspected and tested. In addition, NFPA 25 categorizes the level of impact for components not

meeting the standard into three terms: impairment, critical deficiency, or noncritical deficiency. Establishing these categories allows the responsible party to comprehend the potential impact and develop an action plan to address the components that are not code compliant. In addition, NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing,* provides testing protocols for new or existing integrated fire protection and life safety systems, where such testing is required. [8] An integrated system test is the “handshake“ between systems and will confirm that operation, interaction, and coordination of multiple individual systems perform their intended function.

The system was inappropriate for the type of fire in 7 % of the incidents in which sprinklers failed to operate. NFPA 13 outlines how to design a sprinkler system for the selected occupancy or commodity classification. One of the most critical decisions in designing a sprinkler system is determining the occupancy classification or commodity type. NFPA 13 provides minimum design and installation requirements based on the occupancy or commodity classification, including sprinkler discharge criteria, sprinkler spacing and water supply provisions. Throughout a building’s life cycle, the use and occupancy type may change. NFPA 1, *Fire Code*, requires the owner or occupant to evaluate the adequacy of the installed system to ensure the sprinkler system installed is adequate in protecting the space if the use, occupancy type, process or materials have changed. [9]

In another 7 % of sprinkler failures, system components were damaged. Sometimes, this was caused by an explosion or overwhelming fire. NFPA 13 is written with the assumption that the sprinkler system is designed to protect against a single fire originating within the building because the purpose of the standard is to provide a reasonable degree of fire protection for life and property. In others, damage occurred at some point before the fire and had not been repaired. NFPA 25, also known as the “wear and tear” document provide minimum requirements for the inspection, testing and maintenance of sprinkler system components to ensure the installed system is functioning properly.

Sprinkler ineffectiveness

Some of the conditions responsible for sprinkler failures also reduced sprinkler effectiveness. Fig. 6 shows that, the water did not reach the fire in half (51 %) of the fires in which sprinklers were ineffective. In 30 %, not enough water was discharged. In 7 %, system components were damaged. The system inappropriate for the type of fire in 6 %. Lack of maintenance was identified as a factor in 4 % of the incidents. Manual intervention was the cause of 3 % of ineffective systems.

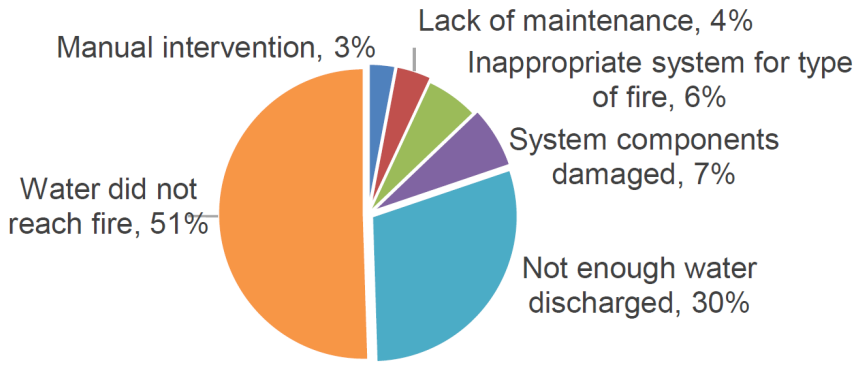

Fig. 6. Reasons for sprinkler ineffectiveness: 2010-2014.

Unwanted activations

In 2014, the USFA released the all-incident database for the first time since 2003. Combined with results from NFPA's fire experience survey, fire departments responded to 29,800 sprinkler activations caused by a system failure or malfunction and 33,600 unintentional sprinkler activations. The latter includes testing the system without notifying the fire department. 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. If a sprinkler system is installed appropriately in accordance with NFPA 13, and the inspection, testing, and maintenance requirements are followed in accordance with NFPA 25 throughout the system's lifecycle, the unwanted activations should be minimized.

Conclusion and discussion

Sprinklers are a very reliable and effective party of fire protection. NFPA standards provide guidance to make them operate even more reliably and effectively. In the rare cases when they fail or are ineffective, human error is usually to blame. NFPA standards provide guidance about how to prevent these problems.

While the death rate was 87 % lower when sprinklers were present, sprinklers cannot eliminate all deaths. When deaths have occurred, the victims were often intimately involved with the ignition. In at least three 2015 cases, the victim had been smoking, either in a chair or in bed. In two cases, the sprinklers completely extinguished the fire. In a third, the fire was 90 % controlled. However, the victims were already fatally injured. In another incident, the victim's clothing caught fire while cooking. The fire did not get hot enough to activate the sprinkler. [9] Workplace explosions can cause fatal injury to those nearby before any sprinkler activation.

We want to promote the tremendous good that sprinklers can accomplish without creating unrealistic expectations. We also want to continue to improve the performance. Future research may lead to systems that can reduce the errors that cause these problems.

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