

# Efficiency and Effectiveness of Sprinkler Systems in the United Kingdom: An Analysis from Fire Service Data



May 2017



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## Foreword

*Since its inception in 1998 the National Fire Sprinkler Network (NFSN) has been working tirelessly alongside colleagues within the fire sector to emphasise and promote the benefits of fire sprinklers to the wider community. One early success was the introduction into Building Regulations of the 2000m<sup>2</sup> limit for large retail premises to be fitted with sprinklers.*

*The membership core of the NFSN is firmly rooted in the Fire and Rescue Services and this collaborative work, alongside the Chief Fire Officer's Association (CFOA), proves that this partnership has once again delivered a powerful message on the effectiveness of sprinklers in the built environment within the United Kingdom.*

*Research such as this is not produced overnight or without much hard work and so I wish to thank everyone involved in the production of what is, a comprehensive and authoritative document. The data clearly proves that sprinklers are both effective and efficient in a wide range of fire scenarios and building types, affording greater levels of fire protection to people, property and the environment.*

*It gives me great pleasure to commend this research document to you, my hope being that it will play an important part in changing hearts and minds to more readily accept sprinklers as an important fire safety tool and to see them employed more widely than is currently the case.*

**Terry McDermott.**

**Chair**

**National Fire Sprinkler Network**



*My first involvement with sprinklers, during my fire service career, was probably when I first ventured into fire safety department of Wiltshire Fire & Rescue Service in 1999. I was quickly introduced to the work of the National Fire Sprinkler Network. In that time I have seen much progress made by the combined efforts of those that see the benefits of sprinklers, be that fire services, the sprinkler industry, insurers, lobbying bodies and the more enlightened of our politicians. In my career I have seen first-hand how sprinklers can reduce the impact of fires on business and people's lives. I have also been at the scene of a fire where the occupants would almost certainly have died if it wasn't for the presence of a sprinkler system.*

*It heartens me to think that increasingly sprinklers appear in the guidance documents for fire safety in the built environment. I applaud the devolved administrations in their approach to regulate the inclusion of sprinklers in many types of buildings. I had the privilege of being in the public gallery of the Welsh Assembly when the historic vote to regulate for sprinklers in new residences was passed.*

*Throughout my years of working with many likeminded and passionate individuals in the promotion of sprinklers, we have been repeatedly challenged to produce the evidence of the effectiveness of sprinklers and also rebuff the unfounded counter claims about water damage and that they all go off at once.*

*I am delighted that this key analysis has been undertaken. It has been carried out independently. Data was supplied by every single one of the United Kingdom's fire and rescue services. Thousands of incidents have been analysed, so we can provide definitive evidence of the effectiveness and reliability of sprinkler systems in the UK. I feel it provides a compelling case for further inclusion of sprinklers in the built environment so that lives can be saved, property can be protected and UK PLC can continue to grow.*

**Julian Parsons**

**On behalf of the National Fire Chiefs  
Council**



**NFCC**  
National Fire  
Chiefs Council

## Summary

1. This report provides a detailed analysis of data on fires in premises in the UK in which sprinkler systems were fitted over the period 2011 to 2016. Data were provided by 47 Fire and Rescue Services.
2. The cases analysed amounted to 2,294 incidents of which 1,725 (75%) were in non-residential buildings and 414 (18%) in dwellings.
3. The aim of the analysis was to provide an authoritative assessment of the reliability and effectiveness of sprinkler systems in controlling and extinguishing fires and in preventing damage.
4. The effectiveness and reliability of sprinklers has been assessed with regard to two key criteria:
  - When sprinklers operate how effective are they in extinguishing or controlling fires and thus preventing damage? (performance effectiveness)
  - How reliable are sprinklers in coming into operation when a fire breaks out? (operational reliability)
5. In the data set there were 945 cases in which sprinklers were activated. The impact of the sprinkler system is known for 677 fires of these cases. Across all fires for which data were available, the sprinkler systems contained or controlled the fires in 62% of incidents and extinguished the fire in 37% of incidents. Hence, **the performance effectiveness of sprinkler systems was 99% across all building types.**
6. A further measure of effectiveness is obtained by comparing average areas of damage from fires in residential buildings with sprinklers and from all fires in residential buildings. Fires in dwellings where sprinkler systems operated had an average area of fire damage of under 4 sq. m. This compares to an average area of fire damage of 18 to 21 sq. m. for all dwelling fires in England between 2011/12 and 2015/16<sup>1</sup>.
7. The average area of fire damage in a non-residential building where a sprinkler system was present<sup>2</sup> was 30 sq. m. which is half the average area of fire damage of in comparable “other building” fires in England between 2011/12 and 2015/16<sup>3</sup>
8. There were 1316 fires recorded in the data where a sprinkler system was present but did not operate. Information on the reasons why the sprinkler system did not operate was recorded for 879 fires. In 370 of these cases the fire was in an area not covered by the system; in 115 cases the fire was too small to activate the system; in 18 cases the system was turned off; and in 13 cases the fire was extinguished before activation. Only 57 cases out of 879 were identified where the system could have been expected to work but did not. **This indicates that the operational reliability of the systems was 94%.**
9. In brief, this extensive data analysis shows that sprinklers are highly reliable and effective. They work as intended in 94% of cases and control or extinguish fires in 99% of cases.

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<sup>1</sup> Fire Statistics Table 0204, Fire Statistics Data Tables, Home Office

<sup>2</sup> Excluding one large fire for which the damage data are considered unreliable

<sup>3</sup> Fire Statistics Table 0304, Fire Statistics Data Table, Home Office

# 1 Introduction

## 1.1 Introduction

- 1.1.1 Optimal Economics was appointed by the National Fire Chiefs Council (NFCC) and the National Fire Sprinkler Network (NFSN) to undertake a detailed and comprehensive analysis of data on the activation and performance of sprinkler systems used to control fires in buildings.
- 1.1.2 Fire and rescue services record details of all incidents attended in the Incident Recording System (IRS). Information collected includes information on whether sprinkler systems were present and whether the system was operational during the incident. However, published national fire statistics contain limited information on these issues and it is difficult to measure the performance of these systems from those national statistics. This report makes use of unpublished data collected directly by the NFCC and NFSN from almost all fire and rescue services in the UK to provide a detailed analysis of the performance of sprinkler systems in operating and controlling fires.
- 1.1.3 The report defines two aspects to the performance of sprinkler systems. Operational reliability measures the degree to which systems operate as designed when required and performance reliability measures the effectiveness of the systems when activated.



© West Midlands Fire and Rescue Service

This fire in a seven-unit HMO in Birmingham was caused by an occupant not paying attention to cooking. It caused severe damage to the top floor flat and destroyed part of the roof. The heat and flames also caused damage along the corridors leading to the other flats. Although no occupants were injured in the blaze, the house was left uninhabitable throughout for a period of at least 6 months. The occupants had to relocate and the landlord lost rental income in addition to having to cover the repairs. No sprinklers were fitted in the premises

## 1.2 Structure of Report

- 1.2.1 The remainder of the report is set out as follows:
  - Section 2 provides background information on the data and the framework for the analysis; and
  - Section 3 sets out the analysis and results.

1.2.2 Further information and analysis is contained in the Appendices:

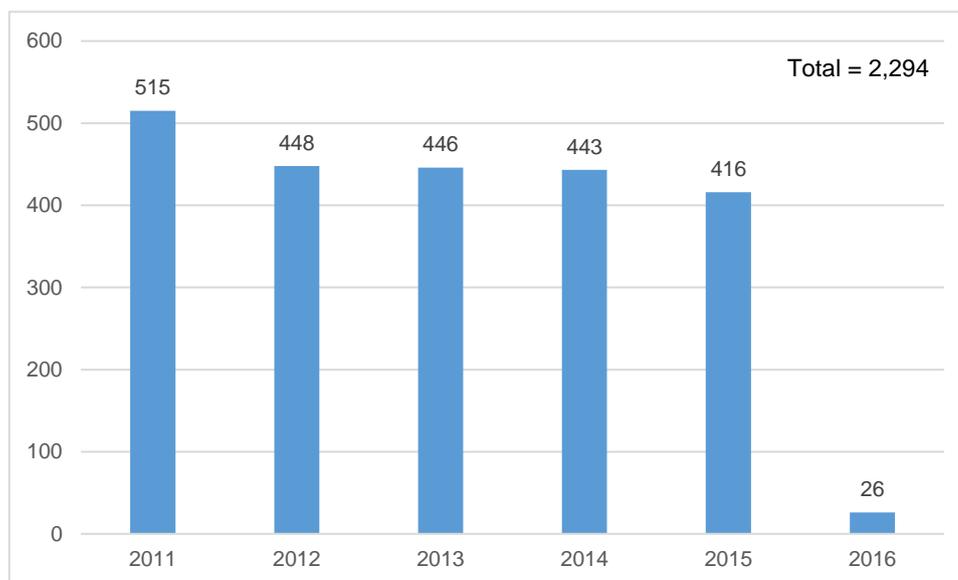
- Appendix A provides information on the characteristics of the data;
- Appendix B sets out detailed analysis by building type; and
- Appendix C provides detailed analysis for four non-residential sectors – industry, retail, warehousing and bulk storage and education.

## 2 Data and Analysis Framework

### 2.1 Sprinkler Data

- 2.1.1 The CFOA and NFSN collected five years of data on fires in premises with sprinklers from 47 fire and rescue services across the UK. A further three services covering island areas confirmed that they did not attend any fires with sprinkler systems. These data provide a very comprehensive dataset on fires in premises with sprinklers in the UK since 2011.
- 2.1.2 Most services provided data for the calendar years 2011 to 2015, but a number of services provided data for the financial years 2011/12 to 2015/16. For presentation, the data are analysed by calendar year. In total, data were provided for 2,294 sprinkler fires in buildings. The distribution of fires by year is shown in Figure 1 with Figures A1 and A2 in Appendix A providing details of the number of fires by region and by fire and rescue service. The number of fires in premises with sprinklers in 2011 was over 500 while the number of fires in the other years varied between 400 and 450. Data for 2016 were incomplete but information was provided on 26 fires,

**Figure 1: Number of Fires with Sprinkler Systems by Year**

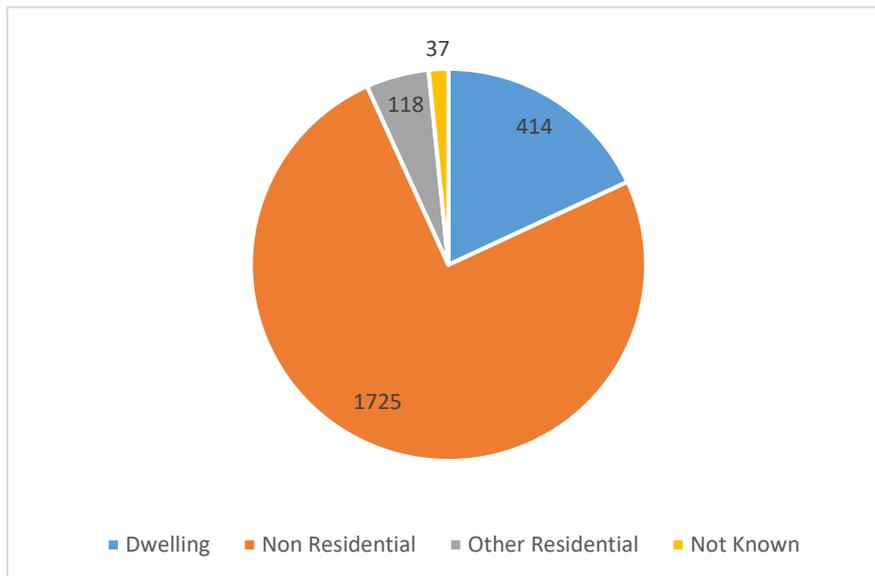


Source: Optimal Economics

Note: 2016 covers January to March only for 11 fire and rescue services

- 2.1.3 The majority of the 2,294 fires with sprinkler systems (1,725 or 75%) were in non-residential buildings with a further 414 (18%) in dwellings (see Figure 2). Figure 3 shows the number of fires by building type and region. While all regions (except for Northern Ireland) had some dwelling fires, dwelling fires in the West Midlands accounted for almost 46% of fires. The position in the West Midlands is understood to reflect local authority policy regarding the use of sprinklers in social housing, particularly in communal bin areas.

**Figure 2: Number of Fires with Sprinkler Systems by Building Type**



Source: Optimal Economics

**Figure 3: Number of Fires with Sprinkler Systems by Building Type and Region**



Source: Optimal Economics

## 2.2 Framework for Analysis

2.2.1 The IRS includes five key fields which are important in the analysis of sprinkler fires:

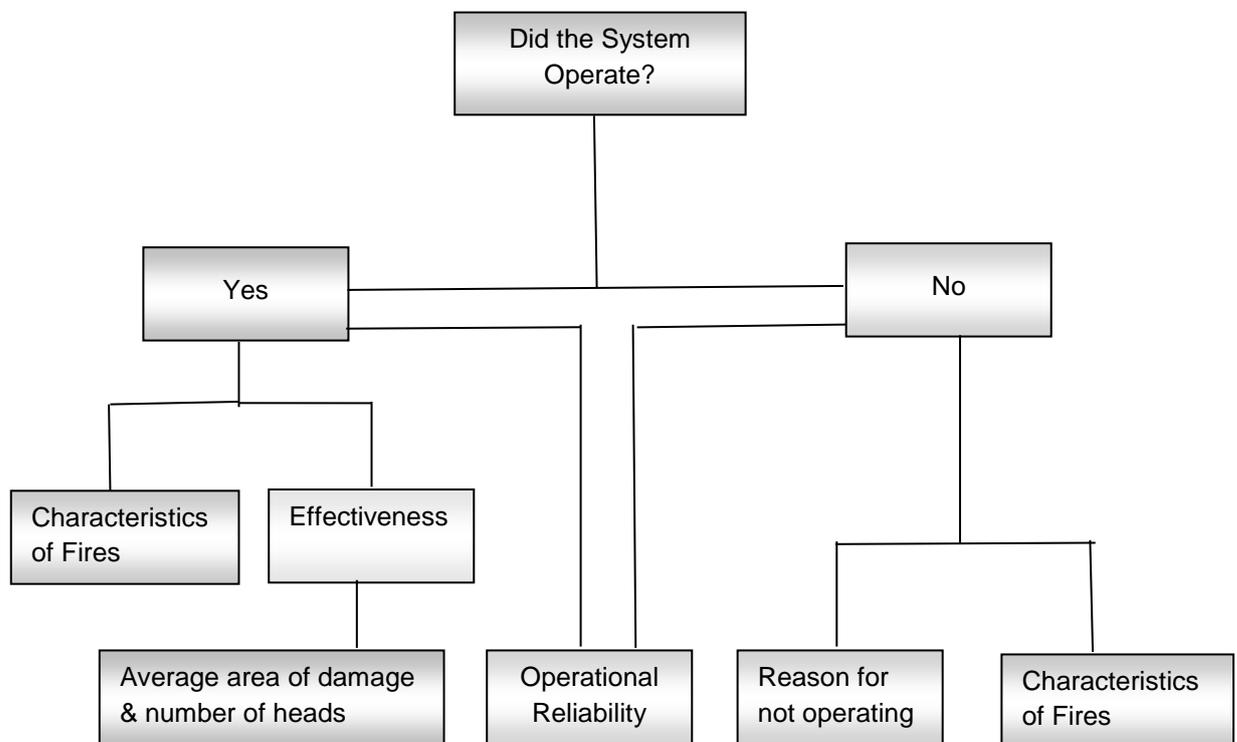
- Did the sprinklers operate?
- What was the location of the sprinklers in relation to the fire?
- How many heads were activated?
- What was the impact on the fire?

- In cases where the sprinkler did not operate, what was the reason the sprinkler did not function?

2.2.2 The data also includes information on property type and fire damage which can add to the understanding of the effectiveness of sprinklers.

2.2.3 The framework for the analysis is shown in Figure 4 and starts with the key question of whether the system operated. If the system did operate then the analysis establishes the characteristics of the fires e.g. where the fire was in relation to the sprinkler system (e.g. in the same room, on a different floor), how many heads activated and the extent of damage. The average area of damage and the average number heads activated are also estimated for those records where both the number of heads and area of damage has been provided. The impact of sprinklers on the fire (e.g. extinguished, contained/controlled) is analysed which enables the performance reliability or effectiveness of the system to be assessed.

**Figure 4: Framework for Analysis**



- 2.2.4 If the sprinkler did not operate, the analysis considers the location of the fire in relation to the sprinklers and the reasons why the sprinkler did not operate. Where the system did not operate the analysis considers whether there are reasons that it could *not* be expected to operate e.g. because there was insufficient heat to activate the sprinkler heads. In assessing the operational reliability of the system the analysis takes account of circumstances where the sprinkler system could not be expected to operate.



A fire occurred at a flat in a block of 26 flats in Suffolk. The vulnerable resident had been smoking in bed before going through to the kitchen where he had an epileptic fit. The bed caught fire due to smoking materials. Nearby residents were alerted by both smoke and sprinkler alarms.

A single sprinkler head operated and fully extinguished the fire. Fire Brigade personnel broke into the flat to gain access, finding the occupant unconscious in the kitchen following his seizure. The sprinkler system prevented the situation becoming much more serious and the resident was also able to return to the flat with minimal disruption.

© Suffolk Fire and Rescue Service

### 3 Analysis and Results

#### 3.1 Introduction

3.1.1 Using the framework for analysis set out in Section 2.2, this section presents the results for all building fires for which we have data. The analysis is shown for all fires and by building type (dwellings, non-residential and other residential) with a more detailed breakdown of the different categories within these building types contained in Appendix B.

#### 3.2 Impact of Sprinkler System Operation

3.2.1 Over the five years of the data, sprinkler systems operated in 945 cases. The majority of the incidents (65%) were in non-residential buildings with a further 29% in dwellings. Details of the number of fires where the sprinkler system operated are shown in Table 1.

	<b>Number</b>	<b>%</b>
Dwellings	276	29.2
Non-residential	610	64.6
Other Residential	42	4.4
Building Type Not Known	17	1.8
<b>All Fires</b>	<b>945</b>	<b>100.0</b>

Source: Optimal Economics Analysis

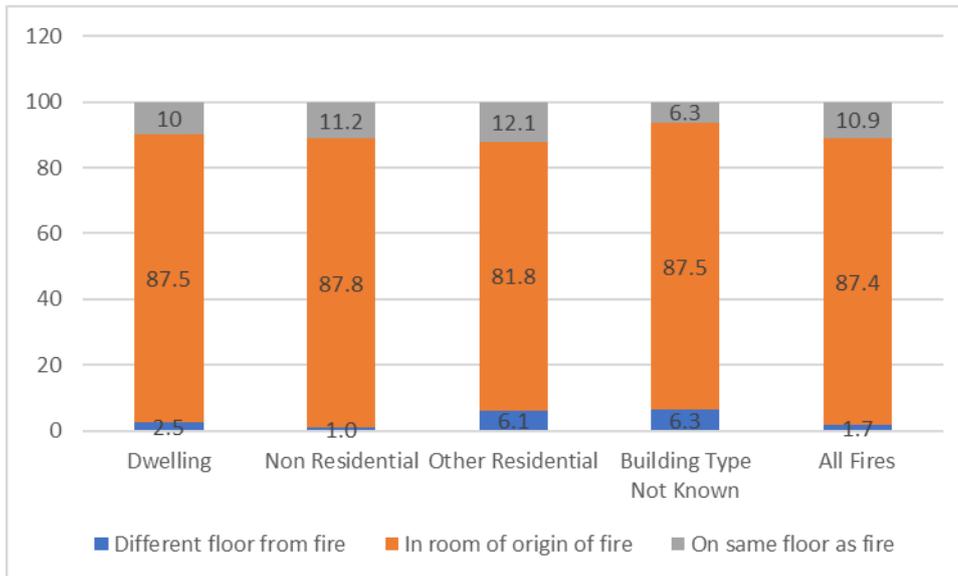


An electric heat lamp in the animal care classroom of a Newcastle school malfunctioned causing a fire with over 200 people on-site. One sprinkler head activated which confined the damage to the room of origin and extinguished the fire. A number of small animals were in the room involved and all survived whilst no other areas of the school were affected. Damage was limited to a wooden bench and minor smoke damage amounting to less than 1% of the whole building. Damage was repaired quickly.

© Tyne and Wear Fire and Rescue Service

3.2.2 Of the 945 fires where the system operated, data on the location of the system are available for 532 cases. For these fires, Figure 5 shows the location of the system in relation to the fire. Across all these cases the sprinkler system was in the room of origin of the fire in 87% of cases.

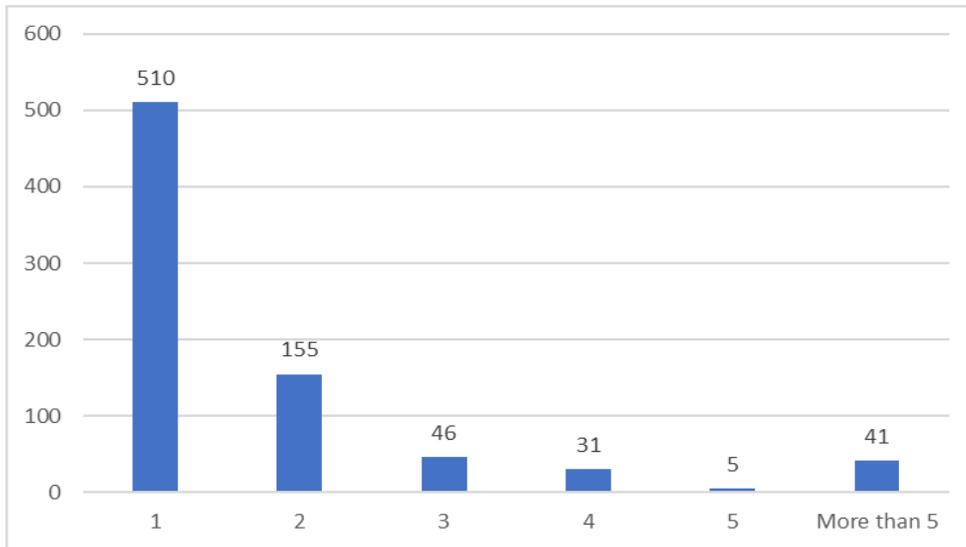
**Figure 5: Location of Sprinkler System where System Operated by Building Type, %**



Source: Optimal Economics

3.2.3 Of the 945 fires where the system operated, data are available on the number of sprinkler heads activated for 788 incidents. The distribution of these fires by number of heads operating is shown in Figure 6. In 65% of fires, only one sprinkler head was activated with a further 20% of fires activating two heads. For 95% of fires where the sprinkler operated, five or less heads were activated. In the remaining 41 fires (5%), more than 5 heads were activated and these larger fires (in terms of the number of heads) tended to be in non-residential buildings - 35 of the 41 incidents.

**Figure 6: Number of Fires by Number of Heads Activated**



Source: Optimal Economics



A fire was reported in a dust extraction unit at a joinery workshop in Nottingham.

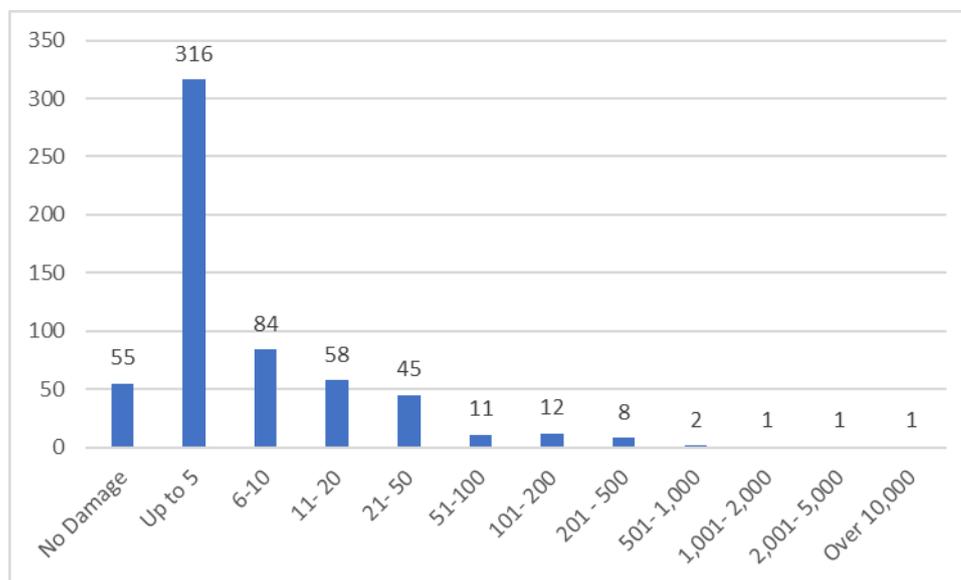
The Fire Service found the fire was located inside the unit and that one sprinkler head above the unit had been activated. This had prevented the fire from spreading to other plant and materials. The unit was on fire internally and had badly smoke logged the workshop but, because the fire was contained, fire-fighters were able to extinguish it without too many problems

Fires in wood-working premises often take hold very quickly, resulting in extensive fire spread and damage. The sprinkler system had prevented this from happening.

© Nationwide Sprinklers

3.2.4 In terms of the area of fire damage, data are available for 594 fires where the system operated. The distribution of these fires by size of area damaged is shown in Figure 7. In the majority of fires where the sprinkler system operated there was a relatively small area of fire damage. Over 62% of the incidents had a fire damage area of up to 5 square metres (sq. m.) with a further 24% of fires having damage between 6 and 20 sq. m. Some 94% of fires where the area of damage is known had damage of less than 50 sq. m. There were no incidents in dwellings or other residential buildings which had an area of fire damage of over 100 sq. m. There was one fire where the area of damage was over 10,000 sq. m. and four fires with between 500 and 5,000 sq. m. of damage. All these fires were in non-residential buildings.

**Figure 7: Number of Fires by Area of Fire Damage (sq. m.)**



Source: Optimal Economics

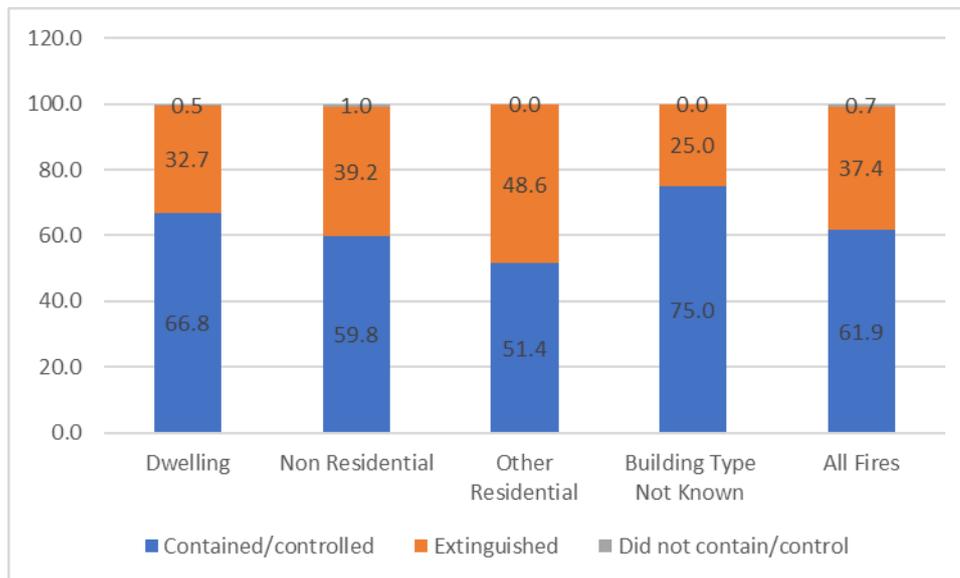
3.2.5 As a sprinkler system should provide sufficient water to control a fire, contact was made with the fire and rescue services reporting the very large fires to understand more about these cases. Further information was provided on three of the five very large fires:

- *Fire with over 10,000 sq. m. of damage:* This fire was in a factory manufacturing tissue paper. The manufacturing process produces a lot of paper fibres/lint which can accumulate around the building. In this case, there were sprinklers in the building, but the paper fibre/lint spread the fire. The dataset notes that only four sprinkler heads operated which is not consistent with damage of over 10,000 sq. m. as more sprinklers would be expected to open. It is possible that the recording of fire damage may not be accurate as there can be uncertainty between what constitutes fire and smoke damage.<sup>4</sup> It is concluded that the fire damage in this case was likely to be less than the 10,000 sq. m. reported and the damage area can be considered an overstatement.

<sup>4</sup> Note that the annual reports for the company were identified and reviewed over three years and there is nothing in the annual reports about a major fire in 2014. Fire damage of such magnitude would normally feature in the annual report.

- *Fire with 2,001-5,000 sq. m. of damage:* This fire was in a plant that handled and recycled plastic hangers comprising two adjoining buildings. The first building was gutted by the fire but the second remains intact. This fire started outside the buildings in a variety of externally stored combustible materials but, due to the nature of the materials, the fire spread. The external fire spread caused an explosion amongst liquid petroleum gas containers which spread the fire significantly to nearby vehicles, further stored goods and then into the factory. The sprinkler system in the factory operated at an early stage, but was overwhelmed by the explosion. The sprinkler system in the warehouse also operated and helped to save the warehouse.
  
  - *Fire 501-1,000 sq. m.:* This fire was in a machine that spread to the roof frame and ducting which made the sprinklers less effective.
- 3.2.6 The additional information provided for the very large fires highlights that specific instances contributed to the large areas of damage reported. However, these fires are very rare, accounting for less than 1% of all fires where the system operated and the area of damage is known.
- 3.2.7 The impact of the sprinkler system in controlling or extinguishing the fire is known for 677 fires of the 945 fires where the system operated and is shown in Figure 8. The data can be used to measure the performance reliability of the system. Performance reliability measures the effectiveness of the system when it is activated and is defined in this report as the proportion of fires (where the sprinkler system operated) which are either contained/controlled or extinguished. Across all fires the sprinkler systems contained or controlled the fires in 62% of incidents and extinguished the fire in a further 37% of incidents. Hence, the performance effectiveness of sprinkler systems is 99% across all building types.
- 3.2.8 The other residential and “building type unknown” categories had the highest performance effectiveness rate with all fires being either contained/ controlled or extinguished. Dwellings and non-residential buildings had performance effectiveness rates of 99%. The other residential building category had a relatively high proportion of fires *extinguished* by the system (49%).

**Figure 8: Impact on Fires where System Operated by Building Type, %**



Source: Optimal Economics

3.2.9 To calculate the average number of heads operating and the average area of damage, the analysis is restricted to the 496 incidents which provided both the number of heads and the area of damage. In calculating the average number of heads operating, it is assumed that, in the “more than 5 heads” category, the number of heads operating is based on the area of damage and the assumption that one head would cover 10 sq. m. For example, if a fire is in the damage range of 51-100 sq. m. the mid-point of the range is 75.5 so eight heads are assumed to operate.

3.2.10 Table 2 shows the average number of heads operating by building type and the number of incidents by building type. The average number of heads operating across all fires was 2.7.

<b>Table 2: Average Number of Heads Activated by Building Type</b>		
	<b>No. of Fires</b>	<b>Average No. of Heads</b>
Dwellings	144	1.5
Non-residential	315	3.3
Other Residential	22	1.7
Building Type Not Known	15	2.1
<b>All Fires</b>	<b>496</b>	<b>2.7</b>
Source: Optimal Economics		

- 3.2.11 Assuming that the average area of damage lies at the mid-point of the damage range the average area of fire damage has been calculated. For the over 10,000 sq. m. category a value of 12,000 sq. m. has been assumed. Details are shown in Table 3 by building type. Two average figures have been calculated – one which is the average area of damage across all fires and one where the fire with damage over 10,000 sq. m. as described above has been excluded.
- 3.2.12 Across all fires the average area of damage is 46 sq. m. but this figure is heavily influenced by one very large fire. If it is excluded, the average area of damage across all fires is halved to 22 sq. m. The damage areas for dwellings and other residential buildings were far smaller than for non-residential properties.



© Hereford and Worcester Fire and Rescue Service

Fire-fighters were called to a shopping centre in Worcester after a fire broke out in the basement of a stationary shop where stock was stored.

Sprinklers fitted in the basement operated as the fire started, effectively containing the fire and allowing fire-fighters to extinguish what was left of the blaze. With the fire out, crews then diverted water from the basement into the drainage system.

There was a minimal amount of damage to stock from the fire and some water damage from the sprinklers. However, without the sprinklers operating, it is very doubtful that the shop would have been able to open for business on the day of the fire.

	<b>No. of Fires</b>	<b>Average All Fires</b>	<b>Average Excluding Fire over 10,000 sq. m.</b>
Dwellings	144	3.7	3.7
Non-residential	315	68.4	30.4
Other Residential	22	7.2	7.2
Building Type Not Known	15	51.2 <sup>1</sup>	51.2 <sup>1</sup>
<b>All Fires</b>	<b>496</b>	<b>46.4</b>	<b>22.2</b>
Source: Optimal Economics			
Notes: (1) – two of the 15 fires in this category had damage in the range 201 to 500 sq. m. which has a substantial effect on the average area of damage. Excluding these two fires reduces the average area of damage to 5.2 sq. m. Both these fires show less than 5 heads operating which suggests that the area of damage may be mis-reported.			

- 3.2.13 Fires in dwellings where the sprinkler system operated had an average area of fire damage of under 4 sq. m. This compares to an average area of fire damage of approximately 18 to 21 sq. m. for *all* dwelling fires in England between 2011/12 and 2015/16<sup>5</sup>. Other residential buildings also had an average area of damage under 8 sq. m.
- 3.2.14 On average, non-residential fires were substantially larger (68 sq. m.) than dwelling fires and other residential fires. This figure may be compared with the reported average area of fire damage of approximately 77 to 85 sq. m. for “other building” fires in England between 2011/12 and 2015/16<sup>6</sup>. Excluding the fire with over 10,000 sq. m. of damage reduces the average area of damage of fires in premises with sprinklers to 30 sq. m. which compares favourably with 59 to 62 sq. m. of damage reported for all “other building” fires in England between 2011/12 and 2015/16 when fires with over 10,000 sq. m. are excluded.
- 3.2.15 The presence of sprinklers appears to be highly effective in reducing the fire damage area in all building types. In residential properties average damage is reduced by at least 75% and in other properties by about half.

<sup>5</sup> Fire Statistics Table 0204, Fire Statistics Data Tables, Home Office

<sup>6</sup> Fire Statistics Table 0305, Fire Statistics Data Tables, Home Office

### 3.3 System did not operate

3.3.1 Over the five years of the data, the sprinkler system did not operate in 1,316 instances with the majority of the incidents (82%) in non-residential buildings. Details of the number of fires where the sprinkler system did not operate are shown in Table 4.

<b>Table 4: Number of Fires where Sprinkler Systems did not Operate by Building Type</b>		
	<b>Number</b>	<b>%</b>
Dwellings	134	10.2
Non-residential	1,087	82.6
Other Residential	75	5.7
Building Type Not Known	20	1.5
<b>All Fires</b>	<b>1,316</b>	<b>100.0</b>
Source: Optimal Economics		



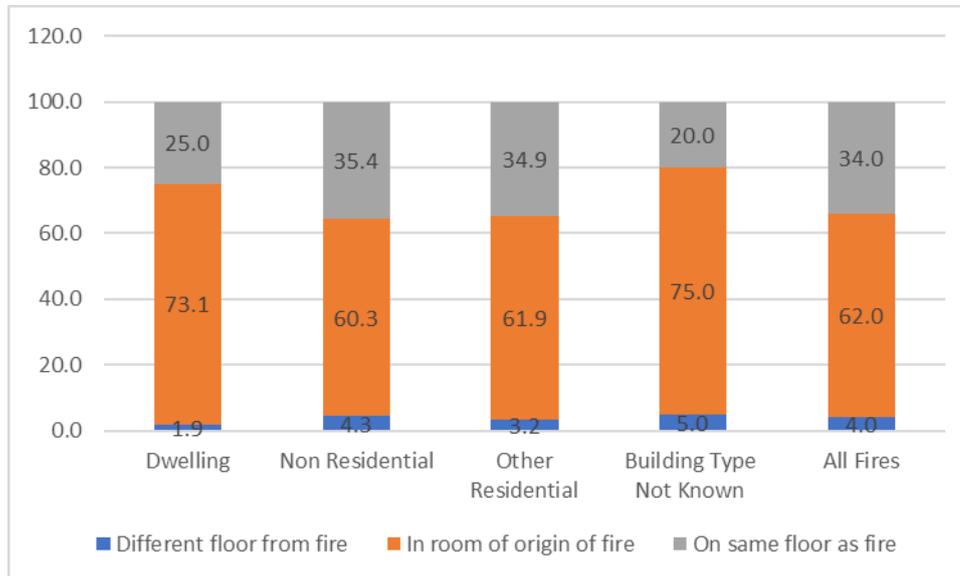
This fire occurred at a large high school in the West Midlands. The 1000 pupils were evacuated as fire spread rapidly through the science block. More than 100 fire-fighters attended the blaze which caused major damage and severe short term disruption to transport links. Pupils experienced long term disruption to their education, with many losing course work as a result of the fire. The damage was estimated to have been at least £15 million.

The school was rebuilt but the new school was not fitted with sprinklers.

© West Midlands Fire and Rescue Service

3.3.2 Of the 1,316 fires where the system did not operate, data are available on the location of the system for 1,050 fires. Figure 9 shows the location of the system in relation to the fire. Across all fires where the sprinkler system did not operate, the system was in the room of origin in 62% of cases compared to 87% of cases when the system did operate (Figure 5). The system was on the same floor but not in the same room as the fire in 34% of incidents where the system did not operate. Where the fire was not in the room of origin of the fire, the system could not have been expected to operate unless the fire grows into that area.

**Figure 9: Location of Sprinkler System where System did not Operate by Building Type, %**



Source: Optimal Economics

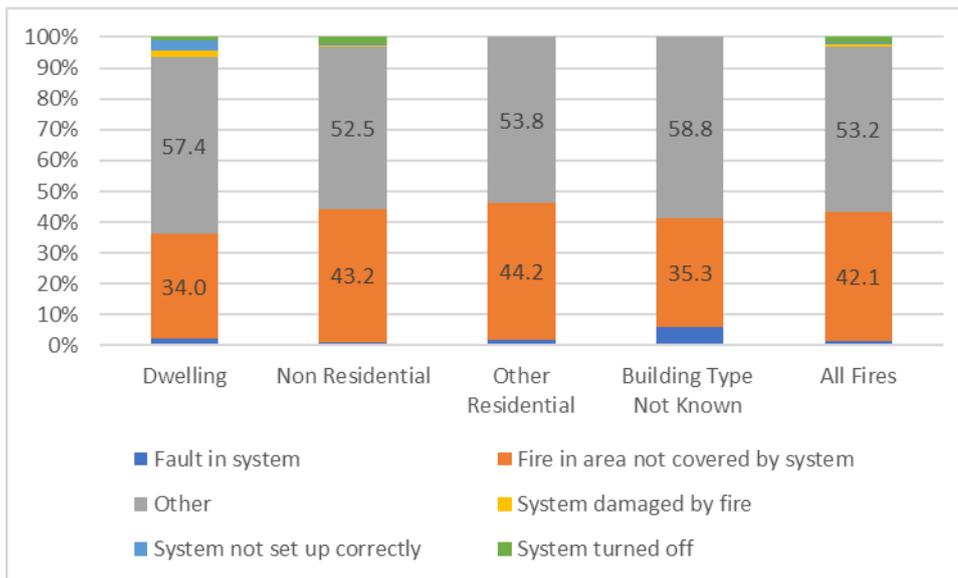
3.3.3 Information on the reasons why the sprinkler system did not operate is available for 879 fires and these are shown in Figure 10. The reasons for the system not operating are dominated by two categories:

- The fire was in an area not covered by the system – 370 incidents (42% of fires)
- “Other” – 468 incidents (53% fires)

3.3.4 There were a number of “system” reasons why the sprinkler did not operate, including:

- Fault in the system – 12 incidents (1.4% of fires)
- System not set up properly – 4 incidents (0.5% of fires)
- System damaged by fire – 7 incidents (0.8% of fires)
- System turned off – 18 incidents (2% of fires).

**Figure 10: Reasons why Sprinkler System did not Operate by Building Type, %**



Source: Optimal Economics

- 3.3.5 Within the reporting system, there is scope to provide more information if “other” is given as the reason for the sprinkler system not operating. A total of 468 incidents (53% of fires) gave “other” as the reason for the system not operating and of these 145 provided further information which is shown in Table 5. Insufficient heat is the main reason for the system not operating.
- 3.3.6 Figure 11 shows the “other” reasons for the system not operating by building type. For dwellings and other residential buildings, insufficient heat was the only “other” reason cited for the system not operating.



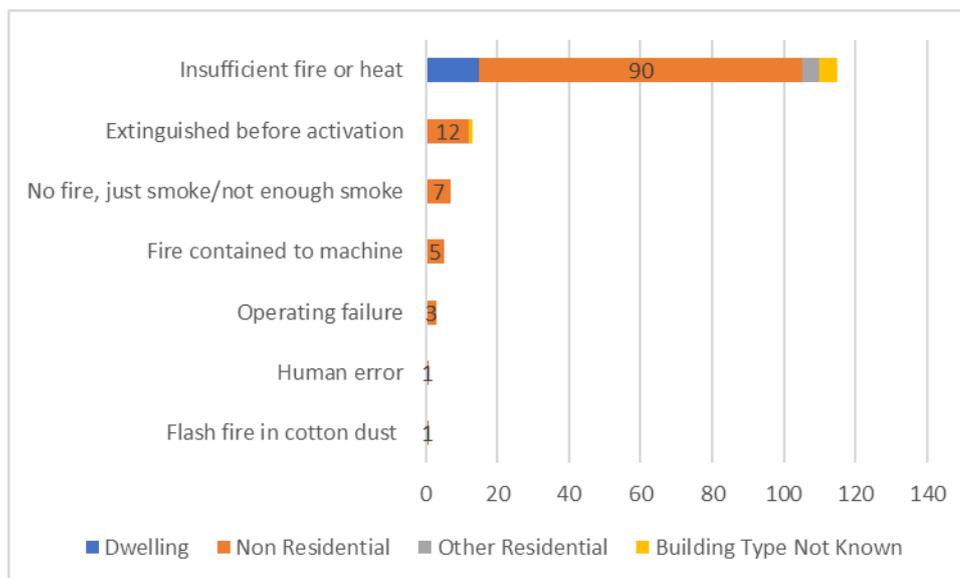
© West Midlands Fire and Rescue Service

This fire destroyed large sections of the National Motorcycle Museum in Birmingham, along with hundreds of exhibits, including rare and vintage motorcycles. The fire is believed to have started outside the building and spread into the roof where it spread rapidly through the roof voids, destroying three of the five exhibition halls, along with their contents. Over 120 fire-fighters attended the fire with poor water supplies at the site proving disadvantageous. The complex was rebuilt with sprinkler protection included and slowly the collection has been rebuilt or replaced.

	<b>Number</b>	<b>%</b>
Insufficient fire or heat	115	79.3
Extinguished before activation	13	9.0
No fire, just smoke/not enough smoke	7	4.8
Fire contained to machine	5	3.4
Operating failure	3	2.1
Human error	1	0.7
Flash fire in cotton dust	1	0.7
<b>Total</b>	<b>145</b>	<b>100.0</b>

Source: Optimal Economics

**Figure 11: “Other” Reasons for System not Operating by Building Type**



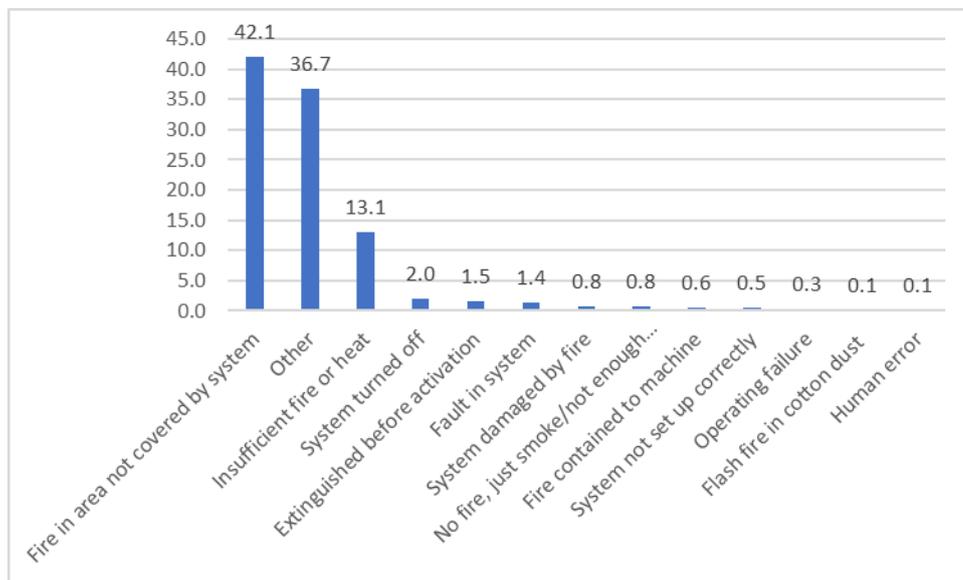
Source: Optimal Economics

3.3.7 Combining the additional information on “other” reasons in Table 5 with the data in Figure 10 yields a more comprehensive analysis of the reasons for systems not operating. Details are shown in Figure 12. From the figure it is clear that in many cases the system could not have been expected to operate including:

- Fire in an area not covered by the system
- Insufficient fire or heat
- Fire extinguished before activation
- Fire contained to machine
- No fire, just smoke/not enough smoke

3.3.8 Hence, in 58% of cases where the system did not operate, it was because it could not be expected to operate, primarily because the fire was in an area not covered by the system or there was insufficient fire or heat. Known cases of system failure are very rare with a fault in the system occurring in 12 cases (1.4% of fires) and operating failure occurring in three cases (0.3%) of fires. In 18 cases (2% of fires), the system was turned off. No further information is available to determine if the system was turned off or decommissioned. If decommissioned, the system could not have been expected to operate and would not be classified as a system failure. However, in the absence of additional information we have assumed that all fires where the system was turned off are system failures.

**Figure 12: Distribution of Reasons for Sprinkler not Operating, %**

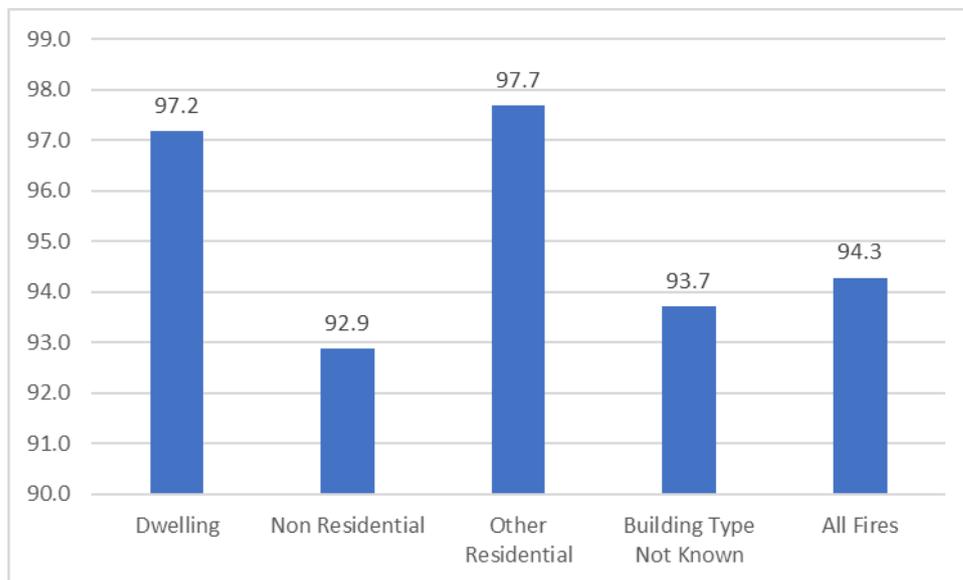


Source: Optimal Economics

- 3.3.9 “Other” remains a relatively large category with 323 fires (37%) where no further information is available. If we assume that these cases had the same profile of reasons for the system not operating as the 145 fires in Table 5 we can make a calculation of operational reliability
- 3.3.10 Operational reliability measures the probability that a system will operate as designed when required. In the circumstances listed in paragraph 3.3.7 the system could not have been expected to operate. Operational reliability can be calculated as the number of fires where the system operated as a proportion of the number of fires where it could be expected to operate<sup>7</sup>. If, as suggested above, we assume that the “unknown” cases had the same profile as the known cases then across all building types, the operational reliability of sprinkler systems was 94%. This may be an understatement of operational reliability as some of the cases where the system was turned off may not be cases of system failure if the system had been decommissioned. Figure 13 shows the reliability by building type.
- 3.3.11 The operational reliability of dwellings and other residential buildings was 97% and 98% respectively while in non-residential buildings operational reliability was 93%.

<sup>7</sup> Of the 879 incidents where the reason is known for the sprinkler system not operating, it could only have been expected to operate in 57 cases (6.5%)

**Figure 13: Operational Reliability by Building Type, %**



Source: Optimal Economics

### 3.4 Data Limitations

- 3.4.1 Paragraph 2.2.1 described the five key fields in the IRS which relate to sprinkler systems. In undertaking the analysis of each of these data fields, there were always instances where some of the incidents did not record an outcome in the data field. These “not knowns” have been excluded from the analysis, but it would enhance any datasets for future analysis if the number of “not knowns” were reduced.
- 3.4.2 The codes used to describe the reasons why the system did not operate are not capturing the main reasons for the system not operating with the “other” category dominating responses. Although there is an option to provide further information for the “other” cases, this information is not provided in the majority of incidents. If a review of the IRS was being undertaken, it would be beneficial to include some additional codes to cover additional reasons for the system not operating. This would reduce the use of “other” as a reason. It is recommended that insufficient heat or fire is added as an additional code.
- 3.4.3 To ensure the calculation of operational reliability is as accurate as possible, it would enhance the analysis if the reason why the system was turned off was known. It is recommended that the code covering the system being turned off is split into two codes with one covering cases where the system has been decommissioned.

### 3.5 Conclusions

3.5.1 The main conclusions to be drawn from the analysis are:

- Sprinkler systems are very effective when they operate, containing/controlling or extinguishing the fire in 99% of cases.
- In terms of damage reduction, where sprinklers operate they reduce damage to residential properties by 75% and to non-residential properties by around 50%.
- When the system does not operate, this is almost always because it could not be expected to operate. It is concluded that in 94% of cases where the system did not operate, it was because the system could not have been expected to operate.
- Operational reliability measures the probability that a system will operate as designed when required. Across all building types, the operational reliability of sprinkler systems is 94%.



© West Midlands Fire and Rescue Service

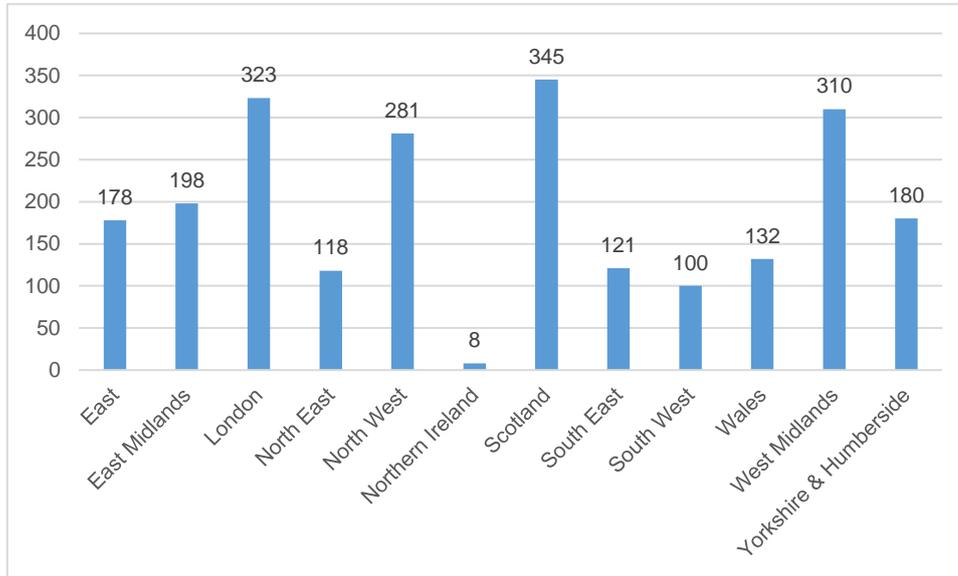
A fire broke out in the A&E department of Sandwell and District Hospital in West Bromwich with the fire and smoke spreading rapidly and large sections of the hospital evacuated, including operating theatres which were in use at the time. Some patients were transported in emergency vehicles so that their treatment could continue at other hospitals nearby. The fire was particularly severe and caused £11 million of damage. The A&E was completely rebuilt at a cost of £18m. As a result of the lessons learned from the fire, sprinkler provision was provided as part of the rebuild programme.

# Appendix A

## Data Characteristics

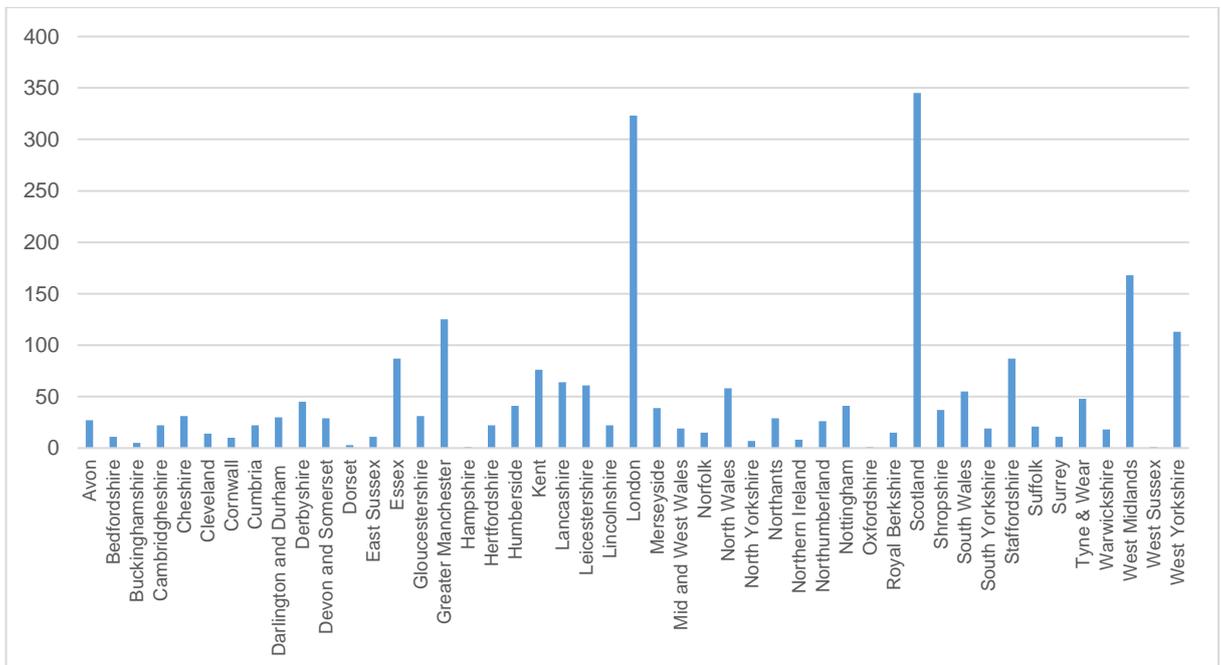
## Appendix A

**Figure A1: Number of Fires by Region, 2011 - 2016**



Source: Optimal Economics

**Figure A2: Number of Fires by Fire and Rescue Service**



Source: Optimal Economics

## Appendix B

### Detailed Analysis by Building Type

## Appendix B: Detailed Analysis by Building Type

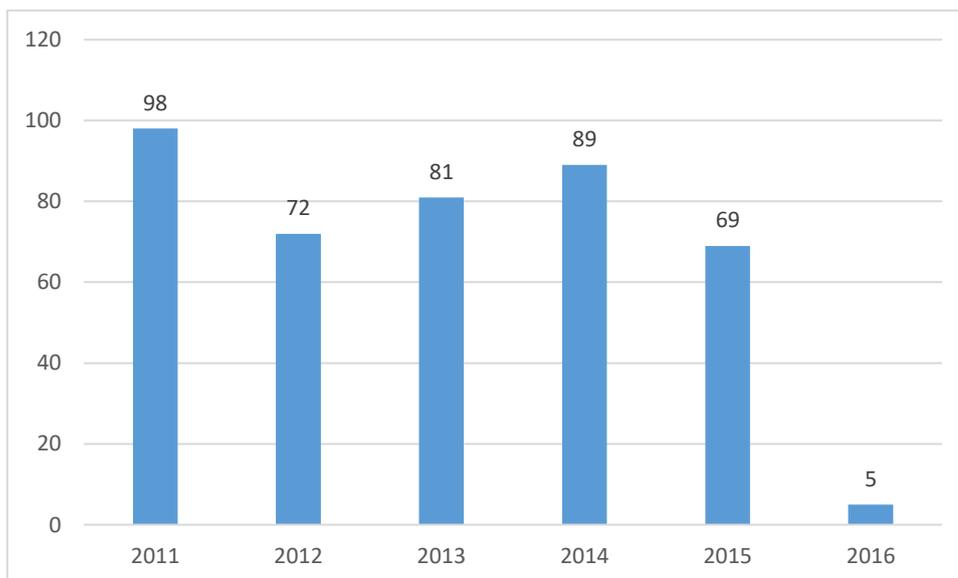
### INTRODUCTION

The main report presents the result of the analysis for all fires by property type i.e. dwellings, non-residential and other residential buildings. This Appendix provides a more detailed breakdown of results for each of these building types.

### DWELLING FIRES

Figure B1 shows the distribution of the 414 dwelling fires where sprinklers were fitted across the period from 2011 with Figure B2 showing the distribution across the different dwelling categories. The number of fires ranged from 98 in 2011 to 69 in 2015. The largest number of fires (190 or 46%) were in purpose built flats with a further 146 (35%) fire in dwellings where the type is unknown.

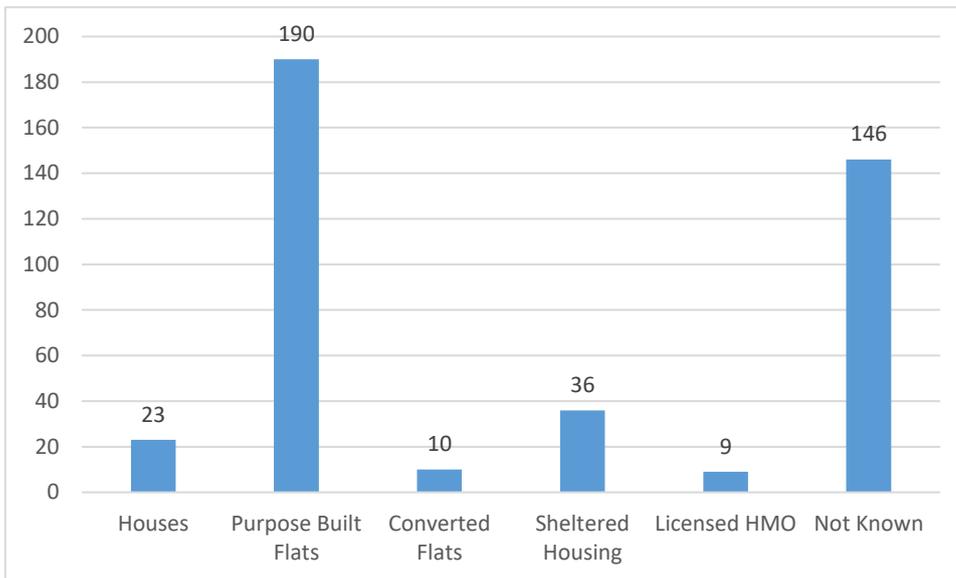
**Figure B1: Number of Fires with Sprinklers in Dwellings by Year**



Source: Optimal Economics

Note: 2016 covers January to March for 11 fire and rescue services

**Figure B2: Number of Fires with Sprinklers by Type of Dwelling**



Source: Optimal Economics

**Dwellings: System Operated**

Of the 414 dwelling fires, the system operated in 276 instances. However, data are limited on the location of the system to 80 fires. Figure B3 shows the location of the system in relation to the fire for these cases. Across all fires where the sprinkler operated, the sprinkler was in the room of origin of the fire in 88% of cases.

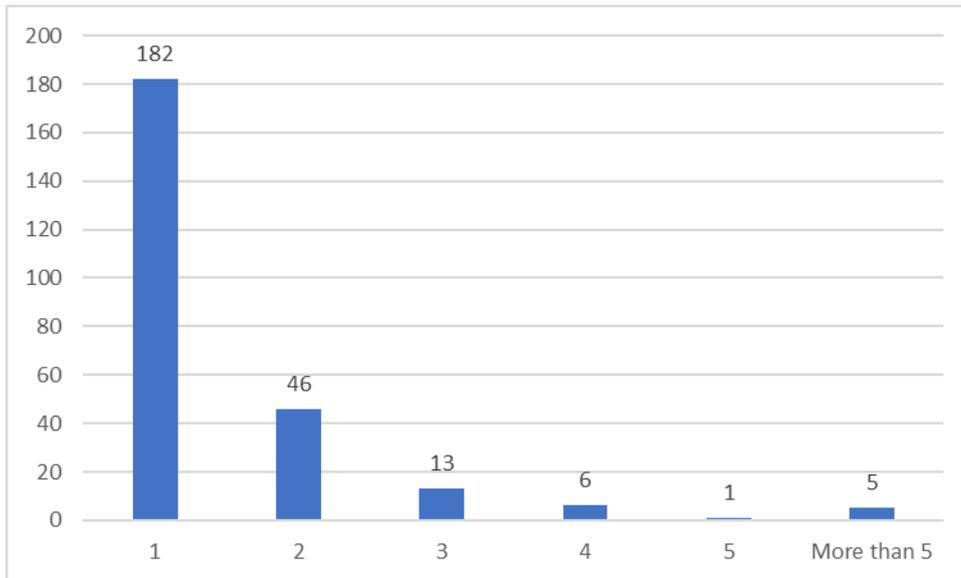
**Figure B3: Location of Sprinkler System where System Operated by Dwelling Type, %**



Source: Optimal Economics

Of the 276 dwelling fires where the system operated, data are available on the number of heads operating for 253 cases. Figure B4 shows the number of fires across the number of heads operating. In the majority of cases (72%), only one head operated.

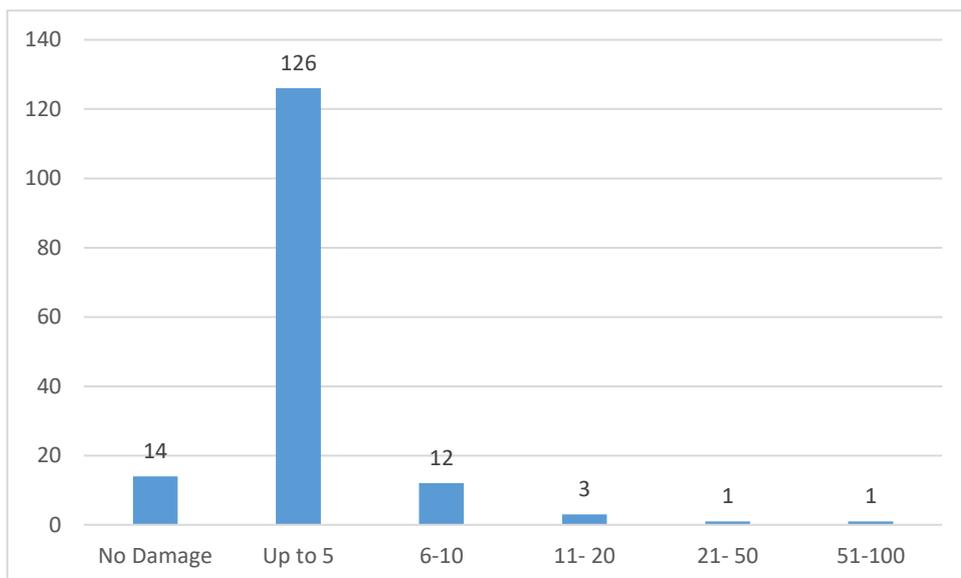
**Figure B4: Number of Dwelling Fires by Number of Heads Activated**



Source: Optimal Economics

In terms of the area of fire damage where the sprinklers operated, data are available for 157 of the 276 fires. The number of fires by area is shown in Figure B5. Some 89% of fires had less than 5 sq. m. of fire damage.

**Figure B5: Number of Dwelling Fires by Area of Fire Damage, sq. m.**



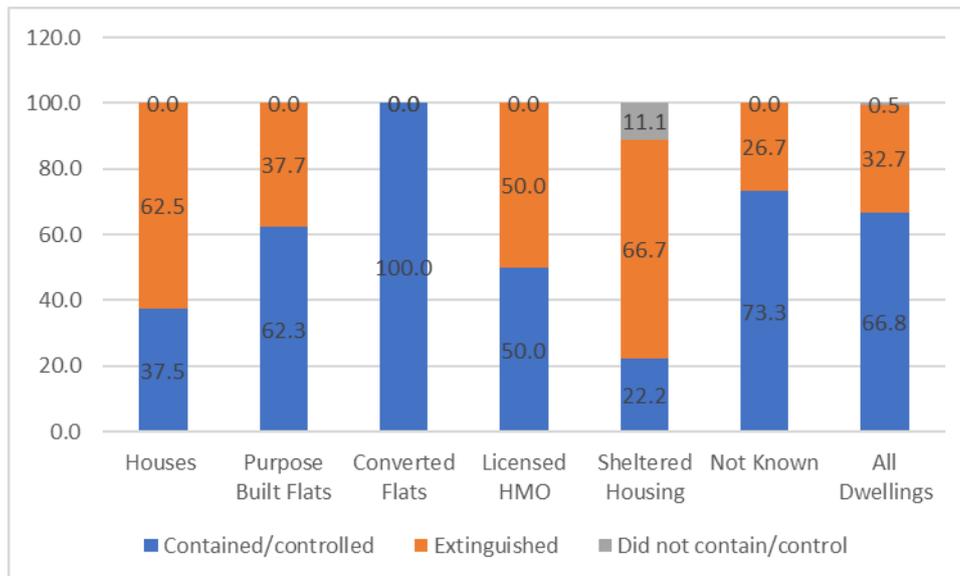
Source: Optimal Economics

Although information on the number of heads operated and area of damage is available for 144 dwelling fires, when these cases are disaggregated by dwelling sub-categories, the sub-category is known for only 54 fires. As the number of cases per sub-category is small, the average number of heads operating and the average area of damage has not been calculated by dwelling sub-category. For all dwelling types the average number of heads to operate was 1.5 and the average area of damage was 3.7 sq. m.

The impact of the sprinkler system on the fire is known for 208 of the 276 fires where the system operated. Figure B6 shows the effectiveness of the system in containing the fire by dwelling type. Across all dwellings, the performance effectiveness of the system in containing/controlling or extinguishing the fire was over 99%.

For all dwelling types except for sheltered housing, the system contained/ controlled or extinguished the fire in 100% of cases. Although the proportion of fires in sheltered housing that were not contained/controlled seems high at 11%, this is only one fire from a total of nine.

**Figure B6: Impact of Sprinkler System on Dwelling Fires**

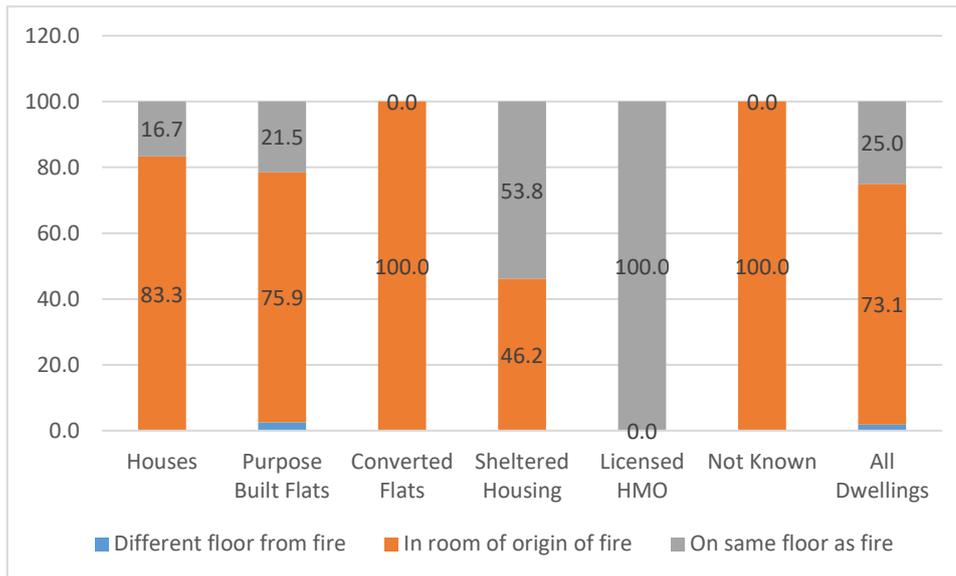


Source: Optimal Economics

**Dwellings: System did not Operate**

Over the five years of data, there were 134 cases where the system did not operate. Data are available on the location of the system for 108 cases and this is shown in Figure B7. The sprinkler system was located in the room of origin of the fire in 73% of incidents where the sprinkler did not activate. In the one licensed HMO case and in seven of the 13 incidents in sheltered housing where the system did not activate, the system was located elsewhere on the same floor as the fire.

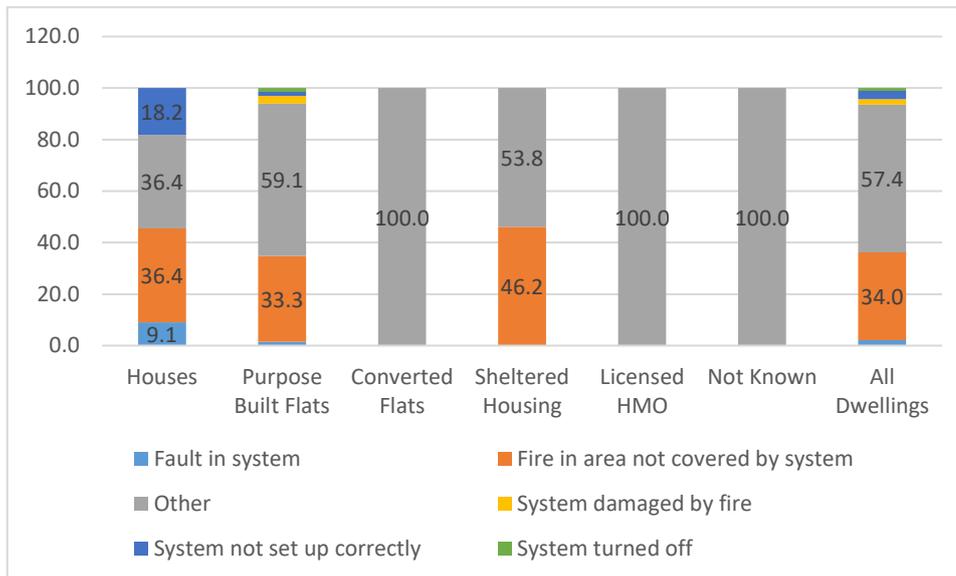
**Figure B7: Location of Sprinkler System in Dwelling Fires where the System did not Activate by Dwelling Type, %**



Source: Optimal Economics

The reason why the system did not operate is known for 94 of the 134 cases. Details are shown in Figure B8. For all categories of dwellings, the main reason why the system did not operate is either the fire is in an area not covered by the system or “other”. Of 54 cases where “other” was given as the reason for the system not operating, 15 cases provided further information and all 15 gave insufficient fire or heat as the reason for non operation.

**Figure B8: Reasons for Sprinkler System not Operating by Dwelling Type**



Source: Optimal Economics

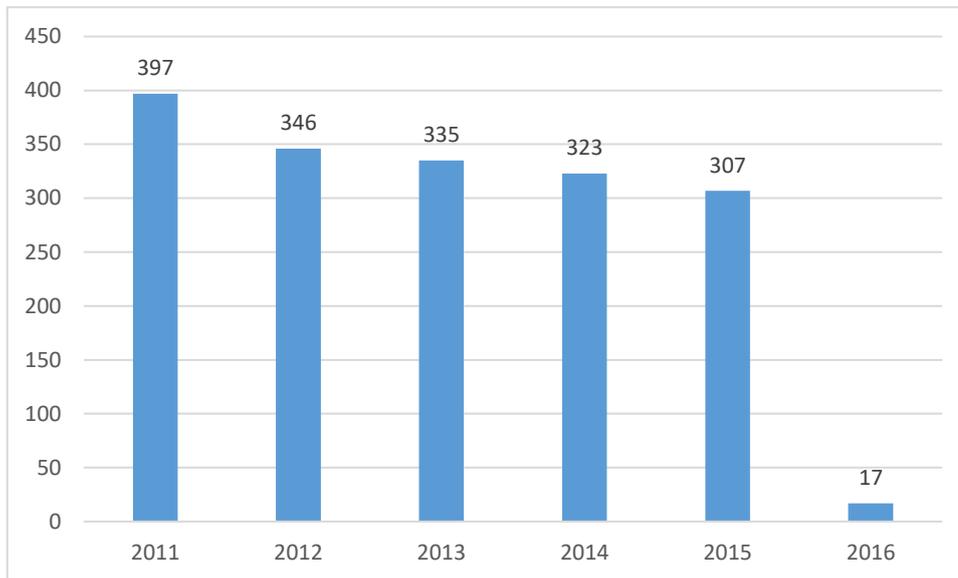
Across all dwelling types and for cases for which data are available, operational reliability was 97%. For converted flats, sheltered housing, licensed HMOs and dwelling type not known, operational reliability is calculated to be 100%. Sprinklers in purpose built flats had operational reliability of 96% while in houses operational reliability was lower at 77%. This lower rate in houses reflects the fact that of the eleven cases where the reason for non-operation is known, there was one incident with a fault in the system and two incidents where the system was not set up correctly. Care should be taken interpreting the reliability figures for individual dwelling categories as the number of incidents by individual category can be small.

## NON-RESIDENTIAL FIRES

Figure B9 shows the number of non-residential fires across the period from 2011 with Figure B10 showing the number of fires by the individual non-residential sectors. The number of fires ranged from 397 in 2011 to 307 in 2015. The largest number of fires (629 or 36%) are in industrial premises (either manufacturing or processing) with a further 443 (26%) of fires in retail premises.

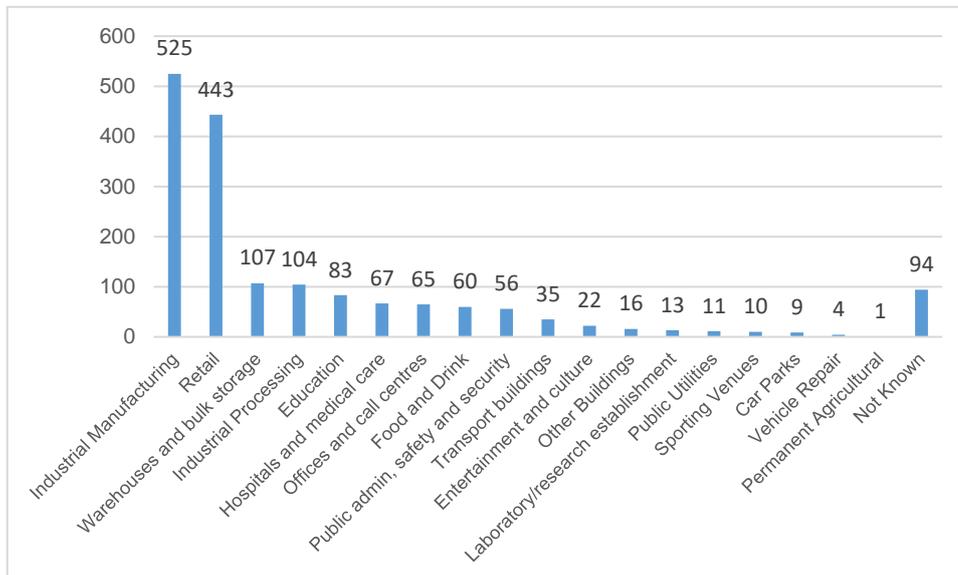
The four non-residential sectors with over 100 fires (industrial (manufacturing and processing combined), retail, warehouses and bulk storage and education) are analysed in further detail in Appendix C.

**Figure B9: Number Fires with Sprinklers in Non-Residential Buildings by Year**



Source: Optimal Economics

**Figure B10: Number of Fires with Sprinklers by Non-Residential Sector**

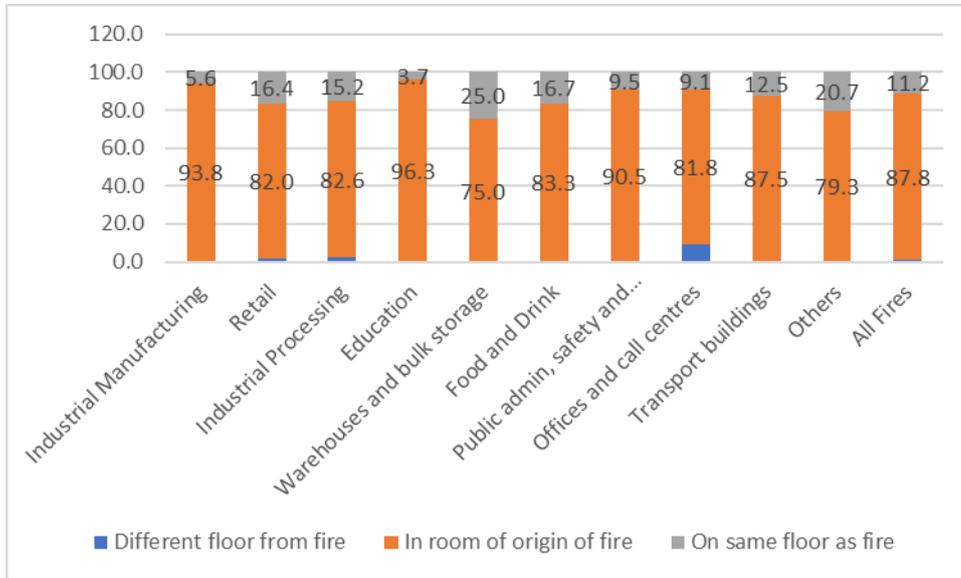


Source: Optimal Economics

**Non-Residential: System Operated**

Of the 1725 non-residential fires, the system operated in 610 instances with data on the location of the system available for 403 fires. Figure B11 shows the location of the system in relation to the fire. Across all fires where the sprinkler operated, the sprinkler was in the room of origin of the fire in 88% of cases.

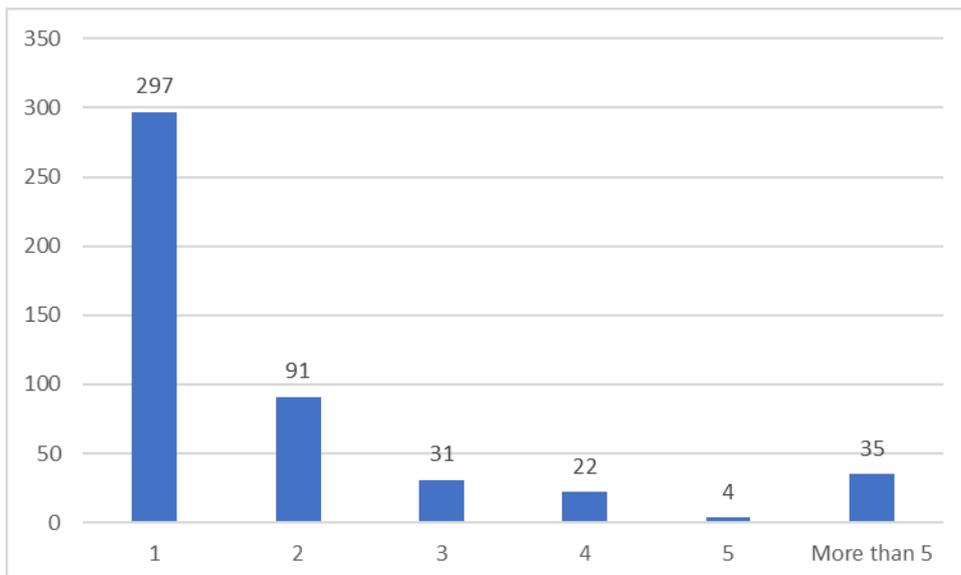
**Figure B11: Location of Sprinkler System where System Operated by Non-Residential Sector, %**



Source: Optimal Economics

Of the 610 non-residential fires where the system operated, data are available on the number of heads operating for 480 cases. Figure B12 shows the distribution of fires across the number of heads operating. In the majority of cases (62%), only one head operated.

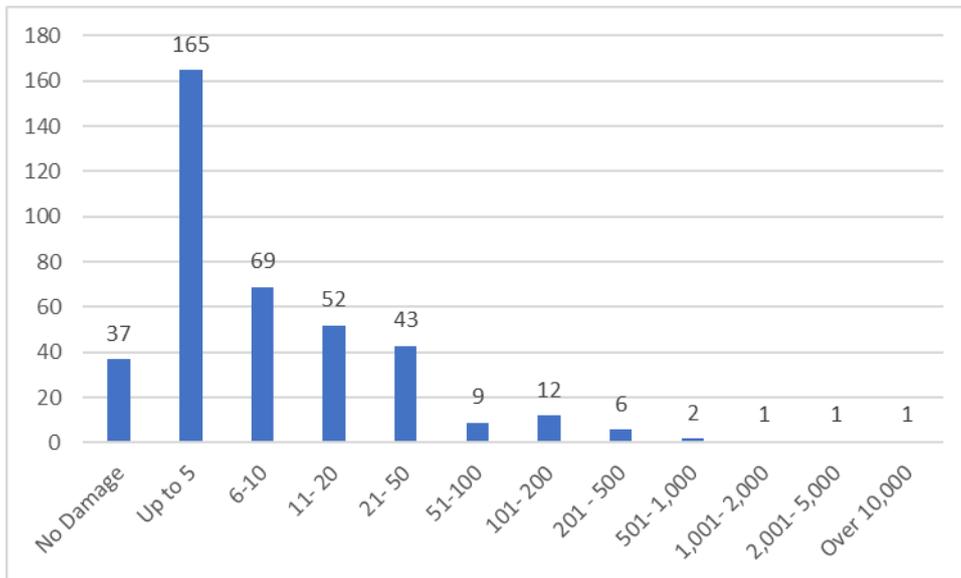
**Figure B12: Number of Non-Residential Fires by Number of Heads Activated**



Source: Optimal Economics

In terms of the area of fire damage where the sprinklers operated, data are available for 398 fires and the number of cases by area of fire damage is shown in Figure B13. Some 68% of fires had less than 10 sq. m. of fire damage.

**Figure B13: Number of Non-Residential Fires by Area of Fire Damage, sq. m.**

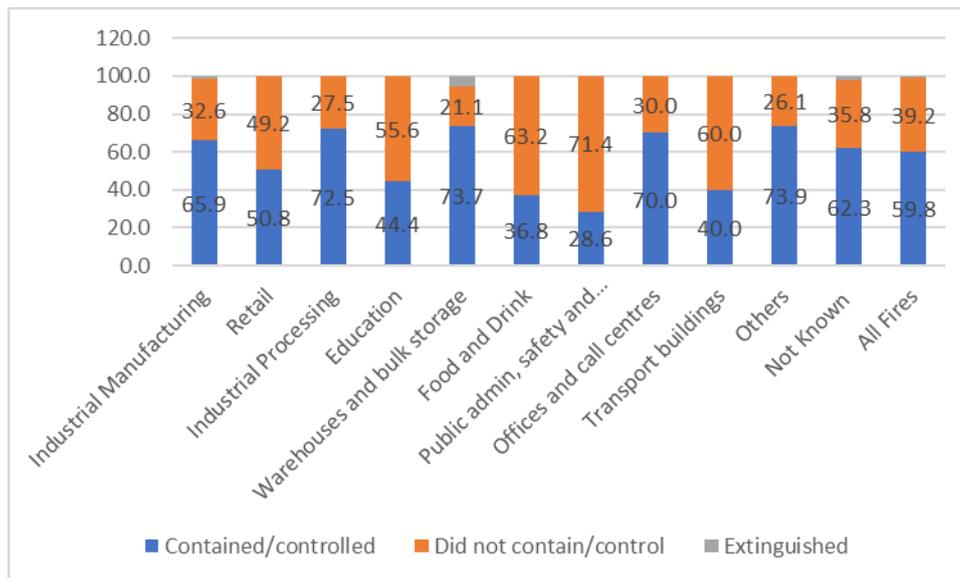


Source: Optimal Economics

The impact of the sprinkler system on the fire is known for 418 of the 610 fires where the system operated. Figure B14 shows the effectiveness of the system in containing the fire by non-residential category. Across all non-residential categories, the performance effectiveness of the system in containing/controlling or extinguishing the fire was 99%.

For retail, industrial processing, education, food and drink, public administration, offices and call centres and transport buildings, the system contained/ controlled or extinguished the fire in 100% of cases. Warehousing and bulk storage had the highest proportion of fires (5%) where the system did not contain the fire.

**Figure B14: Impact of Sprinkler System in Non-Residential Fires by Sector, %**



Source: Optimal Economics

For all non-residential fires the average number of heads to operate was 3.3 and the average area of damage was 68 sq. m. or 30 sq. m. if the one very large fire, where there are some doubts over the accuracy of the data, is excluded. These averages were based on the 315 non-residential fires where the number of heads operating and the area of damage was known. When these fires are disaggregated by non-residential sub-categories, the number of fires in the individual sub-categories is relatively small. Hence, the average number of heads operating and the average area of damage has only been calculated for two sub-categories – industrial manufacturing (including processing) and retail.

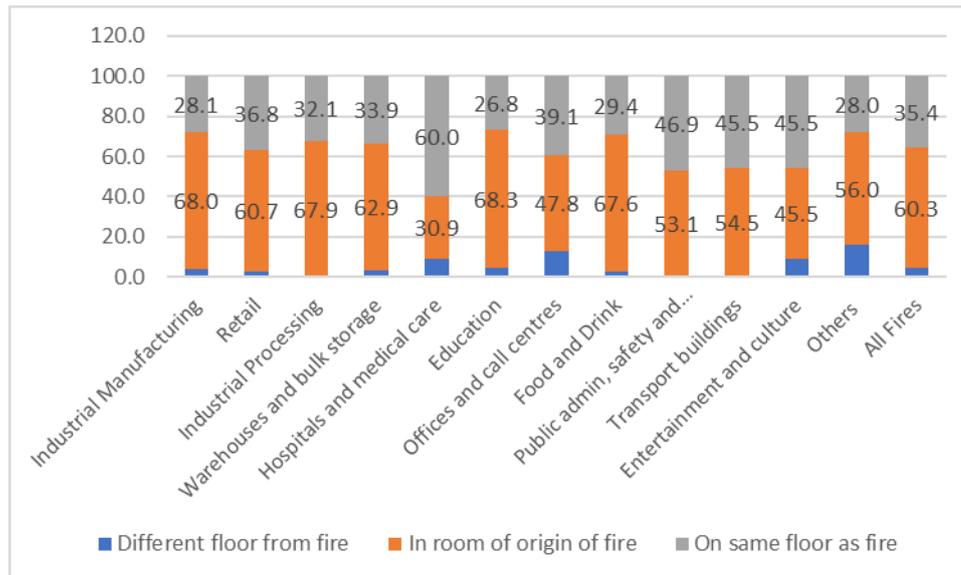
Table B1 shows the average area of fire damage and the average number of heads operating for industrial manufacturing and retail fires. If the large fire is excluded, the average area of damage in industrial manufacturing fires was 24 sq. m. and 18 sq. m. in retail fires. The very large fire was discussed in paragraph 3.2.5 where it was concluded that the fire damage was likely to be less than the 10,000 sq. m. reported.

<b>Table B1: Average Area of Fire Damage for Industrial Manufacturing and Retail Fires, sq. m.</b>		
	<b>Average Number of Heads</b>	<b>Average Damage (Sq. m.)</b>
Industrial Manufacturing (all fires)	2.5	102.0
Industrial Manufacturing (excluding large fire)	2.5	23.7
Retail	2.3	18.0
<b>All Non-Residential (excluding large fire)</b>	<b>3.3</b>	<b>30.4</b>
Source: Optimal Economics		

### Non-residential: System did not Operate

Over the five years of data, the system did not operate in 1,087 cases. Data are available on the location of the system for 859 cases and this is shown in Figure B15. The sprinkler system was located in the room of origin of the fire in 60% of incidents where the sprinkler did not activate.

**Figure B15: Location of Sprinkler System where System did not Operate by Non-Residential Sector, %**

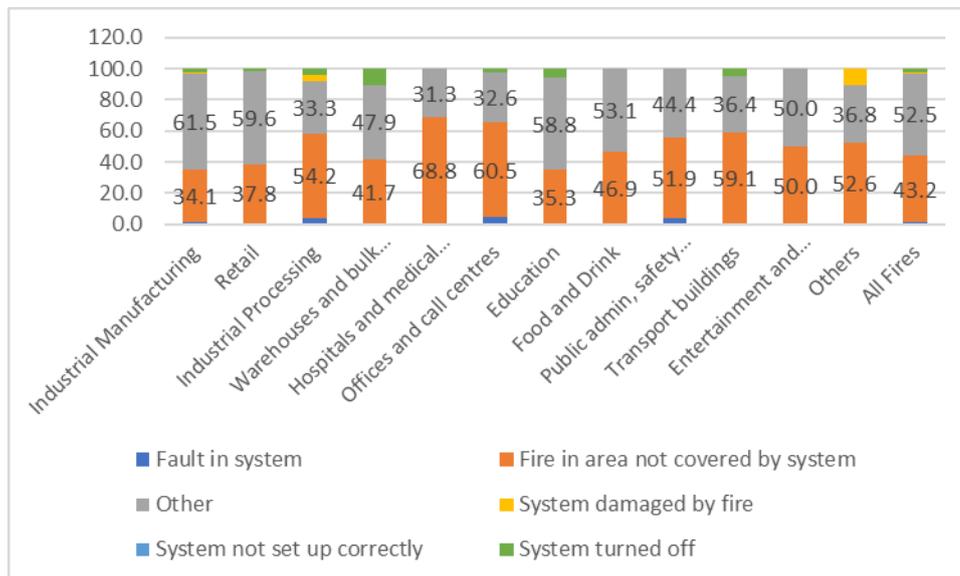


Source: Optimal Economics

The reason why the system did not operate is known for 716 of the 1,087 cases. Details are shown in Figure B16. For all non-residential categories, the main reasons why the system did not operate is either the fire was in an area not covered by the system or “other”. Of 376 cases where “other” was given as the reason for the system not operating, 119 cases provided further information and of these 90 gave insufficient fire or heat as the reason for non operation. Other reasons included:

- Fire extinguished before activation – 12 cases across retail, industrial manufacturing and food and drink
- No fire, just smoke/not enough smoke – 7 cases across retail, industrial manufacturing and hospitals and medical care
- Fire contained to machine – 5 cases across retail, industrial manufacturing and processing

**Figure B16: Reasons for Sprinkler System not Operating by Non-Residential Sector**



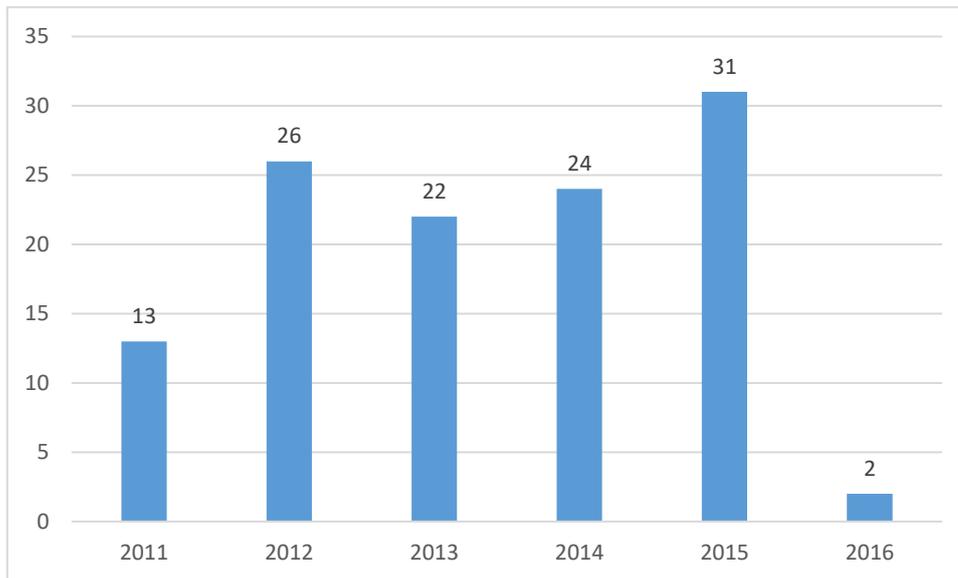
Source: Optimal Economics

Across all non-residential building types, operational reliability was 93%. Education, industrial manufacturing and processing had operational reliability at or above the average figure. A further four sectors (retail, food and drink, public safety and security and others) had operational reliability of over 90%. Operational reliability in the other sectors was between 76% and 82%, but care should be taken interpreting the reliability figures for individual non-residential sectors as the number of incidents where the reasons for non-operation is known by individual sector can be small.

## OTHER-RESIDENTIAL

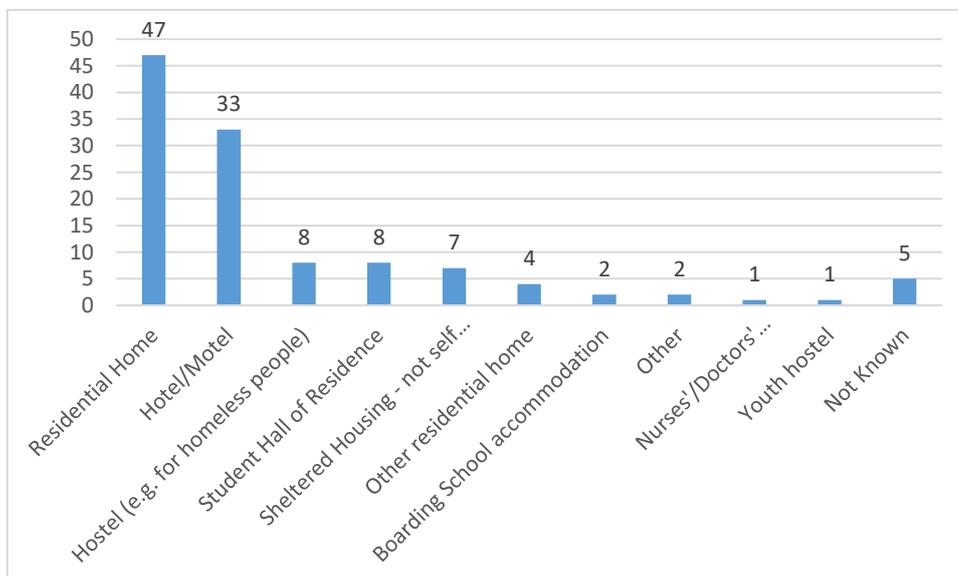
Figure B17 shows the number by year of the 118 other residential fires across the period from 2011 with Figure B18 showing the number across the different other residential categories. The number of fires ranged from 13 in 2011 to 31 in 2015. The largest number of fires was in residential homes with 47 fires (40%) with hotels/motels being the other relatively large category (33 fires or 28%).

**Figure B17: Number of Fires with Sprinklers in Other Residential Buildings by Year**



Source: Optimal Economics

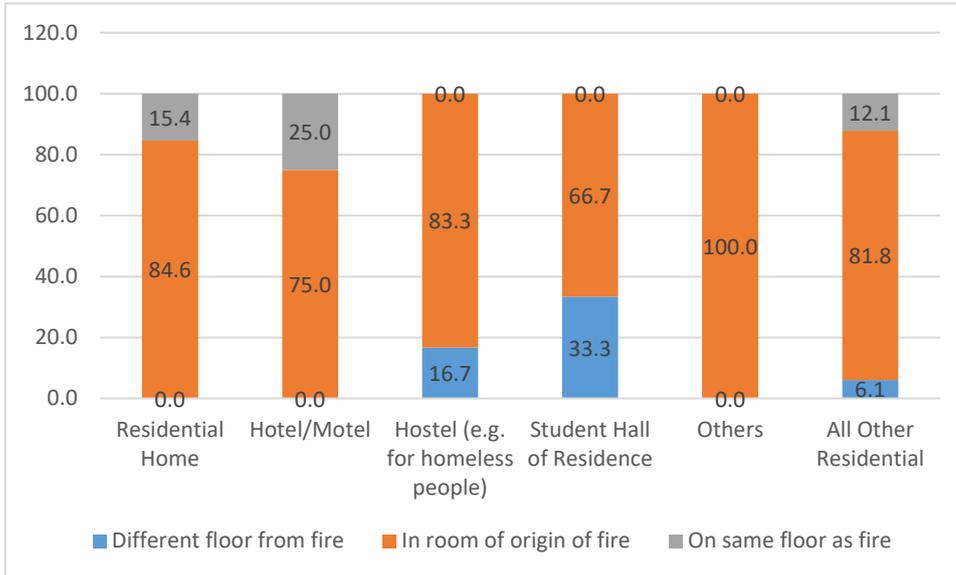
**Figure B18: Number Fires with Sprinklers by Other Residential Sector**



Source: Optimal Economics

Of the 118 other residential fires, the system operated in 42 instances with data on the location of the system available for 33 fires. Figure B19 shows the location of the sprinkler system in relation to the fire. Across all fires where the sprinkler operated, the sprinkler was in the room of origin of the fire in 82% of cases.

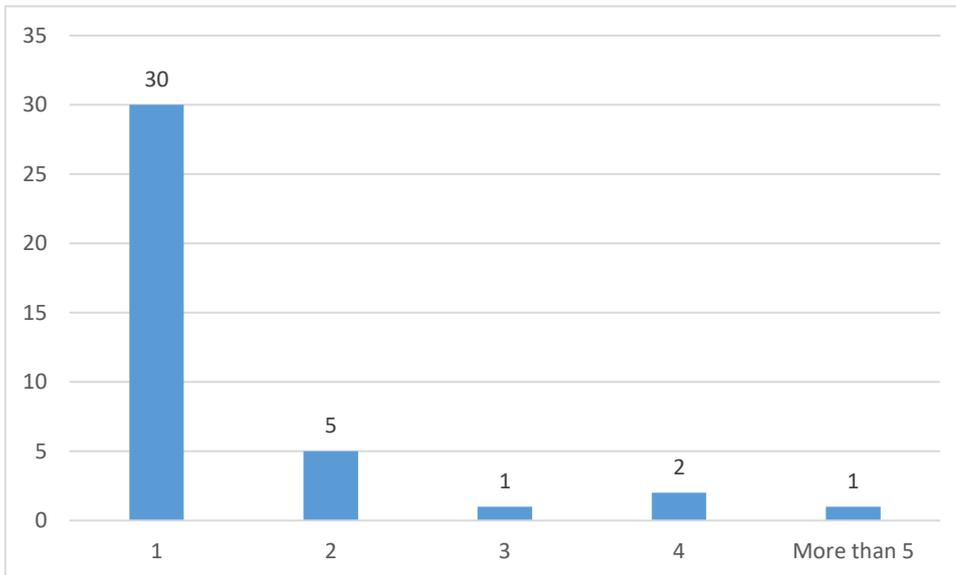
**Figure B19: Location of Sprinkler System where System Operated by Other Residential Sector, %**



Source: Optimal Economics

Of the 42 other residential fires where the system operated, data are available on the number of heads operating for 39 cases. Figure B20 shows the number of fires by the number of heads operating. In the majority of cases (77%), only one head operated.

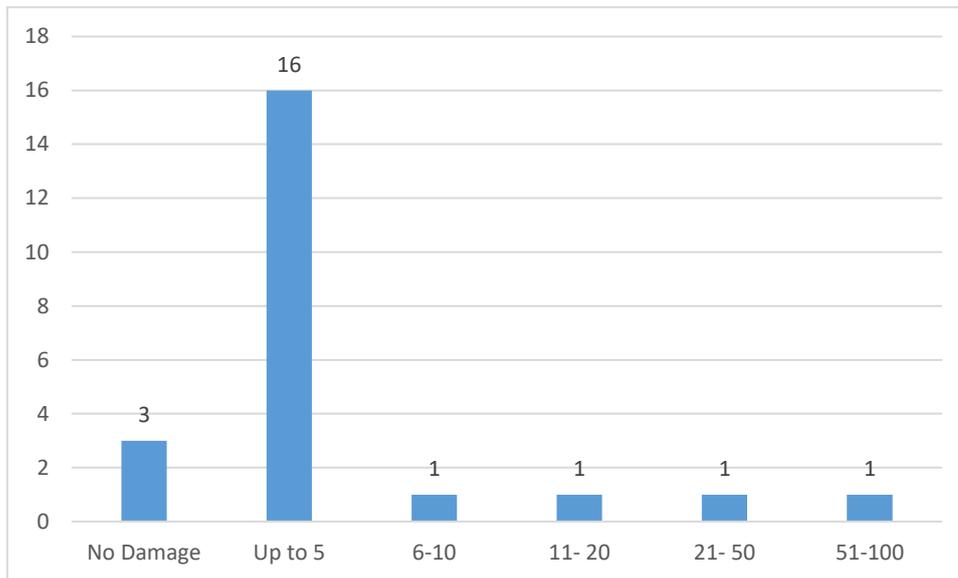
**Figure B20: Number of Other Residential Fires by Number of Heads Activated**



Source: Optimal Economics

In relation to the area of fire damage where the sprinklers operated, data are available for 23 of the 42 fires where the system operated. The number of fires by area of damage is shown in Figure B21. Some 83% of fires had less than 5 sq. m. of damage with the average across all other residential categories just under 8 sq. m.

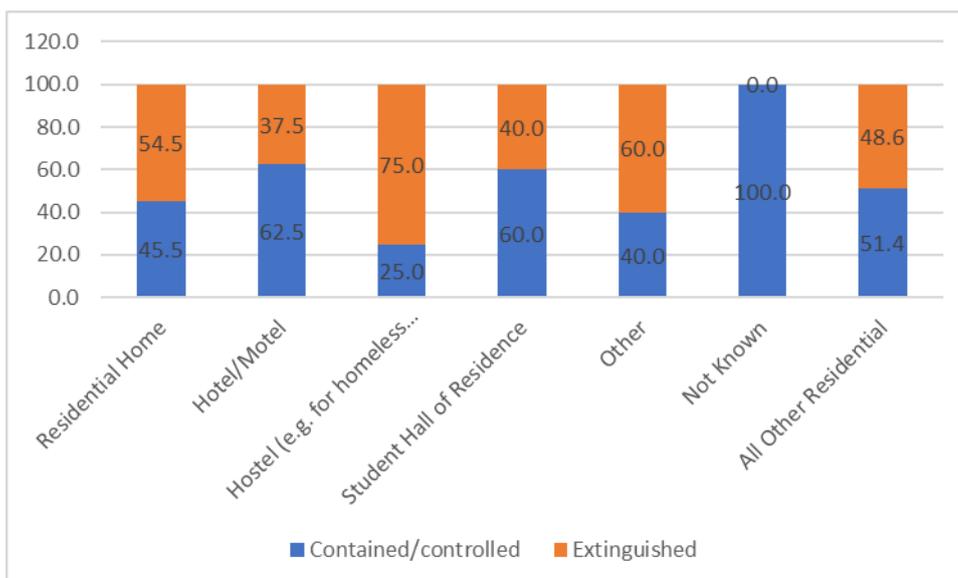
**Figure B21: Number of Other Residential Fires by Average Area of Fire Damage, sq. m.**



Source: Optimal Economics

The impact of the sprinkler system on the fire is known for 35 of the 42 fires where the system operated. Figure B22 shows the effectiveness of the system in containing the fire by other residential sector. Across all other residential categories, the performance effectiveness of the system in containing/controlling or extinguishing the fire was 100%. For residential homes, hostels and “other” sub-categories, the system extinguished the fire in the majority of cases.

**Figure B22: Impact of Sprinkler System on Other Residential Fires, %**



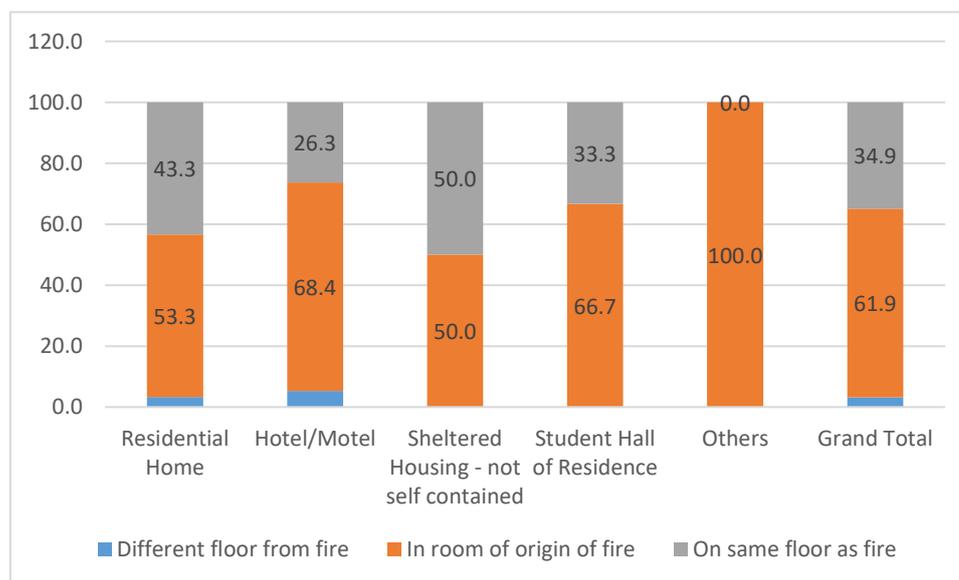
Source: Optimal Economics

Information on the number of heads and area of damage is available for 22 other residential fires, but this is not sufficient to disaggregate by other residential sub-categories. Hence, the average number of heads operating and the average area of damage has not been calculated by other residential sub-category. For all other residential types the average number of heads to operate was 1.7 and the average area of damage was 7.2 sq. m.

**Other Residential: System did not Operate**

Over the five years of data, the system did not operate in 75 cases. Data are available on the location of the system for 63 cases and this is shown in Figure B23. The sprinkler system was located in the room of origin of the fire in 62% of incidents where the sprinkler did not activate.

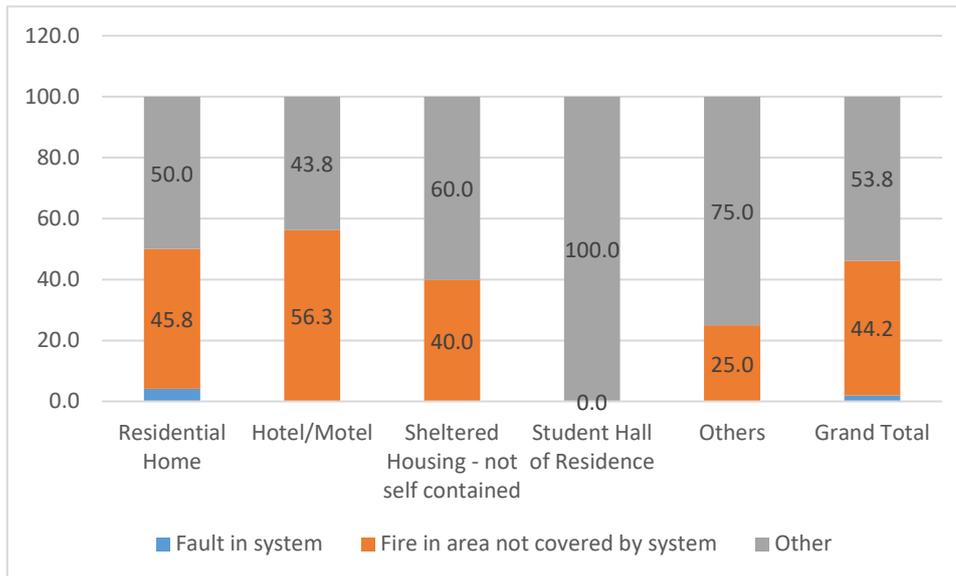
**Figure B23: Location of Sprinkler System where System did not Operate, Other Residential Sectors**



Source: Optimal Economics

The reason why the system did not operate is known for 52 of the 75 cases. Details are shown in Figure B24. For all other residential sectors, the main reasons why the system did not operate were either that the fire was in an area not covered by the system or “other”. There was one incident when there was a fault in the system and this was in a residential home. Of the 28 cases where “other” was given as the reason for the system not operating, 5 cases provided further information and all five gave insufficient fire or heat as the reason for non operation.

**Figure 24: Reasons why Sprinkler System did not Operate, Other Residential Sectors, %**



Source: Optimal Economics

Across all other residential building types, operational reliability was almost 98%. Every sub-sector of other residential buildings had an operational reliability of 100% except for residential homes where the reliability was 93%. This reflects one case where there was a fault in the system. Care should be taken interpreting the reliability figures for individual other residential sectors as the number of incidents where the reasons for non-operation is known by individual sector can be small.

## Appendix C

### Detailed Analysis for Key Non-Residential Sub-Sectors

## Key Sectors

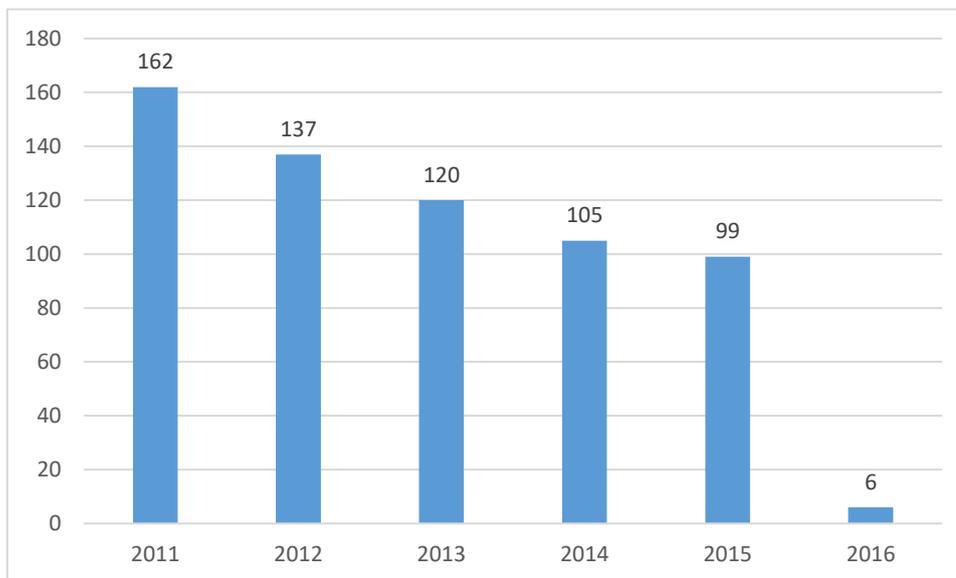
### INTRODUCTION

The analysis of non-residential fires in Appendix B showed that four sectors accounted for 73% of all non-residential fires – industry (manufacturing and processing), retail, warehousing and bulk storage and education. These four sectors can be further disaggregated and this Appendix provides a more detailed breakdown of results for each of these four sectors.

### INDUSTRY

Over the last five years there have been 629 fires in industrial manufacturing or processing premises in which sprinklers were installed. The number by year is shown in Figure C1. On an annual basis, the number of fires has gradually reduced from 162 in 2011 to 99 in 2015.

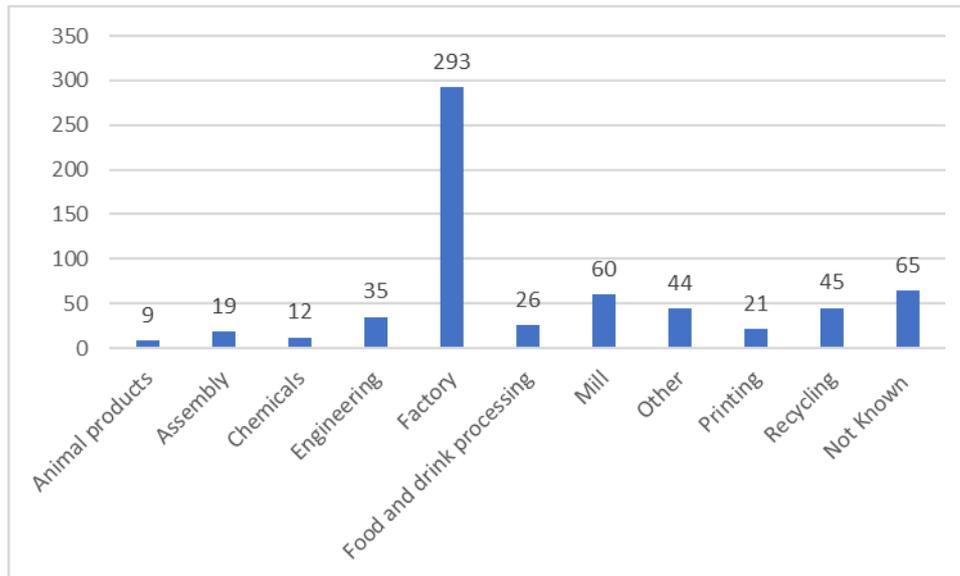
**Figure C1: Number of Fires with Sprinklers in Industrial Premises by Year**



Source: Optimal Economics

Figure C2 shows the number of fires across the different industrial sub-sectors with the largest number of fires occurring in factories (47%).

**Figure C2: Number of Fires with Sprinklers by Industrial Sub-Sector**

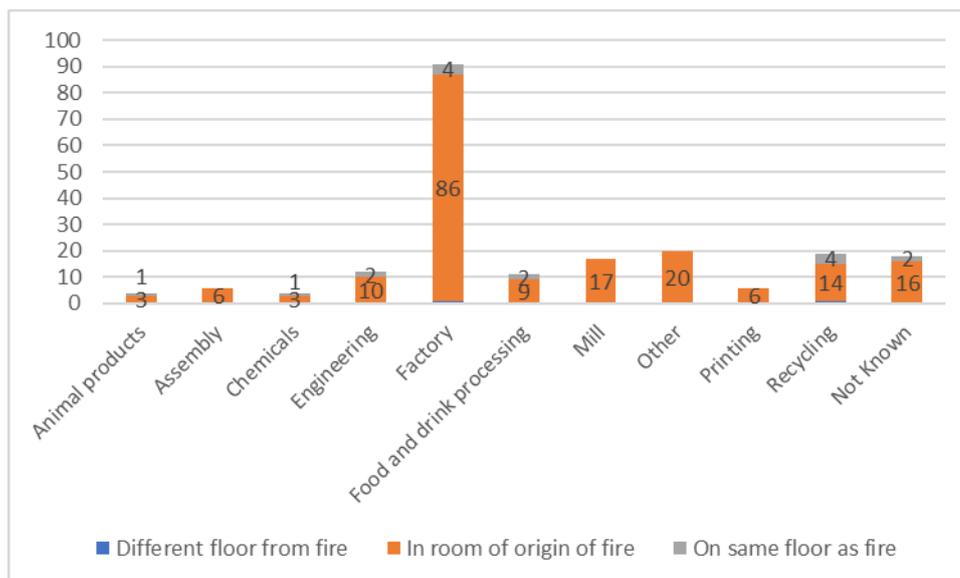


Source: Optimal Economics

**Industrial Fires: System Operated**

Of the 629 fires in industrial premises, the sprinkler system operated in 294 cases. Information on the location of the sprinkler system is available for 208 cases and details are shown in Figure C3. In 91% of cases, the sprinkler system was located in the room of origin of the fire. There were two instances where the sprinkler activated while on a different floor from the fire (one factory and one recycling) and 16 cases where the sprinkler was on the same floor as the fire.

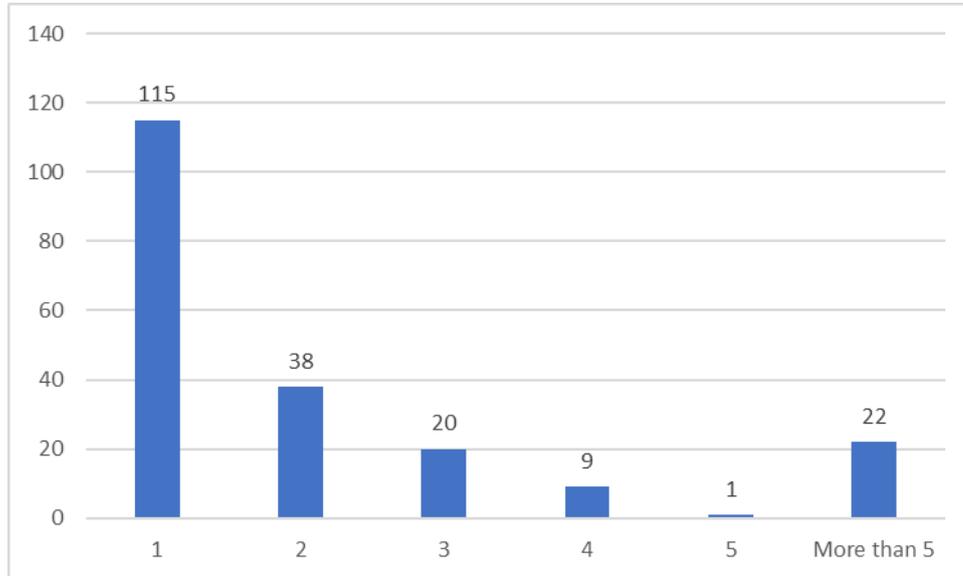
**Figure C3: Location of Sprinkler System where System Operated, Industrial Fires by Sub-Sector**



Source: Optimal Economics

Of the 294 industrial fires where the system operated, data are available on the number of heads operating for 205 incidents. In 115 of the 294 cases (56%), only one head operated. The number of fires by number of heads operated is shown in Figure C4.

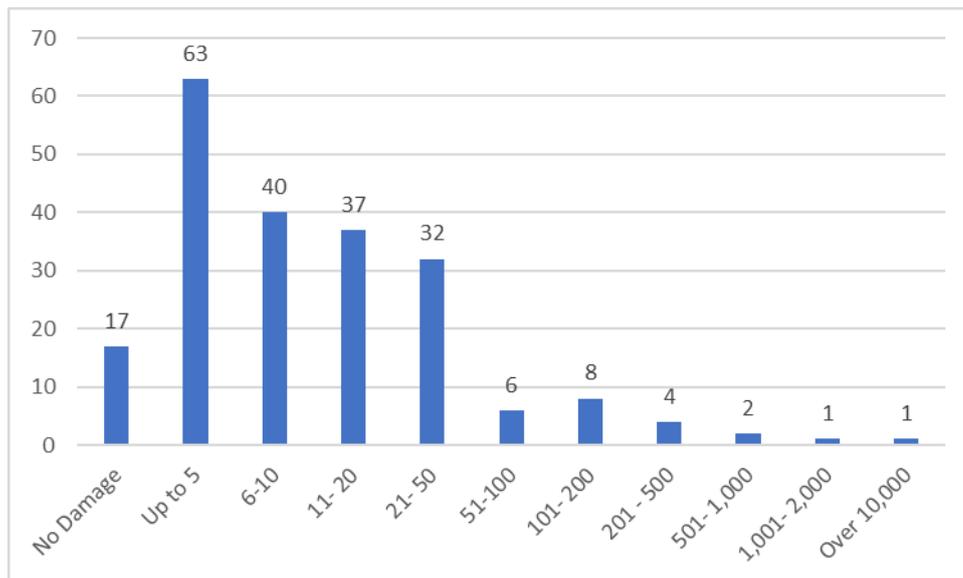
**Figure C4: Number of Fires by Number of Heads Activated, Industry Sub-Sector**



Source: Optimal Economics

In terms of the area of fire damage where the sprinklers operated, data are available for 211 fires. While the majority (189 fires or 90%) had damage of up to 50 sq. m., there were a small number of fires with relatively large areas of damage. The number of industrial fires by area of fire damage is shown in Figure C5.

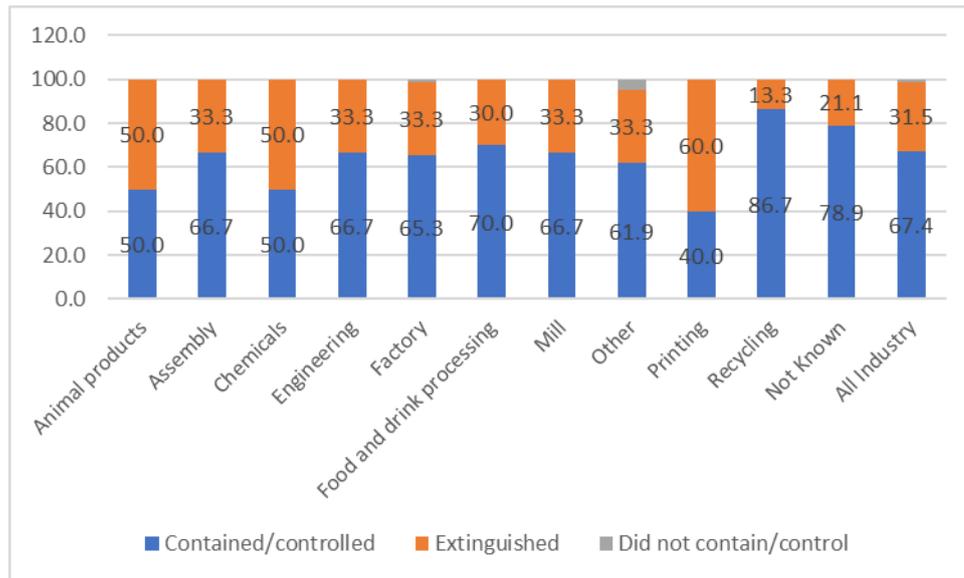
**Figure C5: Number of Fires by Average Area of Fire Damage, Industry Sub-Sector, sq. m.**



Source: Optimal Economics

The impact of the sprinkler system is known for 178 of the 294 fires where the system operated. Figure C6 shows the effectiveness of the system in containing the fire for each industrial sub-sector. Across all industry sub-sectors, the sprinkler system contained/controlled or extinguished the fire in 99% of cases. There were only two cases where the sprinklers did not contain/control or extinguish the fire – one in a factory and one in the other sub-sector.

**Figure C6: Impact of Sprinkler System on Industrial Fires by Industry Sub-Sector, %**

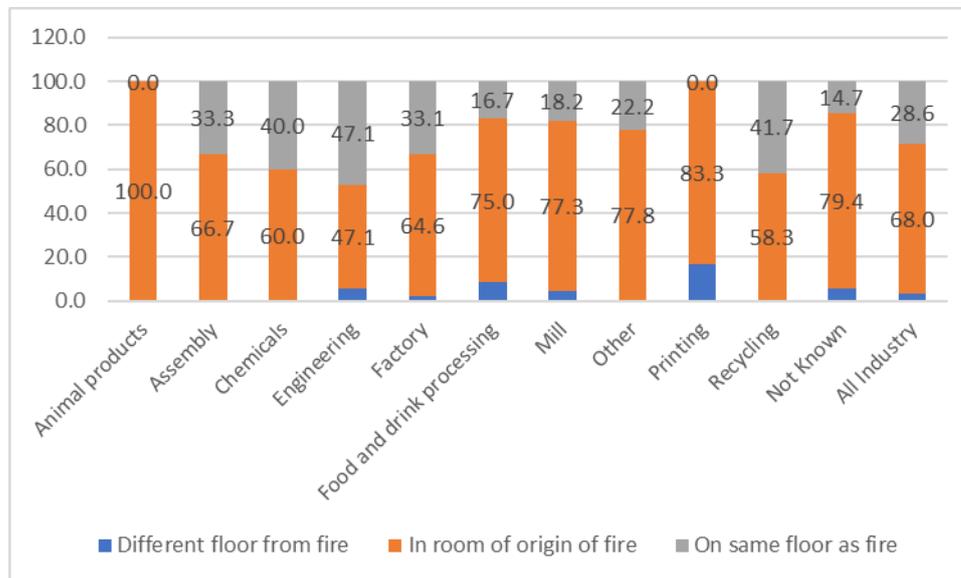


Source: Optimal Economics

**Industry: System did not operate**

Over the five years of the analysis, the system did not operate in 331 cases. In terms of the location of the sprinkler system in relation to the fire, data were available for 259 fires. The sprinkler was located in the room of origin of the fire in 68% of fires where the system did not operate. Details are shown in Figure C7.

**Figure C7: Location of Sprinklers where System did not Operate, Industrial Fires by Sub-Sector, %**



Source: Optimal Economics

The reason why the system did not operate is known for 203 of the 331 fires with a summary of the reasons provided in Figure C8. In 74 of the 203 cases (36%) the fire was in an area not covered by the system and in a further 118 cases (58%), “other” was given as the reason for the system not operating. The reasons for the system not operating in the other eleven fires were:

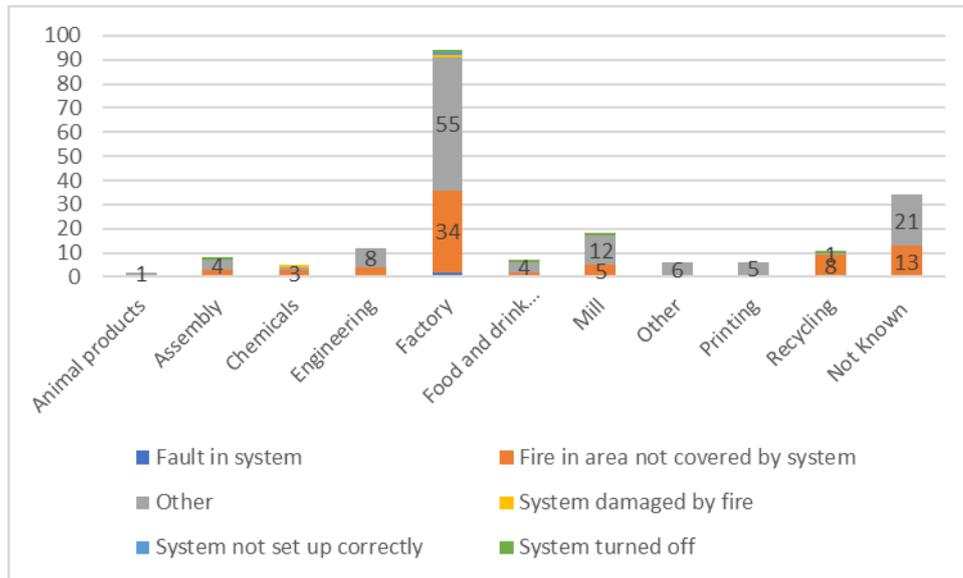
- Fault in the system – 3 fires ( 1 recycling, 2 factories)
- System damaged – 2 fires (1 chemicals, 1 factory)
- System not set up correctly – 1 fire (factory)
- System turned off – 5 fires (1 assembly, 1 factory, 1 food and drink processing, 1 mill, 1 recycling).

Of the 118 cases where “other” was the reason given for the system not operating, 59 cases provided further detail with insufficient heat being cited in 44 cases (75%). The reasons for the system not operating in the other 15 fires were:

- Extinguished before activation – 6 fires (2 factories, 1 mill, 1 printing, 2 not known)
- Fire contained to machine – 4 fires (1 factory, 2 other, 1 not known)
- Flash fire in cotton dust – 1 fire (mill)
- Not enough smoke – 3 fires (1 food and drink processing, 1 mill, 1 not known)
- Operating failure – 1 fire (other).

In the cases where there was insufficient heat or the fire was in an area not covered by the system, the sprinklers could not be expected to operate. Across all industrial sub-sectors in cases where the system did not operate, it could not have been expected to operate in 93% of those cases.

**Figure C8: Reasons for Sprinkler System not Operating, Industrial Fires by Sub-Sector**

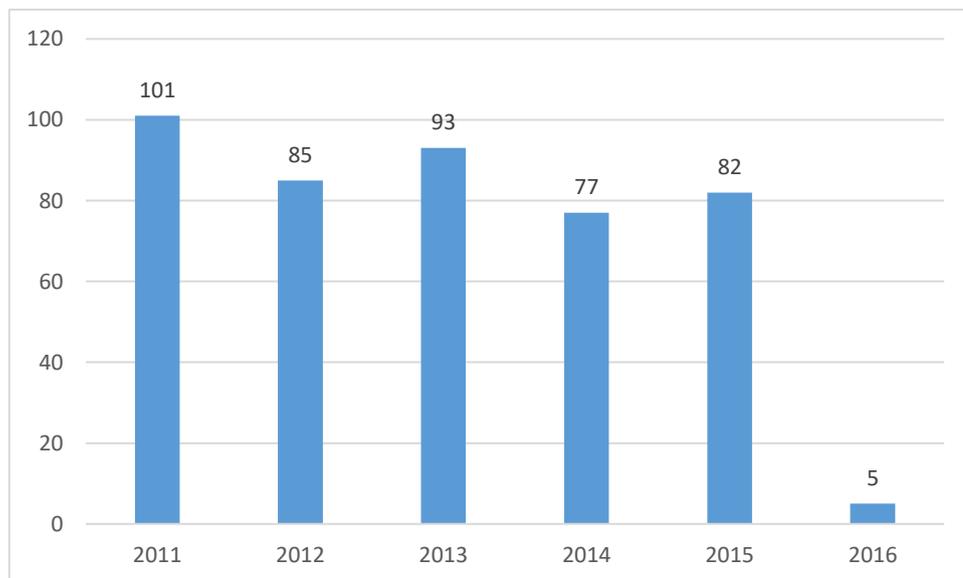


Source: Optimal Economics

## RETAIL

Over the last five years there have been 443 fires in retail premises in which sprinklers were installed. The number of fires by year is shown in Figure C9. On an annual basis, the highest number of fires was in 2011 (101 fires) and the lowest in 2014 (77 fires).

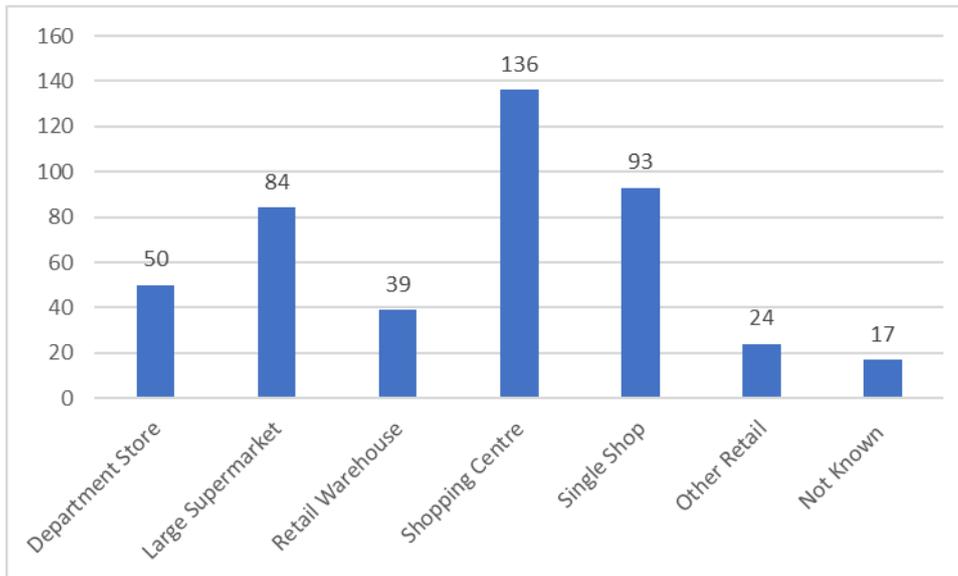
**Figure C9: Number of Fires with Sprinklers in Retail Premises by Year**



Source: Optimal Economics

Figure C10 shows the number of fires across the different retail sub-sectors with the largest number of fires occurring in shopping centres (31%).

**Figure C10: Number of Fires with Sprinklers by Retail Sub-Sector**

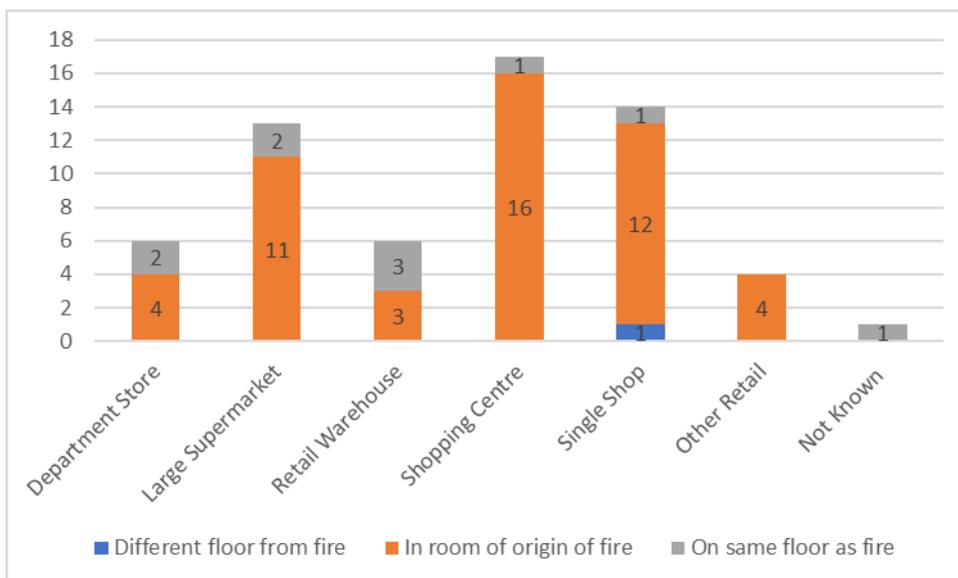


Source: Optimal Economics

**Retail Fires: System Operated**

Of the 443 fires in retail premises, the sprinkler system operated in 94 cases. Information on the location of the sprinkler system is available for 61 cases and details are shown in Figure C11. In 82% of cases, the system was located in the room of origin of the fire. There was one incident where the sprinkler activated while on a different floor from the fire and 10 cases where the sprinkler was on the same floor as the fire.

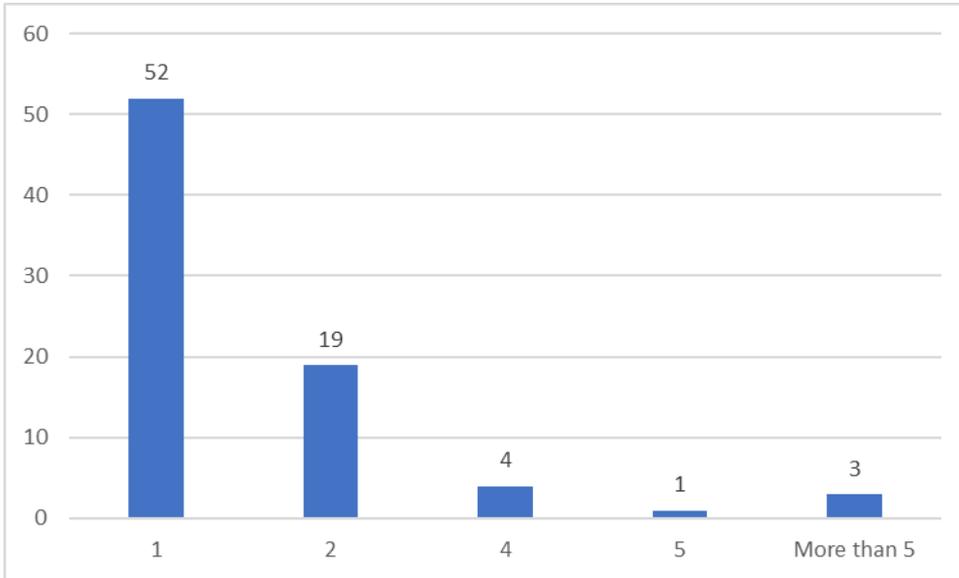
**Figure C11: Location of Sprinkler System where System Operated, Retail Sub-Sectors**



Source: Optimal Economics

Of the 94 retail fires where the system operated, data are available on the number of heads operating for 79 incidents. In 52 of the 79 cases (66%), only one head operated. The number of fires by number of heads operated is shown in Figure C12.

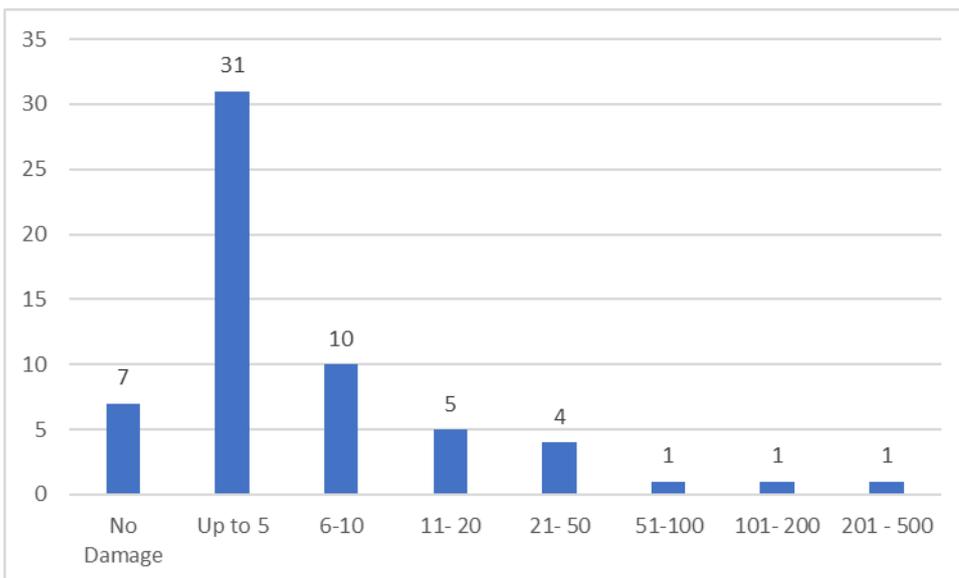
**Figure C12: Number of Retail Fires by Number of Heads Activated**



Source: Optimal Economics

In relation to the area of fire damage where the sprinklers operated, data are available for 60 fires. While the majority (38 fires or 63%) had fire damage of up to 5 sq. m., there were a small number of fires (3 or 5%) with areas of damage in excess of 50 sq. m. Details are shown in Figure C13.

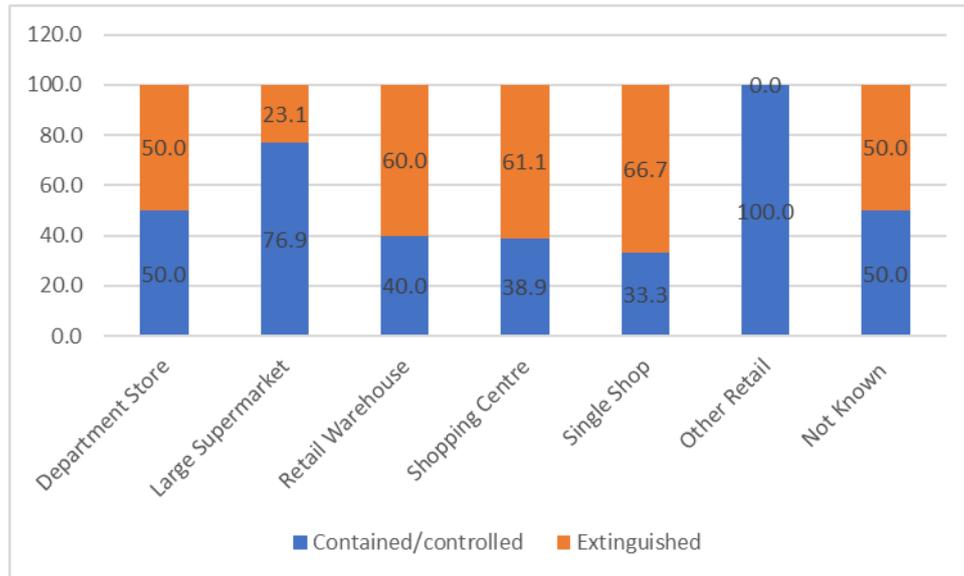
**Figure C13: Number of Fires by Area of Fire Damage, Retail Sub-Sectors, sq. m.**



Source: Optimal Economics

The impact of the sprinkler system is known for 63 of the 94 fires where the system operated. Figure C14 shows the effectiveness of the system in containing the fire for each retail sub-sector. Across retail as a whole, the sprinkler system contained/controlled or extinguished the fire in all cases. That is, the performance effectiveness of the sprinklers where they operated was 100% across all types of retail premises

**Figure C14: Impact of Sprinkler System by Retail Sub-Sector**

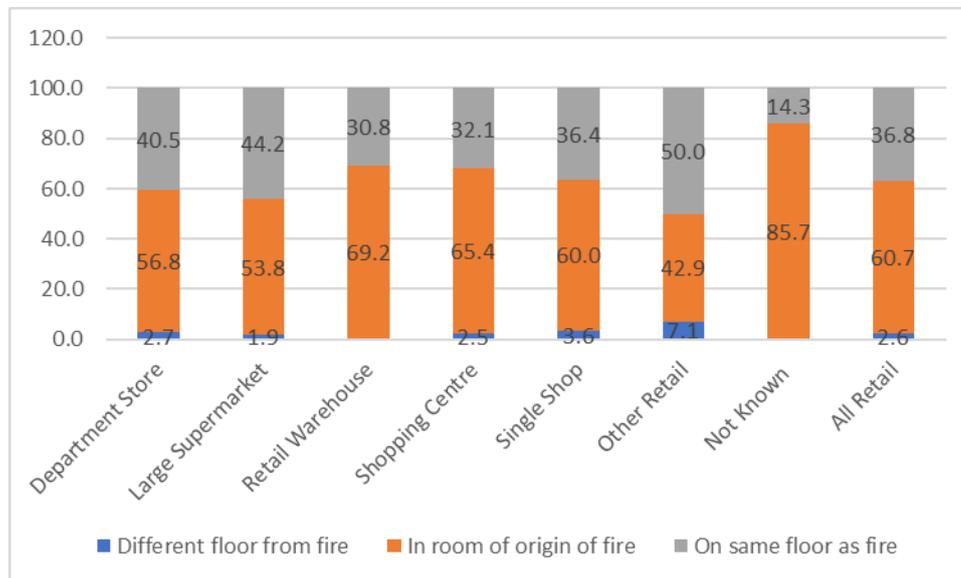


Source: Optimal Economics

**Retail Fires: System did not Operate**

Over the five years of the analysis, systems in retail premises did not operate in 338 cases. In terms of the location of the sprinkler system in relation to the fire, data were available for 272 fires. The sprinkler was located in the room of origin of the fire in 61% of fires where the system did not operate.

**Figure C15: Location of Sprinkler System where System did not Operate, Retail Sub-Sectors, %**



Source: Optimal Economics

The reason why the system did not operate is recorded for 230 of the 338 fires with a summary of the reasons provided in Figure C16. In 87 of the 230 cases (38%) the fire was in an area not covered by the system and in a further 137 cases (60%), “other” was given as the reason. The reasons for the system not operating in the remaining six fires were:

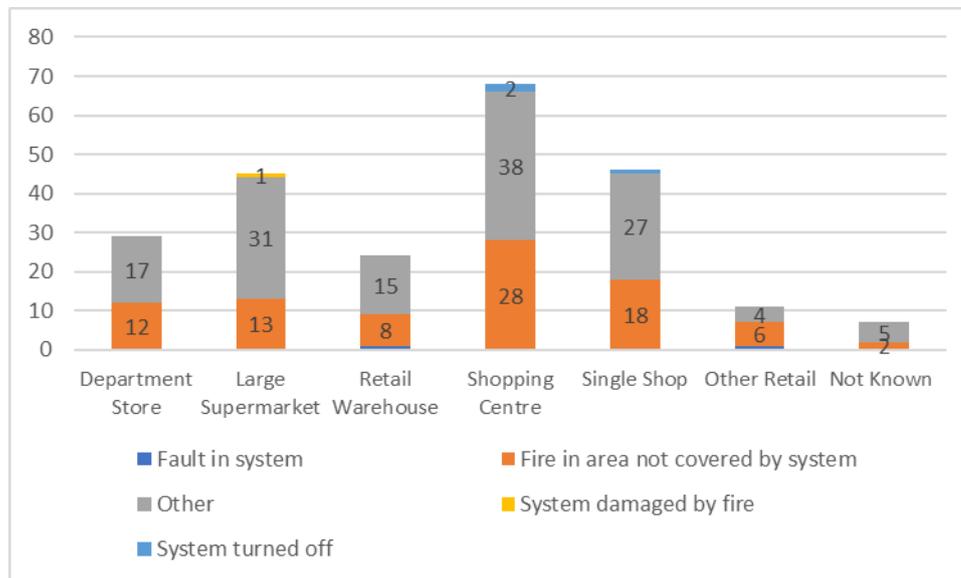
- Fault in the system – 2 fires ( 1 retail warehouse, 1 other retail)
- System damaged – 1 fire (1 large supermarket)
- System turned off – 3 fires (2 shopping centre, 1 single shop).

Of the 137 cases where “other” was the reason given for the system not operating, 40 provided further detail. Insufficient heat was cited in 32 cases (80%). The reasons for the system not operating in the other eight fires were:

- Extinguished before activation – 4 fires (2 retail warehouse, 1 large supermarket, 1 not known)
- Fire confined to machine – 1 fire (1 single shop)
- No fire, just smoke – 3 fires (2 shopping centres, 1 single shop).

In the cases where there was insufficient heat, the fire was in an area not covered by the system, or the fire was extinguished before activation, the sprinkler could not have been expected to operate. Across all retail sub-sectors where the system did not operate, the available data indicates that the systems could not have been expected to operate in 97% of cases.

**Figure C16: Reasons why Sprinkler System did not Operate by Retail Sub-Sectors**

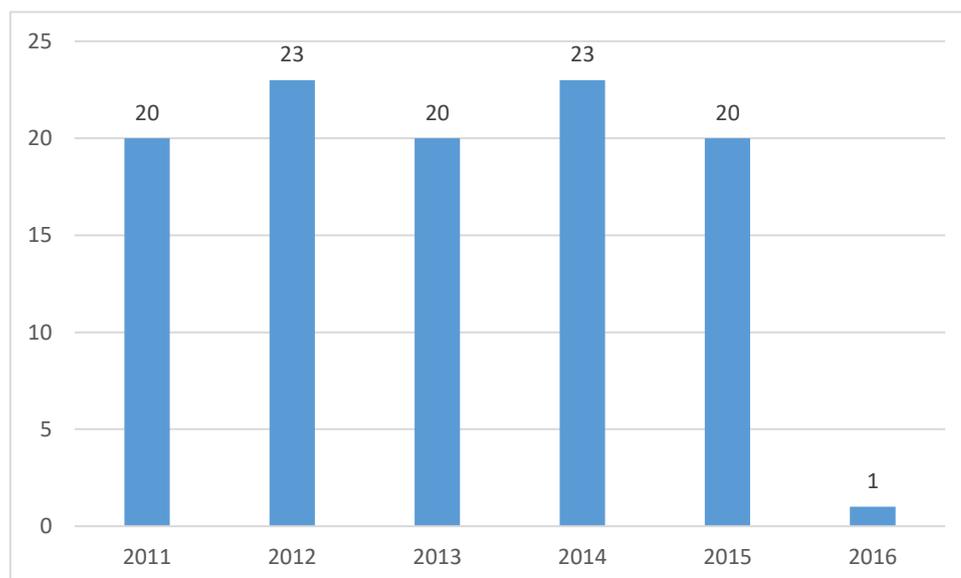


Source: Optimal Economics

### WAREHOUSING AND BULK STORAGE

Over the last five years there have been 107 fires in warehouse and bulk storage premises in which sprinklers were installed. The number of fires by year is shown in Figure C17. The number of fires is very consistent at around 20 to 23 per year.

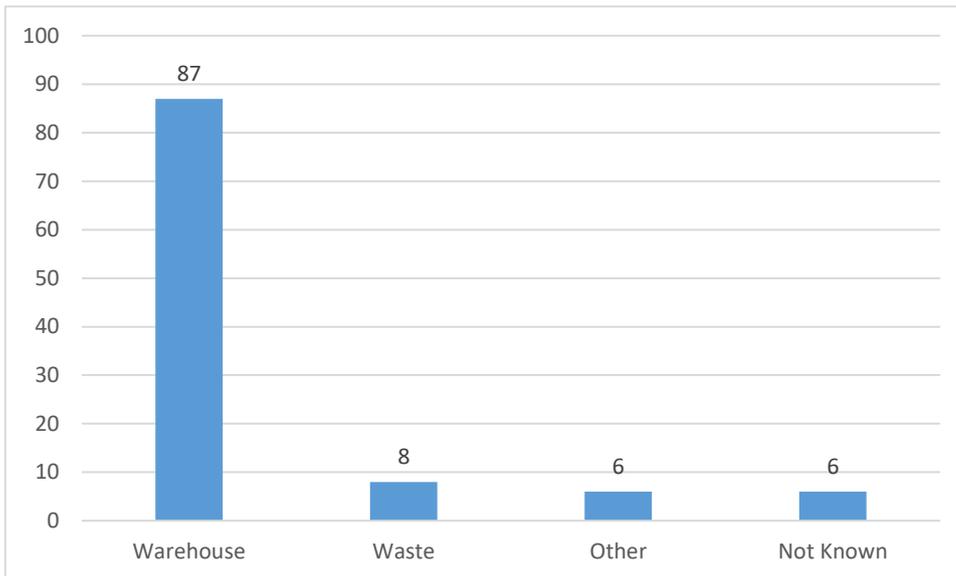
**Figure C17: Number of Fires with Sprinklers in Warehouses and Bulk Storage Premises by Year**



Source: Optimal Economics

Figure C18 shows the number of fires in the different warehousing and bulk storage sub-sectors with the largest number of fires occurring in warehouses (81%).

**Figure C18: Number of Fires With Sprinklers by Warehousing and Bulk Storage Sub-Sectors**

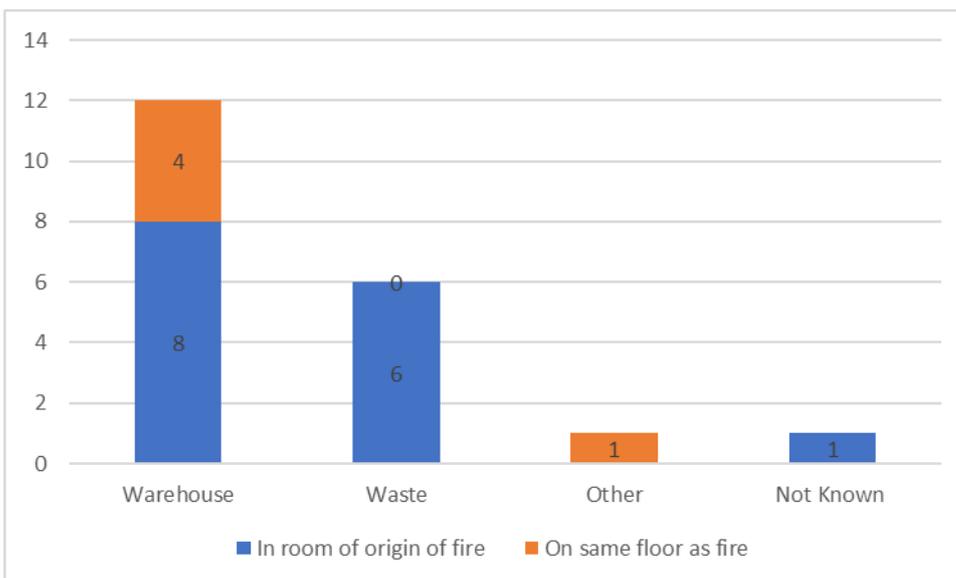


Source: Optimal Economics

**Warehousing and Bulk Storage Fires: System Operated**

Of the 107 fires in warehousing and bulk storage premises, the sprinkler system operated in 31 cases. Information on the location of the sprinkler system is available for 20 cases and details are shown in Figure C19. In 75% of cases, the system was located in the room of origin of the fire. There were five incidents where the sprinkler activated while on the same floor as the fire.

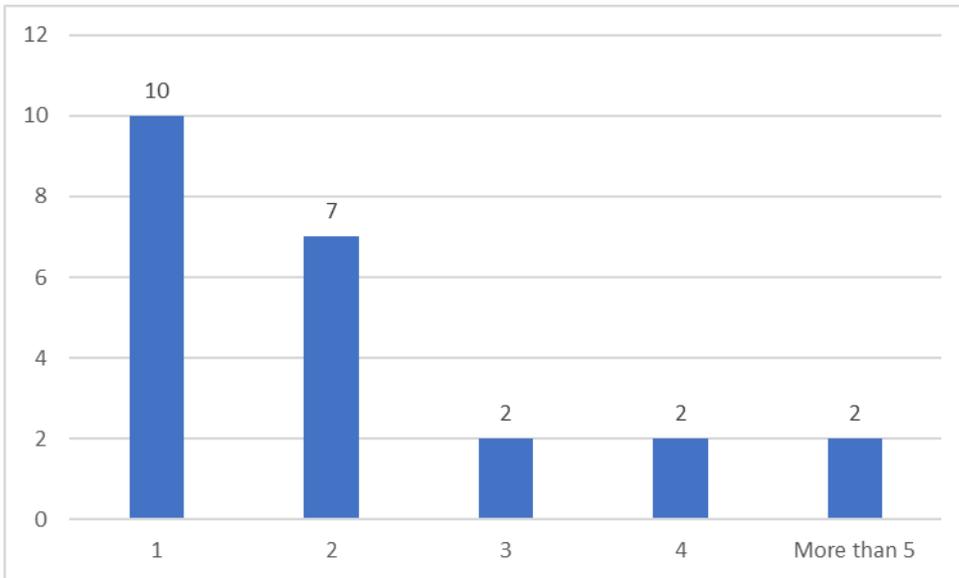
**Figure C19: Location of Sprinkler System where System Operated, Warehousing and Bulk Storage Sub-Sectors**



Source: Optimal Economics

Of the 31 warehousing and bulk storage fires where the system operated, data are available on the number of heads operating for 23 incidents. In 10 of the 23 cases (43%), only one head operated. The number of fires by number of heads activated is shown in Figure C20.

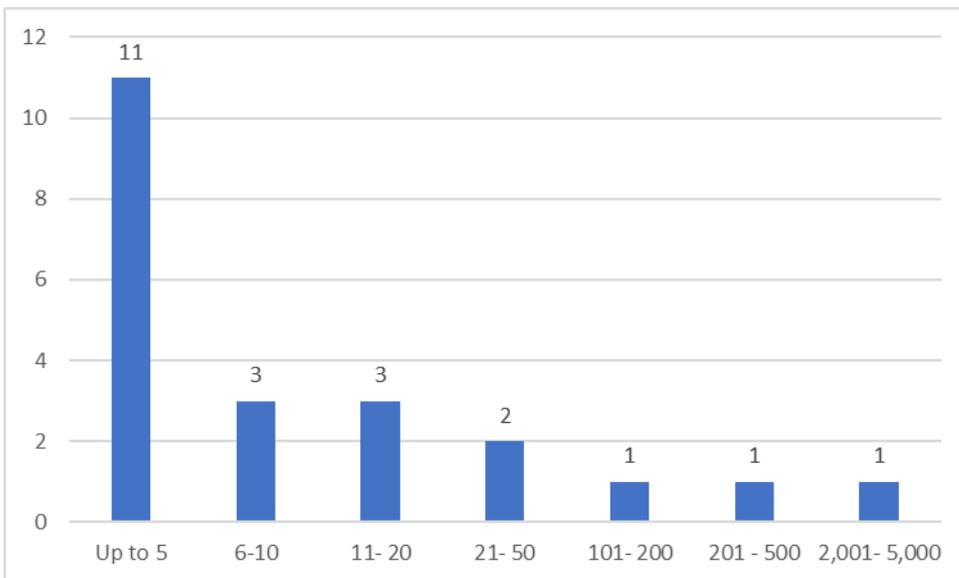
**Figure C20: Number of Fires by Number of Heads Activated, Warehousing and Bulk Storage Sub-Sectors**



Source: Optimal Economics

In terms of the area of fire damage where the sprinklers operated, data are available for 22 fires. The number of warehousing and bulk storage fires by area of fire damage is shown in Figure C21. The majority (86%) of fires had damage of under 50 sq. m. with only three fires having higher areas of damage.

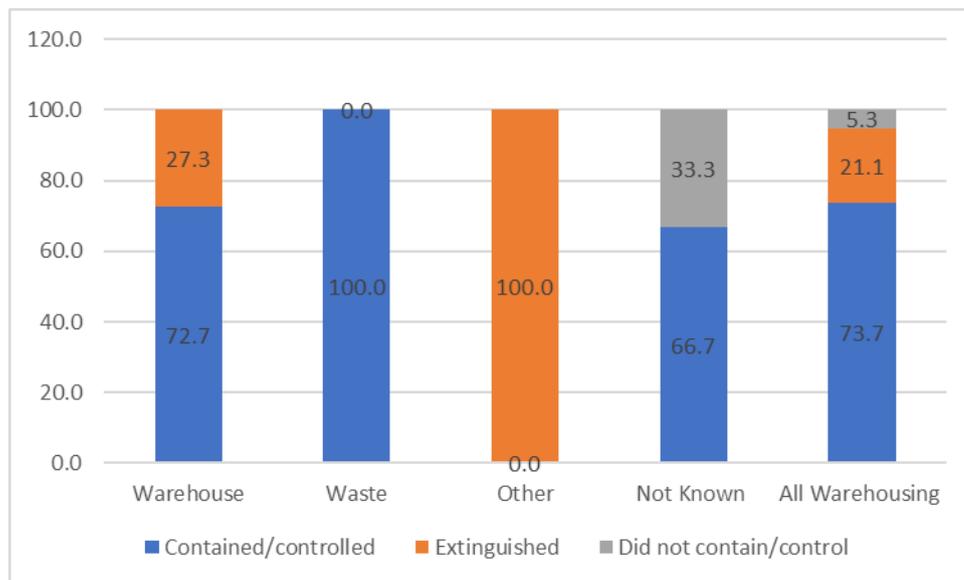
**Figure C21: Number of Fires by Area of Fire Damage, Warehousing and Bulk Storage Sub-Sectors, sq. m.**



Source: Optimal Economics

The impact of the sprinkler systems is known for 19 of the 31 fires where the system operated. Figure C22 shows the effectiveness of the system in containing the fire for each warehousing and bulk storage sub-sector. Across all sub-sectors, the sprinkler system contained/controlled or extinguished the fire in 95% of cases. In the warehouse, waste and other sub-sectors, the performance effectiveness of the sprinklers was 100%. The overall effectiveness drops to 95% as there was one incident (sub-sector not known) where the srpinklers did not contain the fire.

**Figure C22: Impact of Sprinkler System, Warehousing and Bulk Storage Sub-Sectors, %**

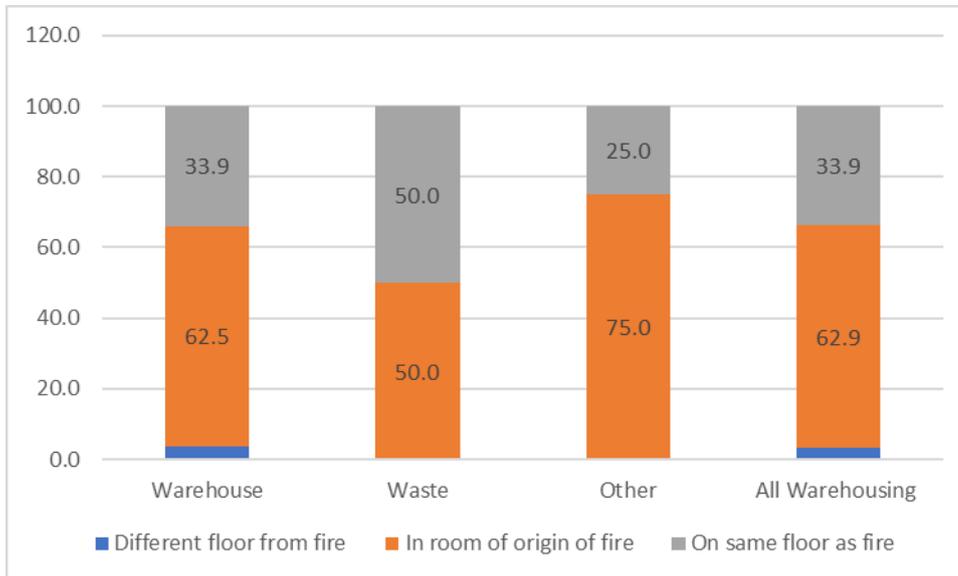


Source: Optimal Economics

**Warehousing and Bulk Storage Fires: System did not Operate**

Over the five years of the analysis, the system did not operate in 73 cases. In terms of the location of the sprinkler system in relation to the fire, data were available for 62 fires. The sprinkler was located in the room of origin of the fire in 63% of fires where the system did not operate. Details are shown in Figure C23.

**Figure C23: Location of Sprinkler System where System did not Operate, Warehousing and Bulk Storage Sub-Sectors**



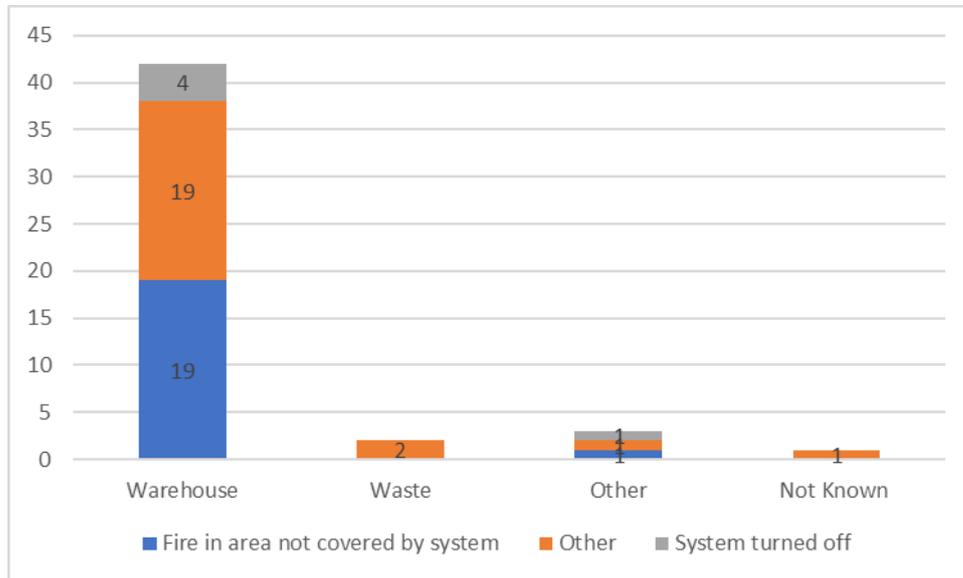
Source: Optimal Economics

The reason why the system did not operate is recorded for 48 of the 73 fires with a summary of the reasons provided in Figure C24. In 20 of the 48 cases (42%) the fire was in an area not covered by the system and in 23 cases (48%) “other” was given as the reason. In five other fires the system did not operate because it was turned off.

Of the 23 “other” reasons cited for the system not operating, five cases provided further detail with insufficient heat being cited in four of the five cases (80%). In the other incident, operating failure was cited as the “other” reason for the system not operating.

In the cases where there was insufficient heat or the fire was in an area not covered by the system, the sprinkler could not be expected to operate. Across all warehousing and bulk storage sub-sectors where the system did not operate, the available data indicates that the systems could not have been expected to operate in 80% of cases.

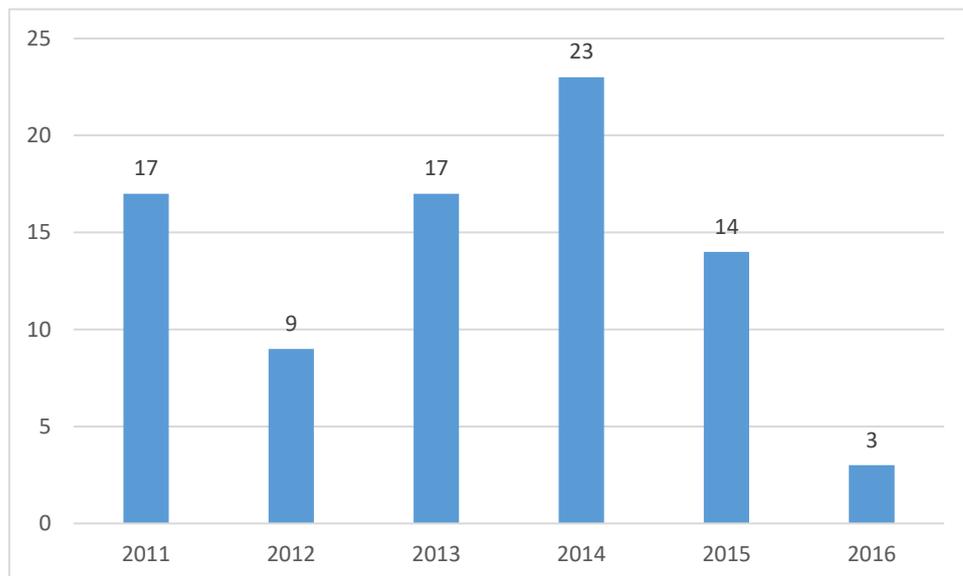
**Figure C24: Reasons why Sprinkler System did not Operate, Warehousing and Bulk Storage Sub-Sectors**



## EDUCATION

Over the last five years there have been 83 fires in educational establishments in which sprinklers were installed as shown in Figure C25. On an annual basis, the number of fires ranges from nine in 2012 to 23 in 2014.

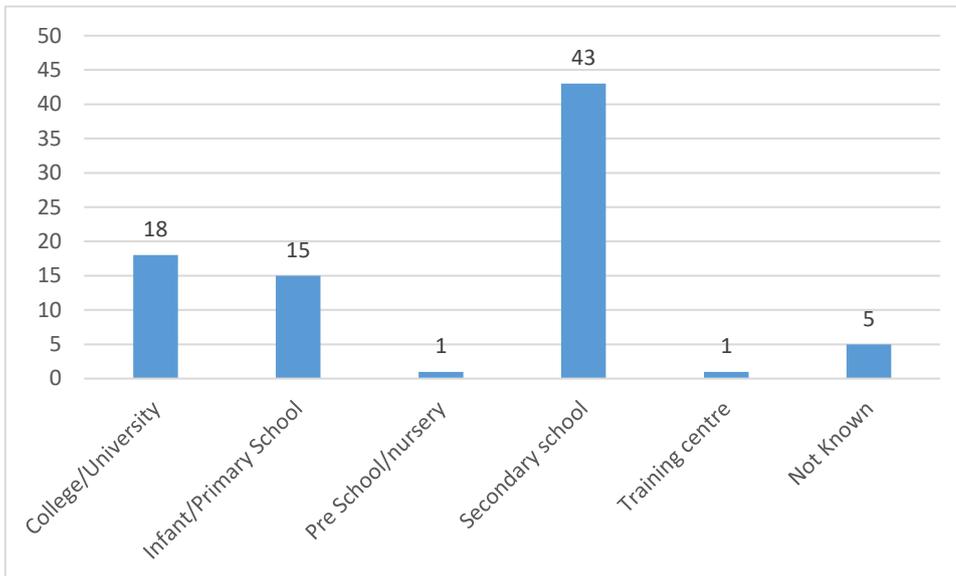
**Figure C25: Number of Fires in Educational Establishments with Sprinklers by Year**



Source: Optimal Economics

Figure C26 shows the number of fires by different educational sub-sectors. The majority of fires are in schools – 52% in secondary schools and 18% in infant/primary schools.

**Figure C26: Number of Fires with in Premises with Sprinklers by Educational Sub-Sector**

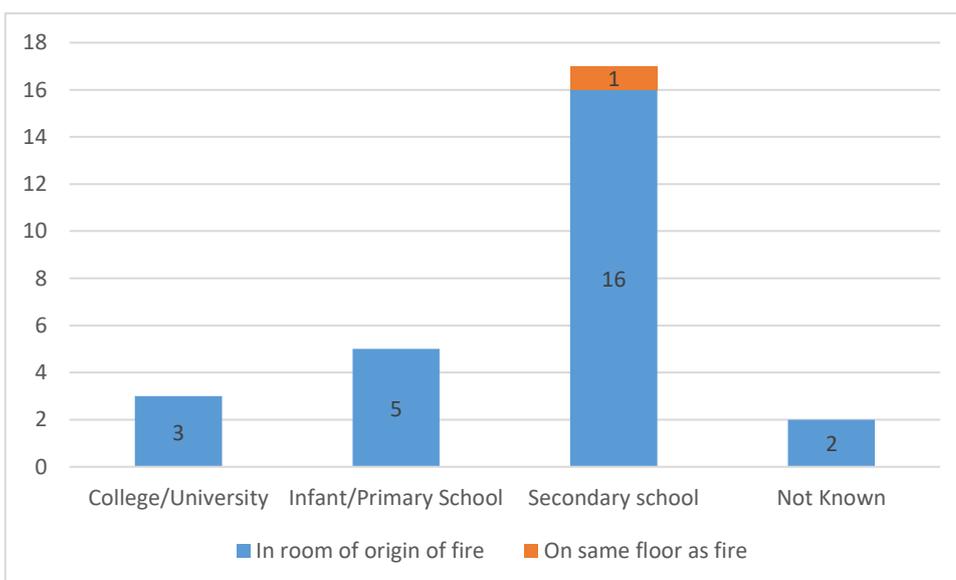


Source: Optimal Economics

**Education: System Operated**

Of the 83 fires in educational establishments, the sprinkler system operated in 34 cases. Information on the location of the system is available for 27 cases and details are shown in Figure C27. In all but one of these cases, the system was located in the room of origin of the fire.

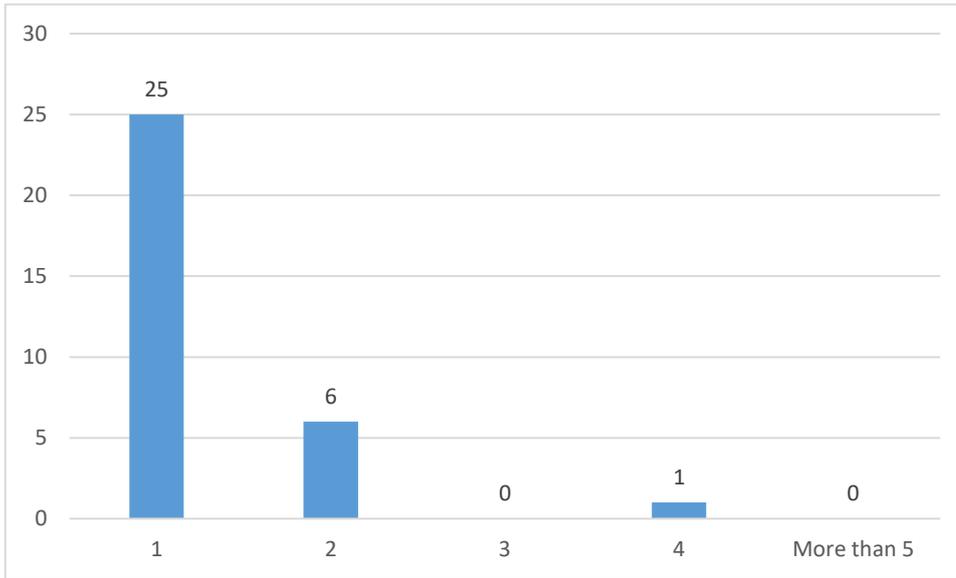
**Figure C27: Location of Sprinkler System where System Operated, Education Sub-Sectors**



Source: Optimal Economics

Of the 34 educational fires where the system operated, data are available on the number of heads operating for 32 incidents. In 25 of the 32 cases (78%), only one head operated. Details are shown in Figure C28.

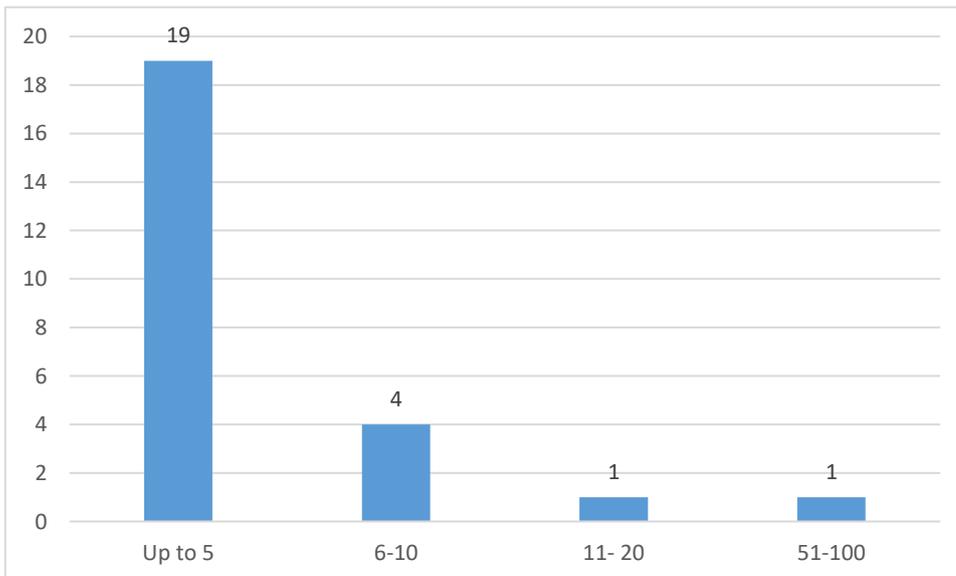
**Figure C28: Number Fires by Number of Heads Activated, Education Sub-Sectors**



Source: Optimal Economics

In terms of the area of fire damage where the sprinklers operated, data are available for 25 fires. Nineteen of the fires (76%) had fire damage of up to 5 sq. m. with a further four (16%) having between 6 and 10 sq. m. of fire damage. Details are shown in Figure C29.

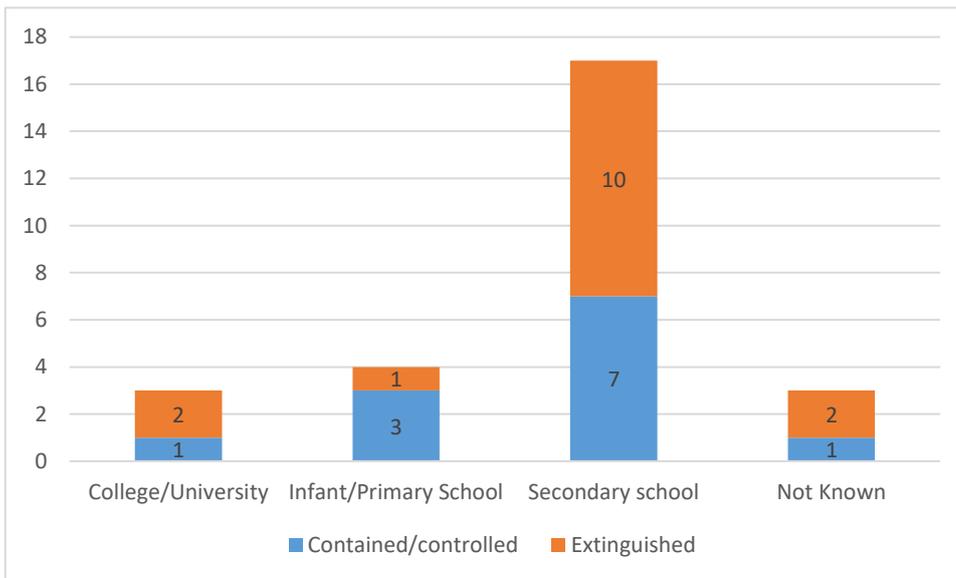
**Figure C29: Number of Fires by Average Area of Fire Damage, Education Sub-Sectors**



Source: Optimal Economics

The impact of the sprinkler system is known for 27 of the 34 fires where the system operated. Figure C30 shows the effectiveness of the system in containing the fire for each educational sub-sector. For all educational sub-sectors, the sprinkler system contained/controlled or extinguished the fire in every case. Hence the performance effectiveness of sprinklers in educational establishments was 100%.

**Figure C30: Impact of Sprinkler System, Education Sub-Sectors**

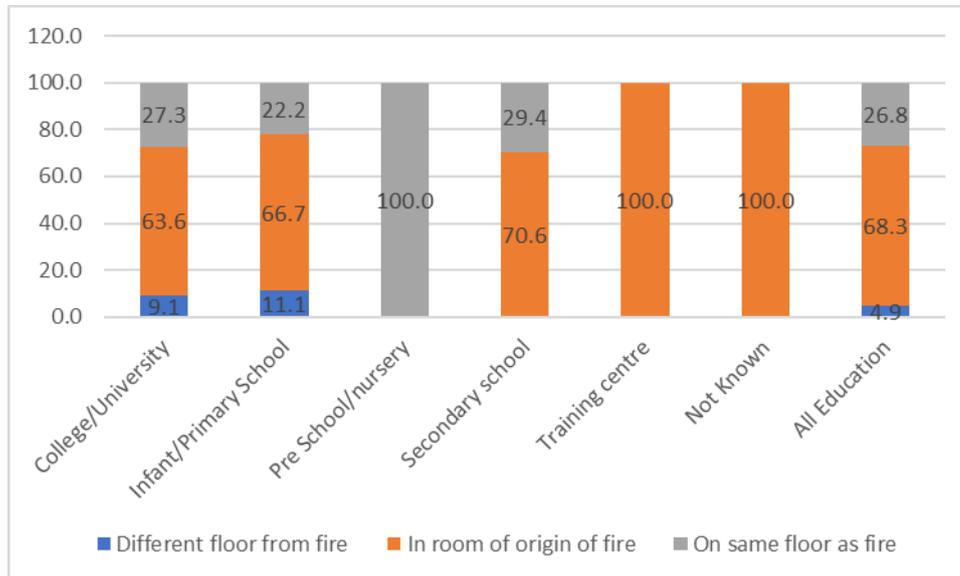


Source: Optimal Economics

**Education: System did not operate**

Over the five years of the analysis, the system did not operate in 48 cases. In terms of the location of the sprinkler system in relation to the fire, data were available for 41 fires. The sprinkler was located in the room of origin of the fire in 68% of fires where the system did not operate. Details are shown in Figure C31.

**Figure C31: Location of Sprinkler System where System did not Operate, Education Sub-Sectors**

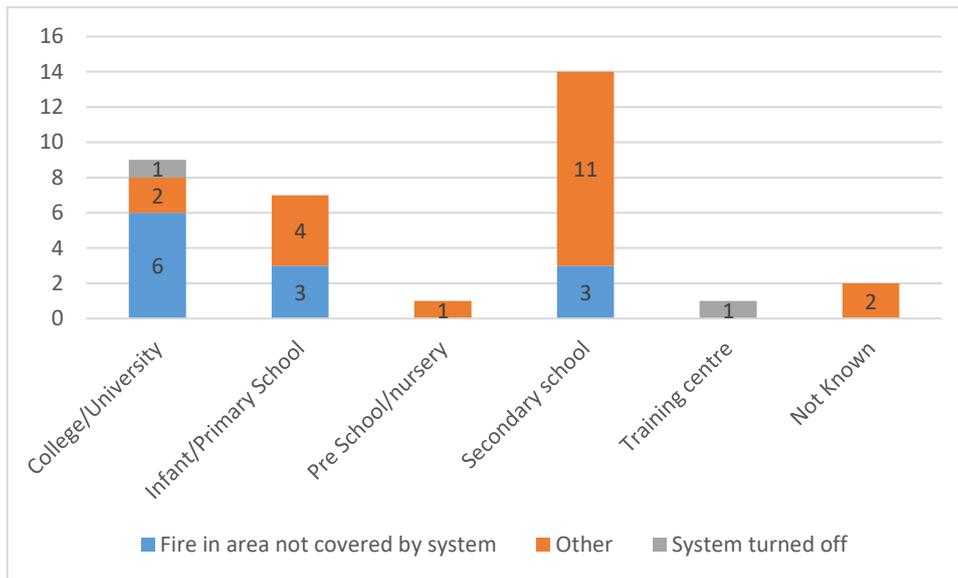


Source: Optimal Economics

The reason why the system did not operate is recorded for 34 of the 48 fires with a summary of the reasons provided in Figure C32. In twelve of the 34 cases (35%) the fire was in an area not covered by the system and in a further 20 cases (59%), “other” was given as a reason. In two cases – one in a college/university and one in a training centre - the system was turned off. Of the 20 “other” reasons for not operating, four cases provided further detail with insufficient heat being cited in all four cases.

In the cases where there was insufficient heat or the fire was in an area not covered by the system, the sprinkler could not be expected to operate. Across all education sub-sectors where the system did not operate, the available data indicates that the systems could not have been expected to operate in 94% of cases.

**Figure C32: Reasons why Sprinkler System did not Operate, Education Sub-Sectors**



Source: Optimal Economics