www.bre.co.uk

BRE Global Client Report

Fire experiments on mobility scooters protected by sprinklers

Prepared for: **Lewisham Homes**

Date: **5 May 2016**

Report Number: **P102574-1000, Issue 3**

BRE Global Ltd
Watford, Herts
WD25 9XX

Customer Services 0333 321 8811

From outside the UK:
T + 44 (0) 1923 664000
F + 44 (0) 1923 664010
E enquiries@bre.co.uk
www.bre.co.uk

Prepared for:
Lewisham Homes
Lewisham Town Hall
Catford Road
London SE6 4RU

Prepared by

Name Dr Sung-Han Koo

Position Fire Research Manager

Date 4 May 2016

Signature 

Authorised by

Name Martin Shipp

Position Technical Director

Date 4 May 2016

Signature 

Executive Summary

BRE Global has been commissioned by the Lewisham Homes to carry out ad-hoc fire experiments of mobility scooters when subjected to sprinkler suppression (BRE proposal no. P102574-1000 Rev3, 8th January 2016). The client's requirements were for BRE to mimic conditions on the client's properties where mobility scooters are going to be stored in sprinkler protected rooms/lounges.

Two experiments were carried out in BRE Global Burn Hall facility on 11th March 2016. The first experiment involved a single mobility scooter with lead acid battery and the second experiment involved three mobility scooters, with one scooter fitted with Li-Ion battery.

The experiments showed that even if two similar mobility scooters are ignited at similar points using identical ignition sources, the fire behaviour and the speed of temperature rise can significantly be different. The experiments also showed that in the experimental compartment used in this project the sprinkler system was able to effectively suppress the fire before the fire reached critical stage in both experiments.

The findings from this project, in particular the "raw" experimental results, will provide a data resource for the fire safety engineering of flats, care homes and sheltered accommodation and other types of occupancies where mobility scooters may be expected to be found.

While providing a valuable bench-mark, the experimental results are necessarily subject to the types and number of mobility scooters used and set-up. Further work to examine a range of types of scooter, suppression types and room dimensions would be of value.

Statement from Lewisham Homes

Lewisham Homes ongoing commitment to manage fire risk to its properties has led to a programme of fitting sprinklers within its sheltered accommodation. The general increase in use of mobility scooters has presented certain challenges around how the risk of fire is managed. Of particular concern is the scooter storage and charging arrangements. The recent use of lithium batteries instead of lead acid batteries to power scooters has added further risks because of their unpredictable and adverse reaction when subjected to fire. A number of solutions for storage have been reviewed and implemented but there is still an ongoing difficulty because external areas do not have the closeness which residents want or require for ease of access to their scooters.

Lewisham Homes decided to fund cutting edge research that has not previously been carried out anywhere in the world to assess the effectiveness of domestic sprinklers suppressing or extinguishing a mobility scooter fire. The outcome of the experiment would assist Lewisham Homes in the decision on whether to allow the internal storage and charging of mobility scooters within their sheltered schemes.

Lewisham Homes engaged BRE Global to carry out these experiments. The specification was defined by Stephen Kilden, Lewisham Homes Fire Safety Advisor. As part of the experiment, the plans for sprinkler installations already installed at four different Lewisham Homes sheltered schemes were provided. These installations were carried out to the relevant British Standard. The BRE chose to replicate a room from Waverley Court, one of the sheltered schemes, as it presented the most challenging condition due to the area being covered by a single sprinkler head. The BRE constructed a life size mock-up of the room within their 'Burn Hall' in their testing facility.

Two experiments were carried out;

1) The first experiment involved one mobility scooter being set alight to assess the effectiveness of the sprinkler in suppressing or extinguishing the fire. The seat of the fire was set to replicate a fire starting within the battery housing.

2) The second experiment involved three mobility scooters. One scooter had a lithium battery fitted which posed the additional danger of increases in temperature and the possibility of explosion.

A fire was set to reproduce an electrical fault within the battery housing on this scooter. To imitate an even more challenging event, the two remaining scooters were positioned in such a way as to offer some shielding to the first scooter from the sprinkler head coverage.

Lewisham Homes would like to thank Mr Larry Wright, Mobility Giant Ltd who donated all the scooters at no cost for these experiments.

bre

Table of Contents

Introduction 5
Experimental setup 9
Results 14
Conclusion and recommendations 24
References 25

Introduction

BRE Global has been commissioned by the Lewisham Homes (the client) to carry out ad-hoc fire experiments of mobility scooters when subjected to sprinkler suppression (BRE proposal no. P102574-1000 Rev 3, 8th January 2016). The client's requirements were for BRE to mimic conditions on the client's properties where mobility scooters are going to be stored in sprinkler protected rooms/lounges. The client was looking for reassurance that if a fire develops in one of the scooters then the sprinkler system will be able to at least contain the fire.

BRE was supplied with the layout of rooms with the information on type and number of installed sprinkler heads as Figure 1. Figure 2 shows photos taken by the client in one of the locations (Waverley Court) showing position of the concealed sidewall sprinkler head.

BRE Global was informed by the client that within the area of rooms where the scooters are going to be stored there are the following number of sprinkler heads:

- Talbot Court: Two concealed sidewall sprinkler heads installed at 2.2 m height (ceiling height 2.3 m).
- John Penn House: Two concealed sidewall sprinkler heads installed at 2.5 m height (ceiling height 2.6 m).
- Welland Court: Three concealed sidewall sprinkler heads installed at 2.25 m height (ceiling height 2.35 m).
- Waverley Court: One concealed sidewall sprinkler head installed at 2.15 m height (ceiling height 2.3 m).

There are additional heads in the rooms but they are away from the proposed storage area.

The client supplied four different scooters (see Figure 3) to BRE Global on 1st March 2016 and asked that three should be used together in one experiment and one should be used in a second experiment.

The client also wished to assess one scooter equipped with a lithium-ion battery and three other scooters with typical lead-acid batteries (shown in Figure 4). This information was important as Li-Ion batteries can undergo thermal runaway and release flammable gases and consequently create more severe conditions [1].

The client informed BRE Global that their sprinkler installers, Domestic Sprinklers, agreed to carry out sprinkler head installation and to provide sprinkler heads for the experiments. The sprinklers heads were identical to those installed in the client's properties.

BRE Global was informed by the client that Domestic Sprinklers confirmed that the sprinkler designs in the client's premises conform to BS 9251 [2] and the BAFSA TG1 document [3].

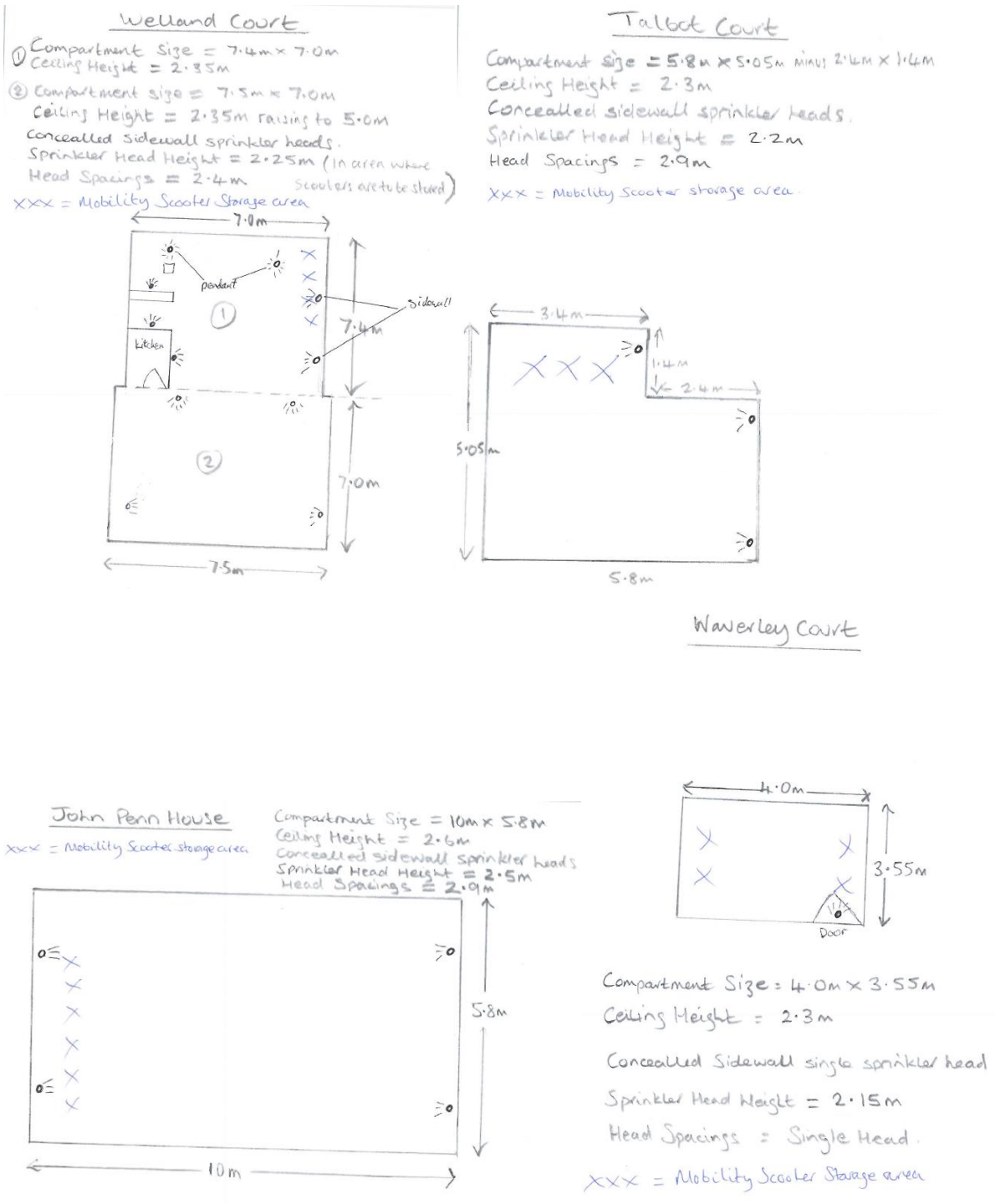

Figure 1 – Sketch showing dimensions of the rooms where scooters will be stored, provided by the client

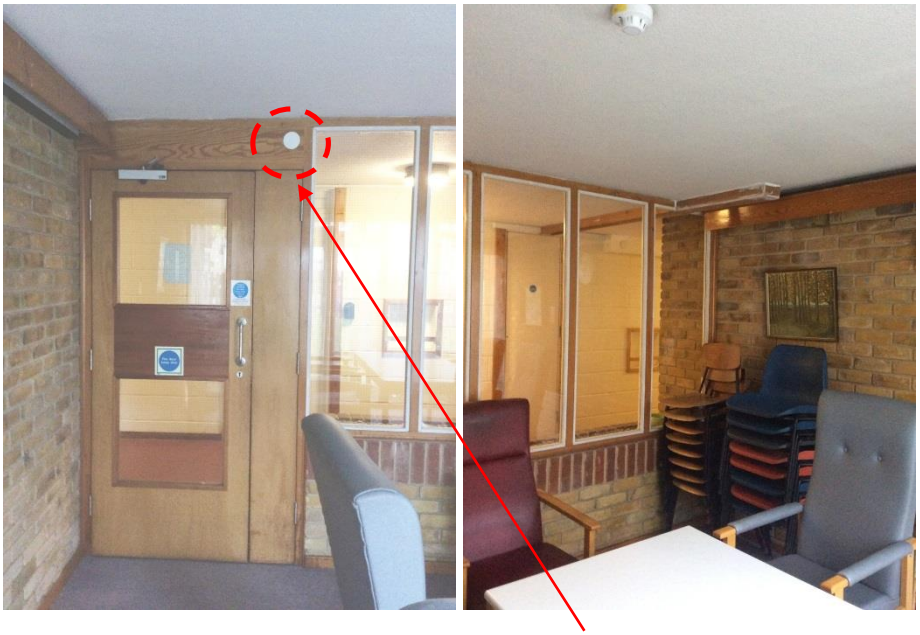

Figure 2 – Photos from Waverley Court. Left image showing the location of the concealed sprinkler head

Figure 3 – The mobility scooters which were supplied by the client for the fire experiments.

Figure 4 – Lead-acid batteries installed in the scooters.

Disclaimer: This work does not provide any formal BRE approval or certification of any product used in the project. The mobility scooters used in the fire experiments in this project were selected solely on the basis of availability. None of the scooters were selected on the basis of make or model. None of the findings in this research programme should be taken as suggesting that any particular make or model of mobility scooter performs better or worse in fire, compared with any other make or model.

Experimental setup

Having analysed drawings supplied by the client (Figure 1), it was agreed by BRE Global and the client that the worst case fire scenario may occur inside the room in Waverley Court and a potential fire in a mobility scooter located in the left upper corner of that room (furthest away from the sprinkler head) may create the worst conditions since the sprinkler head is located at the greatest distance from the potential fire origin as compared with other premises. Additionally the whole room is protected by one sprinkler head.

Therefore the client agreed that the experimental compartment would have the dimension of 4 m x 3.55 m with a ceiling height of 2.3 m which is identical with the room in the Waverley Court, but constructed in a simpler manner, i.e. no glazing panels and bricked walls were used. A door opening of 2 m x 0.82 m was included (without a door). The compartment was lined with a single layer of 15 mm plasterboard fixed from the internal side to timber studs.

A single concealed sidewall sprinkler head was located at 2.15 m height and installed by the client's subcontractor, Domestic Sprinklers. The sprinkler head was installed from a CPVC sprinkler pipe with 6.5 bar static pressure and 200 litre/min flow rate at 2.0 bar working pressure.

Scooters were not charged or plugged into the electricity mains during the fire experiments.

The experimental compartment was erected in BRE Burn Hall facility as shown in Figure 5 and two experiments were carried out.

Figure 5 – Photo showing experimental compartment

For both experiments the door opening to the compartment was kept open during the experiments as this would create more severe conditions (a higher Heat Release Rate could develop if the sprinkler did not contain the fire) and it allowed visual observations.

A scooter in each experiment was ignited by means of a textile strip soaked in a small amount of accelerant and located close to the battery compartment in order to simulate a fire started by an electrical fault. This was expected to be sufficient to ignite the scooter based on the previous fire experiments performed by BRE Global (see http://www.bre.co.uk/filelibrary/Fire%20and%20Security/FI---Trust-Report-Mobility-Scooters-May-15.pdf for further information).

In the first experiment (Experiment #1), a single mobility scooter fitted with lead acid battery was located at the corner of the compartment as shown in Figure 6 and Figure 7.

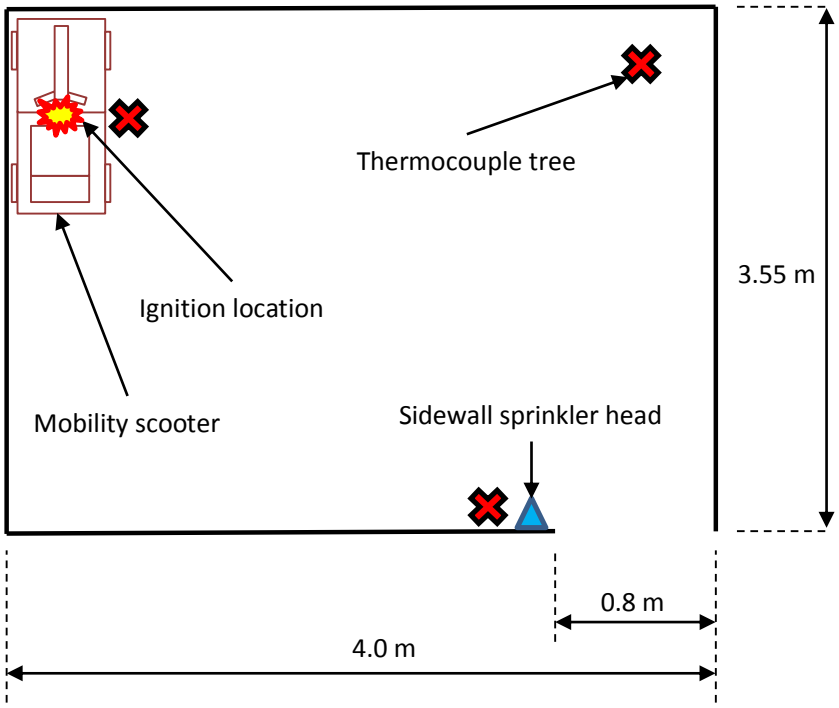

Figure 6 – Layout of the compartment for Experiment #1, not to scale

Figure 7 – Photo of a mobility scooter located at the corner of the compartment, Experiment #1

In the second experiment (Experiment #2), three scooters were parked inside the experimental compartment with one parked to provide a shielding effect, i.e. parked next to the scooter being the source of fire to create more challenging conditions as shown in Figure 8 and Figure 9. In this experiment, one scooter was fitted with a Li-Ion battery as a fire source.

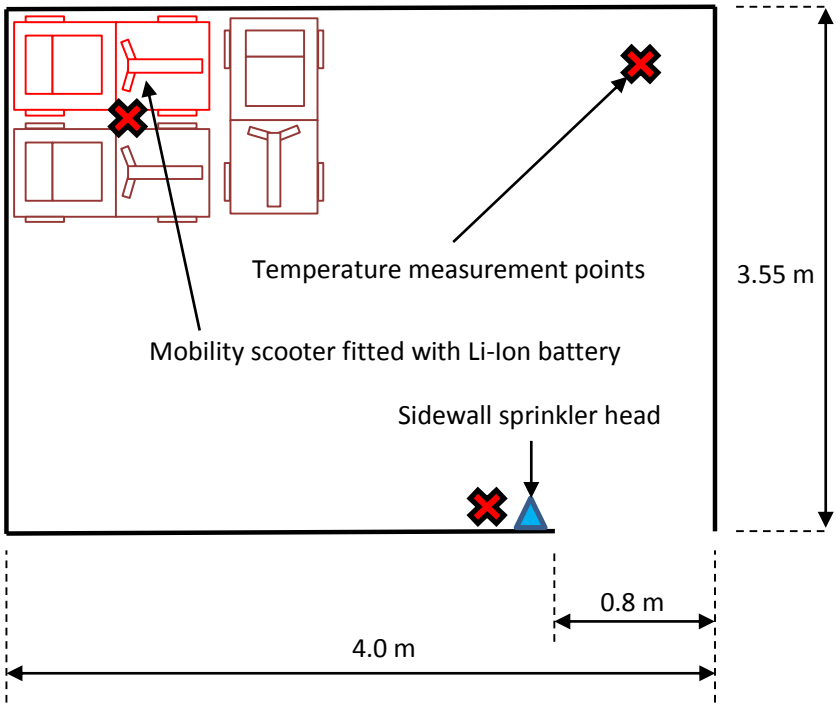

Figure 8 – Layout of the compartment for Experiment #2, not to scale

Figure 9 – Photo of mobility scooters located at the corner of the compartment, Experiment #2 (Note damage to the compartment from Experiment #1)

For Experiment #2, the fire was started in a scooter (fitted with a Li-Ion battery) parked in left hand corner furthest away from the sprinkler head. Other scooters were parked as shown in the figure above as close to each other as expected in reality. The sprinkler head (and cover) was replaced with a new one after the first experiment as shown in Figure 10.

The fire was initiated in one scooter only as it was considered to be highly unlikely a fire will develop in two or three scooters at the same time (unless deliberate arson action is envisaged).

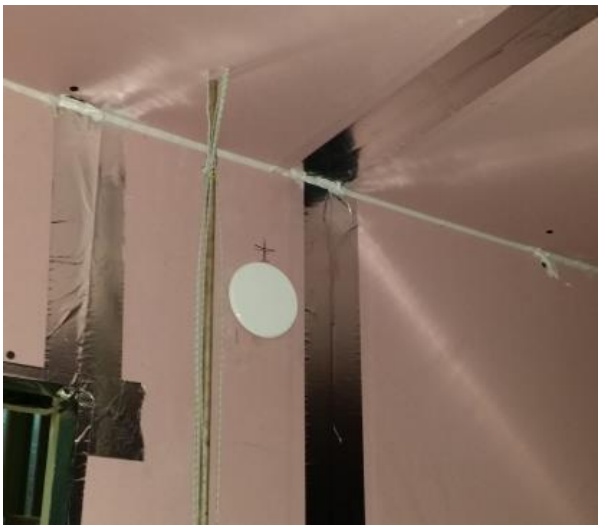

Figure 10 – Photo of a sprinkler head and cover installed next to the compartment opening

Temperatures within the compartment were measured by mineral insulated stainless steel sheathed type K thermocouples fitted on three thermocouple trees, each tree being equipped with minimum five thermocouples fixed at various heights as shown in Figure 11.

The first thermocouple tree was located over the proposed fire location; the second tree was positioned about 3 m away from fire origin; and the last tree close to sprinkler head.

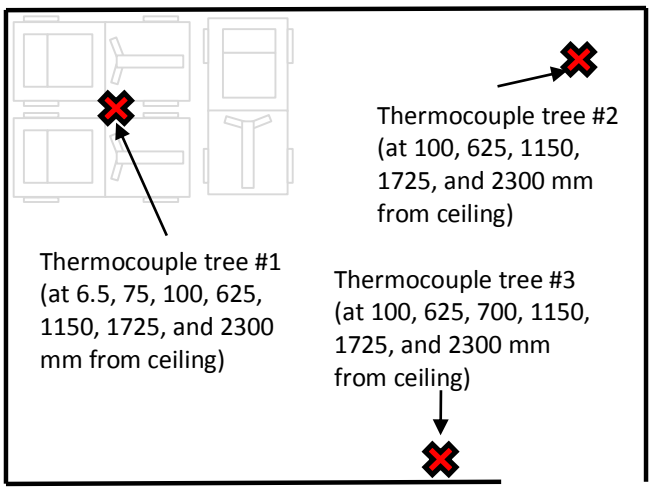

Figure 11 – Location of thermocouple trees, both experiments, not to scale

The experiments were to be performed according to the procedure described below.

1) Safety briefing for staff and visitors.
2) Start temperature data acquisition system and video cameras.
3) Manual ignition of one scooter.
4) Undertake visual observations during initial fire development.
5) Record the time of sprinkler head activation and any other significant events.
6) The experiment continues for 30 minutes after sprinkler head activation.
7) Manual extinguishment of the fire by our staff members after 30 minutes of sprinkler head activation.

Note: The 30 minutes duration was agreed with the client as being the minimum period of sprinkler operation for residential properties [2].

Results

Two experiments were carried out in BRE Global Burn Hall facility on 11th March 2016.

The experiments were viewed by total of thirteen people from the Lewisham Homes, Department of Communities and Local Government, The British Automatic Fire Sprinkler Association Limited, London Fire Brigade, Domestic Sprinklers Limited, and Paragon Community Housing Limited.

Experiment #1

Experiment #1 took place from 09:45. The fire was initiated close to the battery compartment of a mobility scooter equipped with a lead acid battery as shown in Figure 12.

Figure 12 – Ignition of a mobility scooter in Experiment #1

Approximately two minutes after ignition, black smoke started to come out from the compartment as shown in Figure 13 and at about 5 minutes from ignition the flame spread to the seat of the mobility scooter as shown in Figure 14. At about 6 minutes 25 seconds, the sprinkler activated. After the sprinkler started to suppress the fire, thick smoke was produced and no useful visible observation could be made as shown in Figure 15.

Figure 13 – Black smoke coming out from compartment, Experiment #1
(Left: front view, right: side view)

Figure 14 – Flame spread to mobility scooter seat, Experiment #1

Figure 15 – Thick smoke coming out from the compartment after sprinkler activation, Experiment #1

At the client's request, the sprinkler was turned off at about 3 minutes after activation to see if the sprinkler had suppressed the fire and if not, whether the fire developed again. The temperature started to rise again reaching up to 780 °C and the fire had to be manually extinguished for health and safety reasons due to excessive smoke in the laboratory.

Figures 16 to 18 present temperature data measured from the three thermocouple trees. The first temperature drop can be observed at about 6.2 minutes from ignition, then re-rise of the temperature from about 9 minutes when the sprinkler was turned off. The temperature at 100 mm from ceiling from the thermocouple tree #3 (next to sprinkler head) showed 63 °C at the point of sprinkler activation.

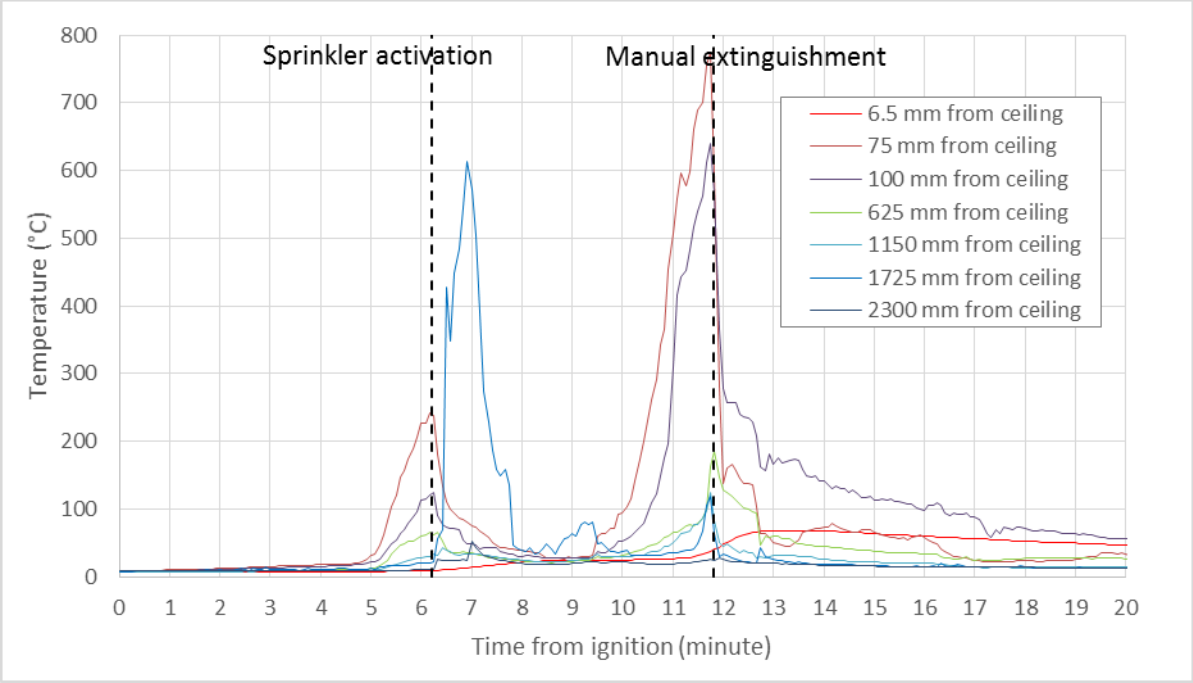

Figure 16 – Temperature data of thermocouple tree #1, Experiment #1

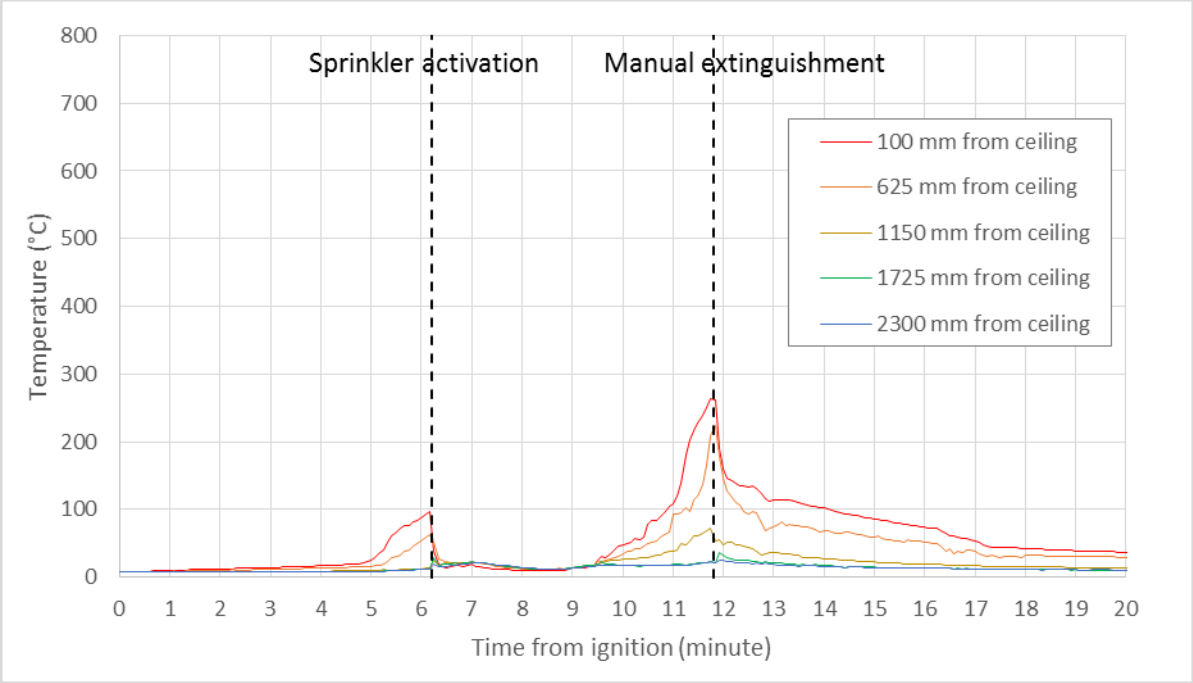

Figure 17 – Temperature data of thermocouple tree #2, Experiment #1

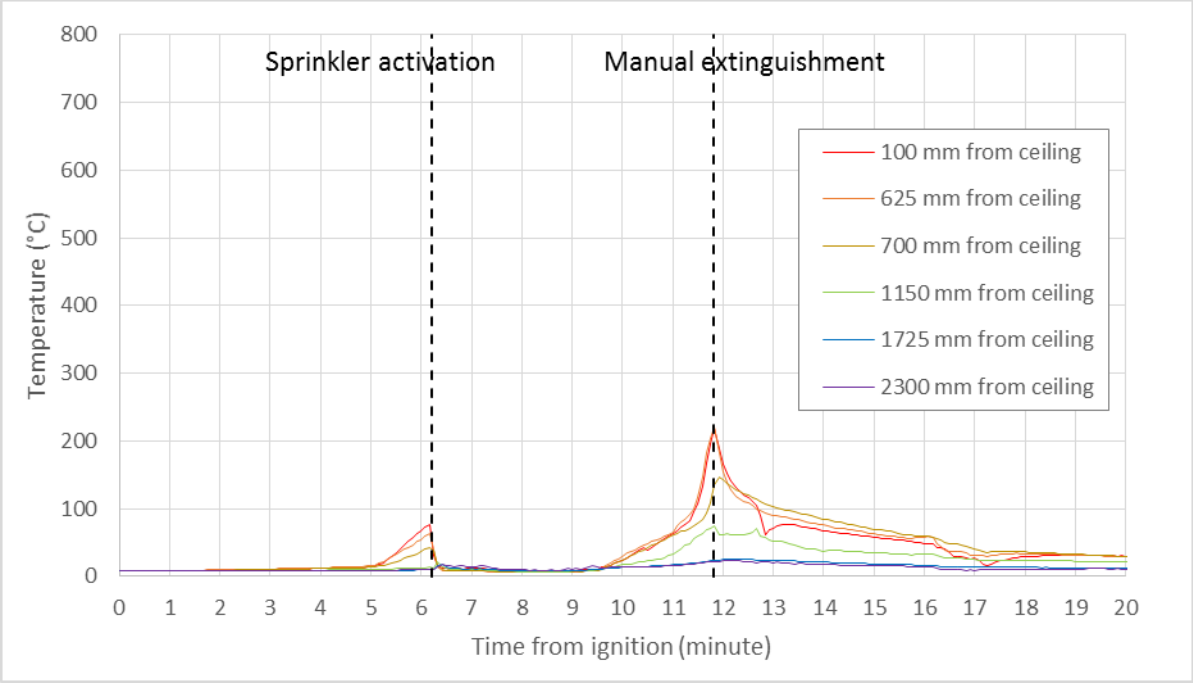

Figure 18 – Temperature data of thermocouple tree #3, Experiment #1

Figures 19 and 20 below show the mobility scooter after Experiment #1. Most of the part of the seat which was made of foam was burnt, however, the remaining body of the mobility scooter was left intact. The lead acid batteries were partially burnt but there was no sign of leakage or explosion.

Figure 19 – Mobility scooter in the compartment after Experiment #1

Figure 20 – Photo showing damage to mobility scooter after Experiment #1

Experiment #2

Experiment #2 took place from 11:00. The sprinkler head was replaced with a new head and three mobility scooters were positioned in place as shown in Figure 9. The fire was initiated close to the Li-Ion battery compartment of the mobility scooter parked at the corner of the compartment as shown in Figure 21.

Figure 21 – Ignition of a mobility scooter in Experiment #2
(Left: immediately after ignition, right: approximately 2 minutes after ignition)

Figure 22 shows the thick smoke coming out from the compartment just before sprinkler activation.

Figure 22 – Thick smoke coming out from the compartment before sprinkler activation, Experiment #2

Figures 23 to 25 show the compartment temperature data measured from the thermocouple trees. Unlike Experiment #1, the temperature rose rapidly and at about 2 minutes 50 seconds, the temperature at 100 mm from ceiling at thermocouple tree #3 (close to sprinkler head) reached about 90 °C and the sprinkler activated. In this experiment, the sprinkler was left to operate for further 10 minutes and the experiment was then terminated since the fire appeared to be suppressed (possibly extinguished).

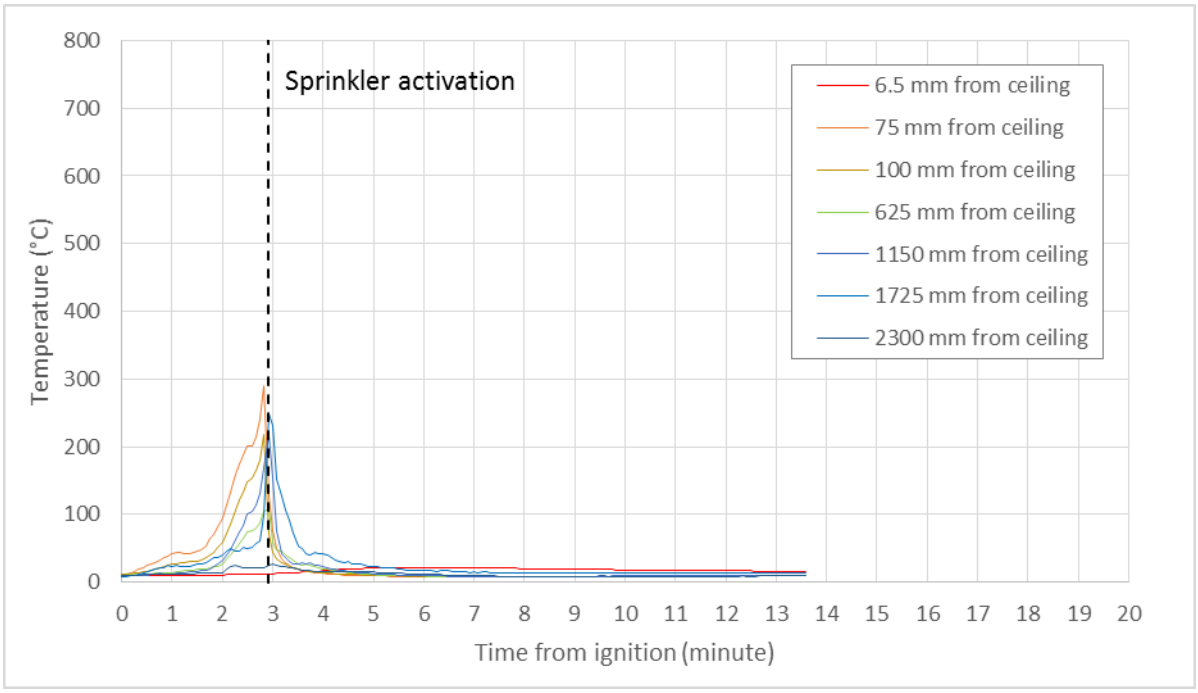

Figure 23 – Temperature data of thermocouple tree #1, Experiment #2

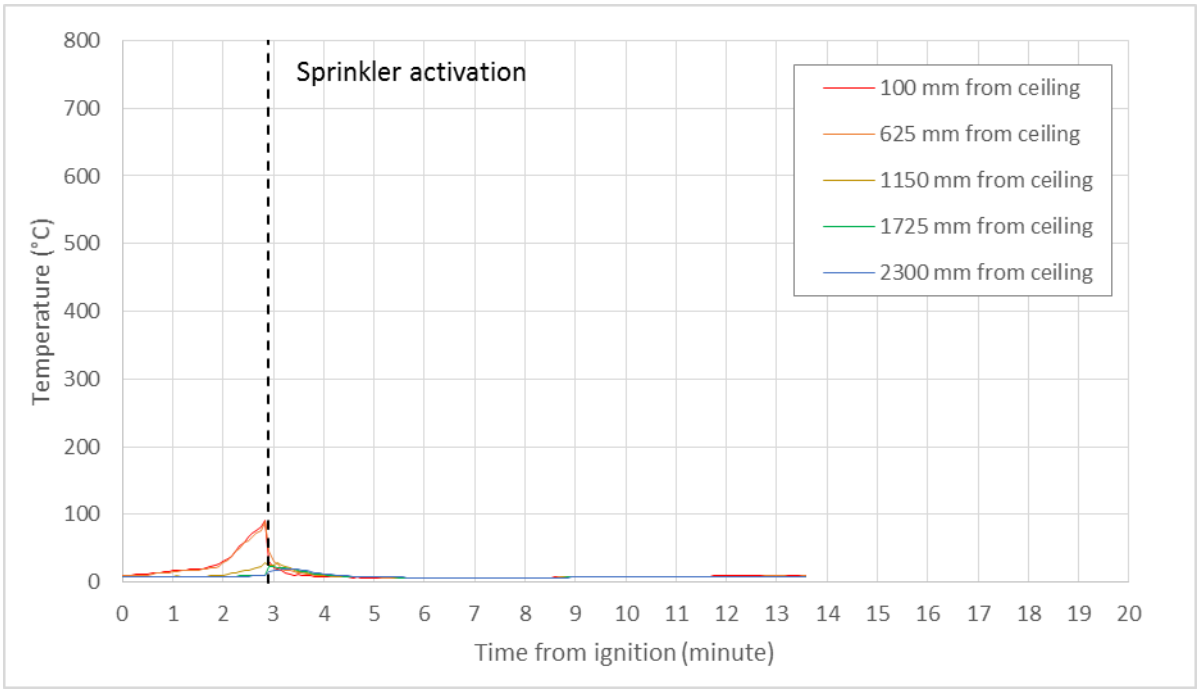

Figure 24 – Temperature data of thermocouple tree #2, Experiment #2

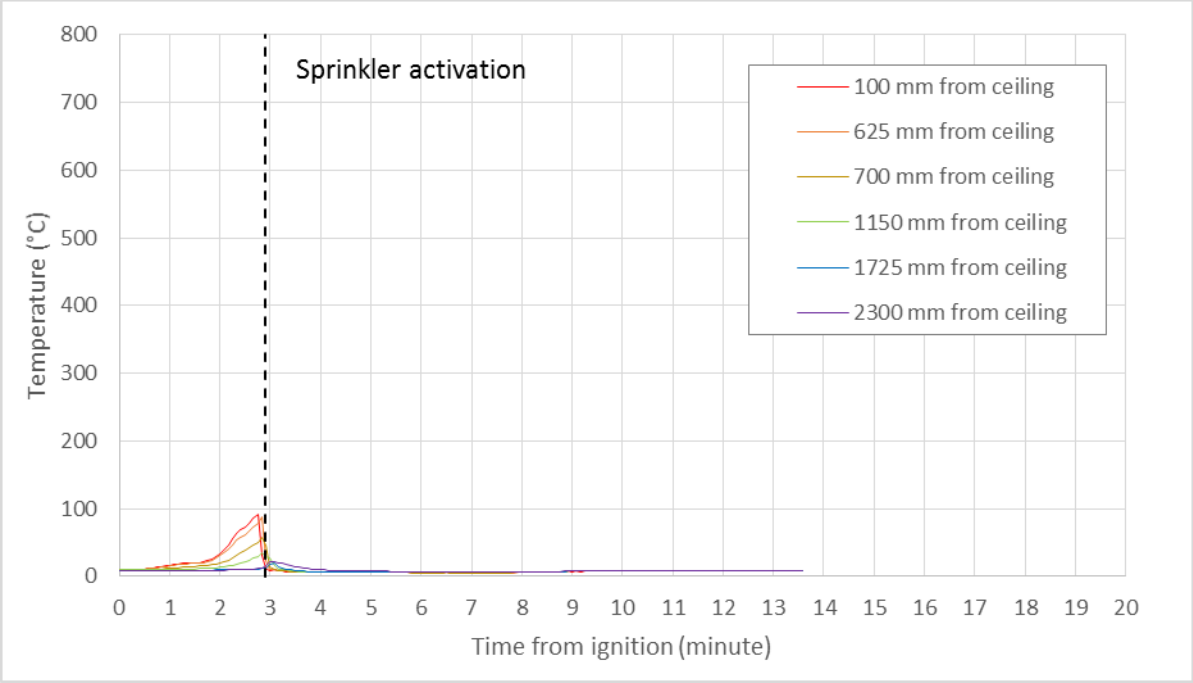

Figure 25 – Temperature data of thermocouple tree #3, Experiment #2

Figures 26 and 27 show the damage to the mobility scooters after Experiment #2. Since the temperature in the compartment rose much more rapidly than Experiment #1, and thus resulting in relatively quicker sprinkler activation the flame spread from the battery compartment to the mobility scooter seat; however, it did not affect the adjacent mobility scooters.

The cover of the Li-Ion battery was heavily damaged, however, it appears that the flame did not penetrate the cover. Consequently the internal material was not affected and there was no explosion.

Figure 26 – Mobility scooters in the compartment after Experiment #2

Figure 27 – Photo showing damage on mobility scooter around Li-Ion battery after Experiment #2

Conclusion and recommendations

Two ad-hoc fire experiments have been carried out on mobility scooters. The first experiment involved a single mobility scooter with lead acid battery and the second experiment involved three mobility scooters, with one scooter fitted with Li-Ion battery. The purpose of the experiments was to understand the fire behaviour when fires starting in a mobility scooters are subjected to sprinkler suppression. The experimental compartment was designed identically to one of the client's existing premises which could potentially provide the worst condition.

In both experiments, the sprinkler system activated and suppressed the fire. In the first experiment (involving one scooter), the sprinkler activated at about 6 minutes 25 seconds from ignition when the temperature of the gas layer near to the sprinkler head reached 63 °C. The fire spread from the battery compartment to the seat but did not significantly affect the remaining body of the mobility scooter.

In the second experiment, the fire spread from the battery compartment to the seat much more quickly resulting in sprinkler activation at about 2 minutes 50 seconds. The surface of the Li-Ion battery fitted in one scooter was heavily damaged, however, there was no further consequences such as explosion. The temperature of the gas layer near to sprinkler head was about 90 °C when the sprinkler activated.

The two experiments showed that even if two similar mobility scooters are ignited at similar points using identical ignition sources, the fire behaviour and the speed of temperature rise can significantly be different. The experiments also showed that in the experimental compartment used in this project the sprinkler system was able to effectively suppress the fire before the fire reached critical stage.

The findings from this project, in particular the "raw" experimental results, will provide a data resource for the fire safety engineering of flats, care homes and sheltered accommodation and other types of occupancies where mobility scooters may be expected to be found.

While providing a valuable bench-mark, the experimental results are necessarily subject to the types and number of mobility scooters used and set-up. Further work to examine a range of types of scooter, suppression types and room dimensions would be of value.

References

[1] http://www.bbc.co.uk/news/business-25733346, accessed on 7 April 2016.

[2] BSI, Fire sprinkler systems for domestic and residential occupancies. Code of practice. BS 9251:2014, London, BSI, 2004.

[3] BAFSA, The design and installation of residential and domestic sprinkler systems, Technical Guidance Note 1, Second edition, BAFSA, 2012.

Report Ends