www.bre.co.uk

BRE Trust Project

Heat release and smoke production from burning Mobility Scooters

May 2015

This report is made on behalf of BRE Global and may only be distributed in its entirety, without amendment, and with attribution to BRE Global Ltd to the extent permitted by the terms and conditions of the contract. Assessments relate only to the items tested/assessed. BRE Global has no responsibility for the design, materials, workmanship or performance of the product or items tested/assessed. This report does not constitute an approval, certification or endorsement of the product tested/assessed.

BRE Global’s liability in respect of this report and reliance thereupon shall be as per the terms and conditions of contract with the client and BRE Global shall have no liability to third parties to the extent permitted in law.

Executive Summary

This is the final report from the jointly funded BRE Trust (contract number 232-14-RM) and Welwyn Garden City Housing Association project titled "Heat release and smoke production from burning Mobility Scooters".

Ensuring fire safety for the residents of care homes and sheltered accommodation for the elderly is one of the biggest challenges facing the fire safety community in the coming decades. The need to maintain fire safety provisions in such buildings often conflicts with the every-day life of the occupants.

But, as well as the potential obstruction to escape, there is now a clear and increasing body of evidence to show that mobility scooters present a fire risk in themselves, often while charging, which can result in the production of quantities of smoke and heat.

The objective of this research has been to quantify the typical production of quantities of smoke and heat from a burning Mobility Scooter. This has been achieved by carrying out experimental measurements of heat release rate and smoke production from burning Mobility Scooters.

The data is intended to be of value to fire engineers, designers, fire risk assessors, and enforcers working in the care home sector since it will provide design parameters and allow an objective assessment to be made of the real fire risks from these machines. It will also inform decision-makers in properties in which mobility scooters are used, in providing information to assist them in determining and managing an appropriate fire safety regime.

This will enable better founded decisions to be made for fire safety in flats, care homes and sheltered accommodations and assist in providing an appropriate level of fire safety for residents with minimal detriment to normal life. The data will also be of benefit to other occupancy types where mobility scooters are in common use such as supermarkets and shopping centres.

The ease with which a mobility scooter fire in a corridor might spread to nearby scooters has been demonstrated.

In this situation, where a number of scooters are burning simultaneously, the fire is exacerbated by heat-feedback and heat release rates in excess of 2½ MW might be achieved from two or three scooters. In the experiment, scooter 1 burned slowly for about 3 minutes and it was only then that scooter 2 became involved. However, temperatures and heat release rate then rapidly rose.

It is evident that a fire involving mobility scooters, within the confines of a corridor or stairway, will create a substantial risk to occupants since the smoke and heat will make such routes impassable and put at risk any occupants who open their doors.

The findings from this research, 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. It follows that bigger scooters (or a greater number of scooters) are likely to lead to far more severe fires and quantities of smoke. Further work to examine a range of types of scooter would be of value.

Disclaimer: The mobility scooters used in the fire experiment in this research programme were selected solely on the basis of availability. Neither scooter was 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.

Table of Contents

Introduction

This is the final report from the jointly funded BRE Trust (contract number 232-14-RM) and Welwyn Garden City Housing Association project titled "Heat release and smoke production from burning Mobility Scooters".

Ensuring fire safety for the residents of care homes and sheltered accommodation for the elderly is one of the biggest challenges facing the fire safety community in the coming decades. The need to maintain fire safety provisions in such buildings often conflicts with the every-day life of people. Many such people depend upon mobility scooters to enable them to get around, maintain some independence and achieve an outside social life. The scooters need to be in or near the home to be of value, and in shared premises are often parked (or even charged) in common areas such as the access corridors which form the escape route from the building.

But, as well as the potential obstruction to escape, there is now a clear and increasing body of evidence to show that mobility scooters present a fire risk in themselves, often while charging, which can result in the production of quantities of smoke and heat.

Welwyn Garden City Housing Association

Welwyn Garden City Housing Association (WGC HA) provides a range of housing, care and support options, mostly for local older people. Since the Association was formed in 1961, its primary purpose has been to provide the highest quality housing. WGC HA's range of services has expanded over the years to include management services for external organisations, such as other locally based housing associations and property management companies. WGC HA's reputation as a leader in resident involvement and participation is achieved by being locally accountable, accessible and remaining of a size where quality will always prevail over quantity [see Ref 1].

BRE Global have been carrying out fire safety risk assessments under commission from Welwyn Garden City Housing Association, in and around Welwyn Garden City, in the last four years. The problems caused by mobility scooters have become apparent as part of this work and as a consequence Welwyn Garden City Housing Association (WGC HA) offered BRE two mobility scooters for the purposes of research into their fire performance. While WGC HA need the data for their own purposes, they are also are keen to make such data available to the wider fire safety and care home communities.

The BRE Trust agreed to support this initiative.

The BRE Trust

The BRE Trust is a research and education charity for the public benefit, registered by the Charity Commission (registered charity number 1092193). It is the owner of BRE and BRE Global. All of the companies owned by BRE Trust contribute their profits to supporting the Trust's mission to champion excellence and innovation in the built environment. The BRE Trust achieves this by funding and managing a strategic research programme in the built environment sector [see Ref 2].

Objective

The objective of this research has been to quantify the rate of production of quantities of smoke and heat from a burning Mobility Scooter. This has been achieved by carrying out experimental measurements of heat release rate and smoke production from burning Mobility Scooters.

The data is intended to be of value to fire engineers, designers, fire risk assessors, and enforcers working in the care home sector since it will provide design parameters and allow an objective assessment to be made of the real fire risks from these machines. It will also inform decision-makers in properties in which mobility scooters are used, in providing information to assist them in determining and managing an appropriate fire safety regime. This will enable better founded decisions to be made for fire safety in flats, care homes and sheltered accommodations and assist in providing an appropriate level of fire safety for residents with minimal detriment to normal life. The data will also be of benefit to other occupancy types where mobility scooters are in common use such as supermarkets and shopping centres.

Disclaimer: The mobility scooters used in the fire experiment in this research programme were selected solely on the basis of availability. Neither scooter was 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.

Background

Mobility scooters offer an enhanced quality of life to large numbers of people who would otherwise be very limited in their ability to get out of their homes.

Rules for mobility scooters and powered wheelchairs are provided by the UK government [Ref 3].

For the purposes of this research we have adopted the following definitions:

- Mobility Scooters - vehicles with three or four wheels and steered using a bicycle style handlebar. They are primarily intended for use outside.
- Motorised Wheelchairs - usually look more like a traditional wheelchair, but with batteries and a motor. They are intended for use inside a building or the immediate vicinity. They are normally stored and recharged within the customer's home.

We note that the DVLA split scooters and wheelchairs into three categories:

- Class 1 - Manual Wheelchairs, i.e. self-propelled or attendant propelled, not electrically propelled. These are not required to be registered with DVLA.
- Class 2 - Powered Wheelchairs and scooters – intended for footway use only with a maximum speed of 4mph and an unladen weight not exceeding 113.4kgs. These are not required to be registered with DVLA.
- Class 3 – Powered Wheelchairs and Scooters with a maximum speed of 8mph generally intended for use on roads/highways. They must be fitted with a device capable of limiting the maximum speed to 4mph for use when travelling on footways. The unladen weight must not exceed 150kgs. These are required to be registered with DVLA.

It is estimated that there are around 300,000 mobility scooters in Britain [Refs 4 and 5].

A market study of mobility scooters in 2014 [Ref 5] found that:

- There is a lack of comprehensive, reliable commercial data on the size of the mobility scooter market and that published data focuses on sales value rather than units sold.
- "Best estimates" put the number of units sold per year at approximately 80,000 and total number of UK users at approximately 300-350,000.
- There is an expectation of high levels of annual sales growth in the sector (5-10%) with evidence of increased advertising and a widening range of retail options - specialist and mainstream shops, charity trading arms, second-hand sales, catalogue and online retailers.

The (non-fire) safety risks of mobility scooters are being questioned [Ref 6] and those injured by these machines seek compensation [Ref 7].

There have been a number of fire incidents involving mobility scooters already reported [Ref 8]. In one case, it is reported that the scooter "exploded" [Ref 9].

There has been a fatal fire involving a mobility scooter left on charge overnight [Ref 10] and a case of a fatal fire that was a result of an arson attack on a scooter [Ref 11].

The fire risks of mobility scooters are already recognised by fire and rescue services and other agencies and advice can be found from a number of these [Ref 12, 13, 14, 15, and 16].

South Yorkshire Fire and Rescue Service have released some results of a survey looking into fires involving mobility scooters [Ref 17].

While mobility scooters can now be found in a wide variety of premises, it is their presence in the common areas of flats and care homes (corridors, stairways and other circulation spaces) and sheltered accommodation with common areas that is causing particular concern. Not all elderly users of mobility scooters appreciate the risks presented to their fellow residents [Ref 18].

New buildings and major refurbishments in England are subject to the Building Regulations in England Ref 19]. Guidance for fire safety in flats in England is given in Approved Document B (Fire safety) to the Building Regulations in England (AD B) [Ref 20], in particular Section B1 "means of escape from flats".

Occupied buildings (new and old) in England and Wales are subject to the Regulatory Reform (Fire Safety) Order 2005 (FSO) [21]. Guidance for fire safety in flats in England and Wales is given in the DCLG guide "Fire Safety Risk Assessment - Sleeping Accommodation" [Ref 22] and in the Local Government Association guide "Fire safety in purpose-built flats" [Ref 23]. Guidance for fire safety in residential care premises in England and Wales is given in the DCLG guide "Fire Safety Risk Assessment - Residential Care Premises" [Ref 24].

All of this guidance advises that common areas of premises should be kept clear of combustible materials.

Description of the project

The objective of this research has been to quantify the rate of production of quantities of smoke and heat from a burning mobility scooter.

This has been achieved by carrying out experimental measurements of heat release rate and smoke production from burning two mobility scooters located in a short "corridor" under the BRE 9m Calorimeter.

Method

The large scale fire experiment was carried out in a "corridor" experimental rig under the large calorimeter hood in the BRE Burn Hall, involving two mobility scooters.

The two scooters were located in the experimental rig, next to each other along one side of the rig, as if parked for charging.

Instrumentation and cameras were started and then a fire was initiated in the charging point of scooter 1 and allowed to develop.

The fire initiation was intended to simulate an arson attack.

The Scooters

The mobility scooters used in the fire experiment and provided to BRE by WGC HA, were selected solely on the basis of availability. Neither scooter was selected on the basis of make or model. See Figures 1 (scooter 1 - red) and Figure 2 (scooter 2 - blue).

The scooters used were in full running order (though not necessarily legally roadworthy). For added realism, a charger unit was attached to scooter 2, but not connected to the mains.

Although the scooters used may be recognisable, in the interests of neutrality the actual make, model and age of each scooter was not recorded.

Hence 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.

Figure 1. Mobility Scooter 1 (prior to experiment).

Figure 2. Mobility Scooter 2 (prior to experiment).

The Experimental Rig

The experimental rig was 3m long and 1.2m wide. The (underside) ceiling height was 2.4m from the floor. The rig comprised a wooden frame, with plasterboard sides and ceiling. See Figure 4 and Figure 5.

Both ends were open, but with a 0.5m deep downstand which was installed to simulate a longer corridor and allow the formation of a smoke layer.

Ignition

The fire was started using a heptane soaked strip of low density fibre board (approximately 25mm x 100mm). This was placed in the charging point of Scooter 1 (circled in Figure 3) under the seat and to the rear.

Figure 3. The Point of Ignition on Scooter 1 (circled).

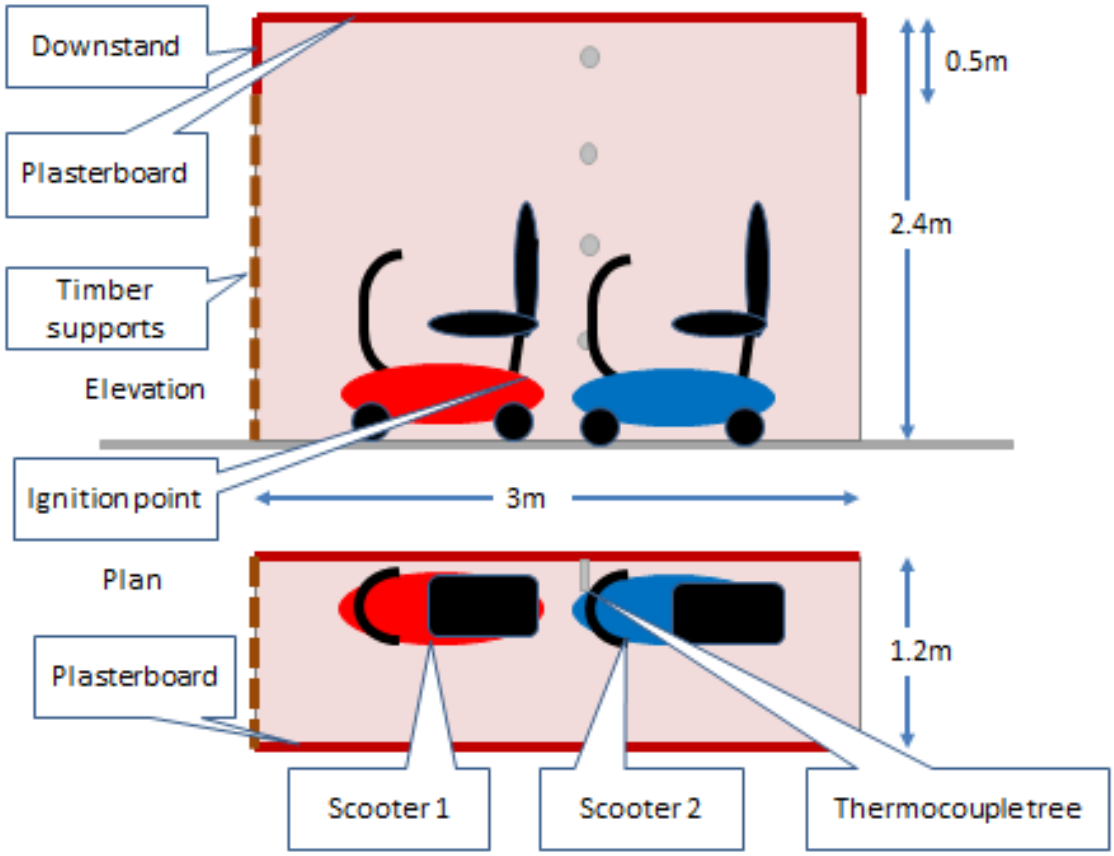


Figure 4. The Experimental Rig (schematic only – not to scale).

Instrumentation

The temperatures in the corridor were measured using 1.5 mm diameter type K stainless steel sheathed thermocouples located in a vertical column between the two scooters at heights of 400mm, 900mm, 1400mm 1900mm and 2400mm from the floor. Fire gases were collected in the BRE 9m calorimeter hood; measurements were made of O_2, CO and CO_2 production rates and the heat release rate and smoke production rate as a function of time were calculated.

The experiments were videoed.

Figure 5. The two mobility scooters in the experimental rig prior to ignition.

Findings

Following ignition of scooter 1, the fire grew slowly for around 3 minutes, after which time it began to develop with ceiling temperatures in the rig reaching 300^{O}C. Within a further 2 minutes, fire spread to scooter 2, which quickly became fully involved since the exterior surfaces had become pre-heated prior to local ignition.

The fire then rapidly increased in intensity, reaching a peak of around 2½ MW (2500 kW) at around 7¼ minutes, with gas temperatures in the top of the rig (i.e. beneath the ceiling) reaching just over 1000^{O}C.

The test was terminated after approximately 7½ minutes using a water jet since the experimental rig was considered to be at risk of collapse.

Figure 6 shows the experiment just after ignition and Figure 7 at 2 minutes after ignition.

Figure 8 shows the experiment approximately 7½ minutes after ignition, just prior to extinguishment. It can be seen that a substantial quantity of smoke was being produced.

Figure 9 shows scooter 1 and Figure 10 shows scooter 2 after the experiment. It should be noted that a substantial amount un-burned material still remains on both scooters.

Figure 6. Just after ignition.

Figure 7. 2 minutes after ignition.

Figure 8. The experiment approximately 7½ minutes after ignition, just prior to extinguishment.

Figure 9. Scooter 1 after the experiment.

Figure 10. Scooter 2 after the experiment.

The following graphs (Figures 11 to 22) show the measurements recorded. Note that time axes are mostly shown in seconds to assist engineering calculations. Figures 13 and 14 are converted to minutes for general convenience. In addition, it should be noted that Figure 11 (and Figure 13) shows the temperature at the lower levels in the corridor rising before the temperature at the ceiling level; this was due to the lower level thermocouples becoming engulfed in flame as the fire spread between the two scooters.

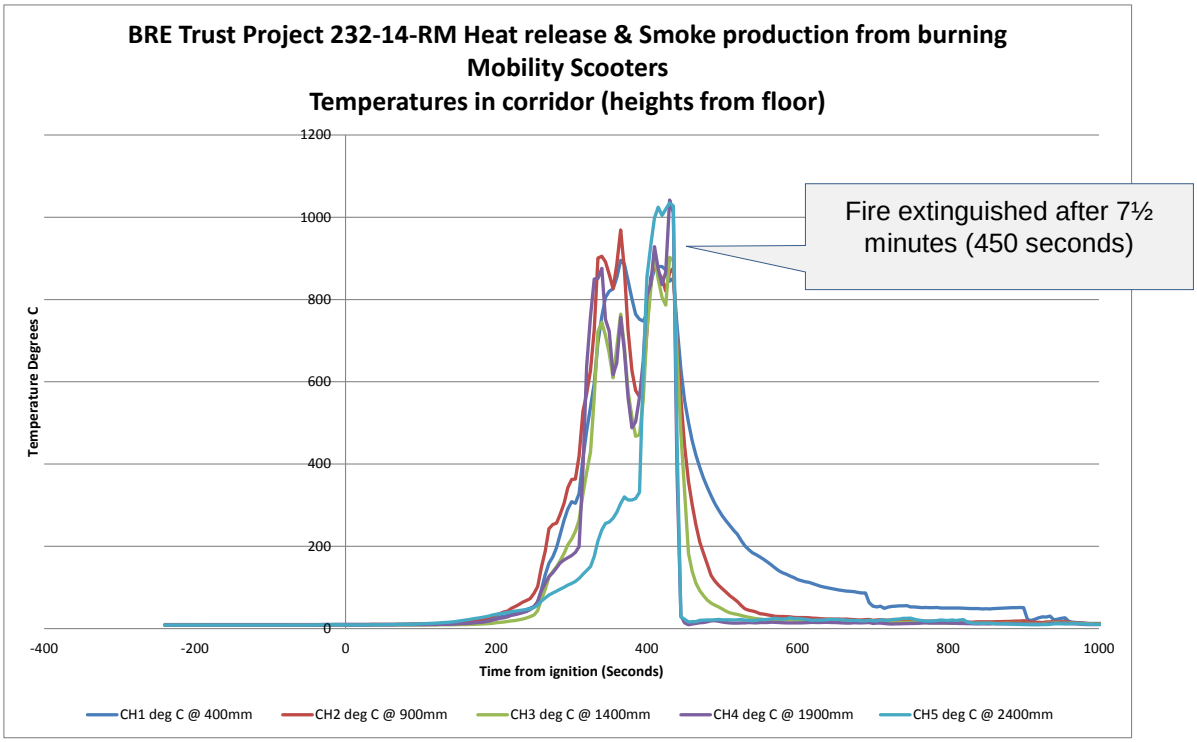


Figure 11. Temperature measurements.

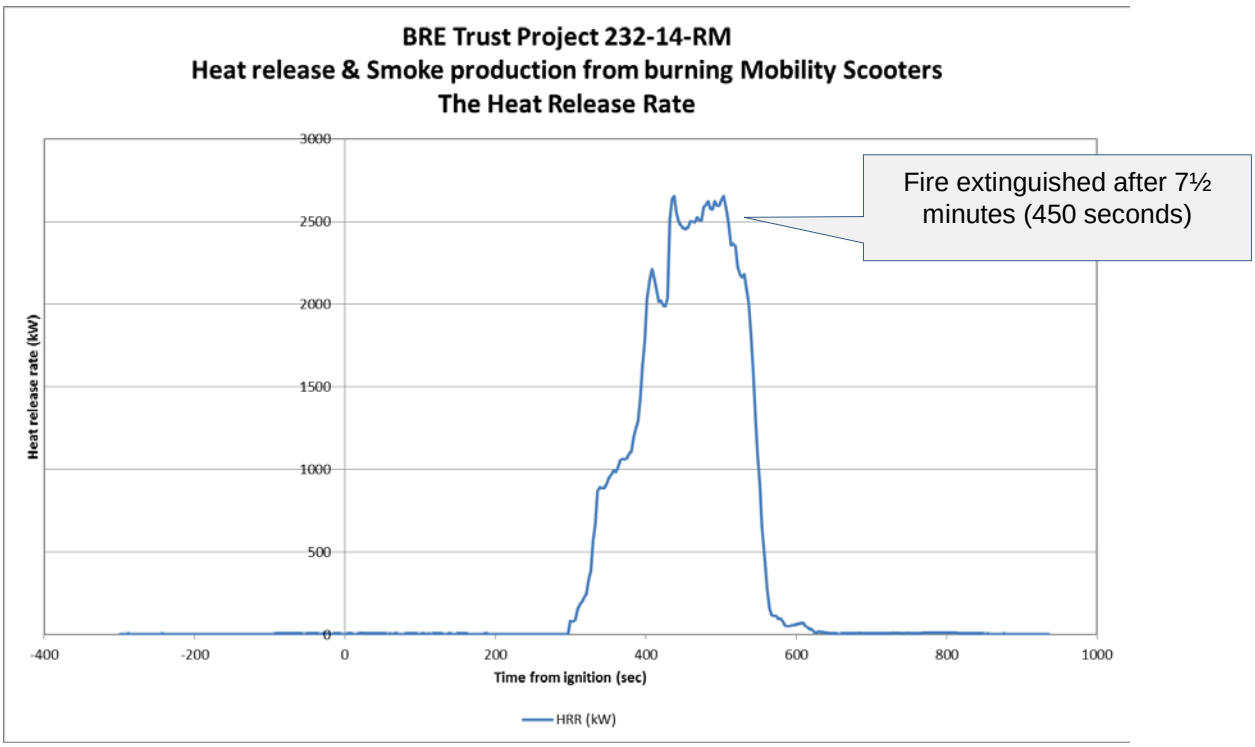
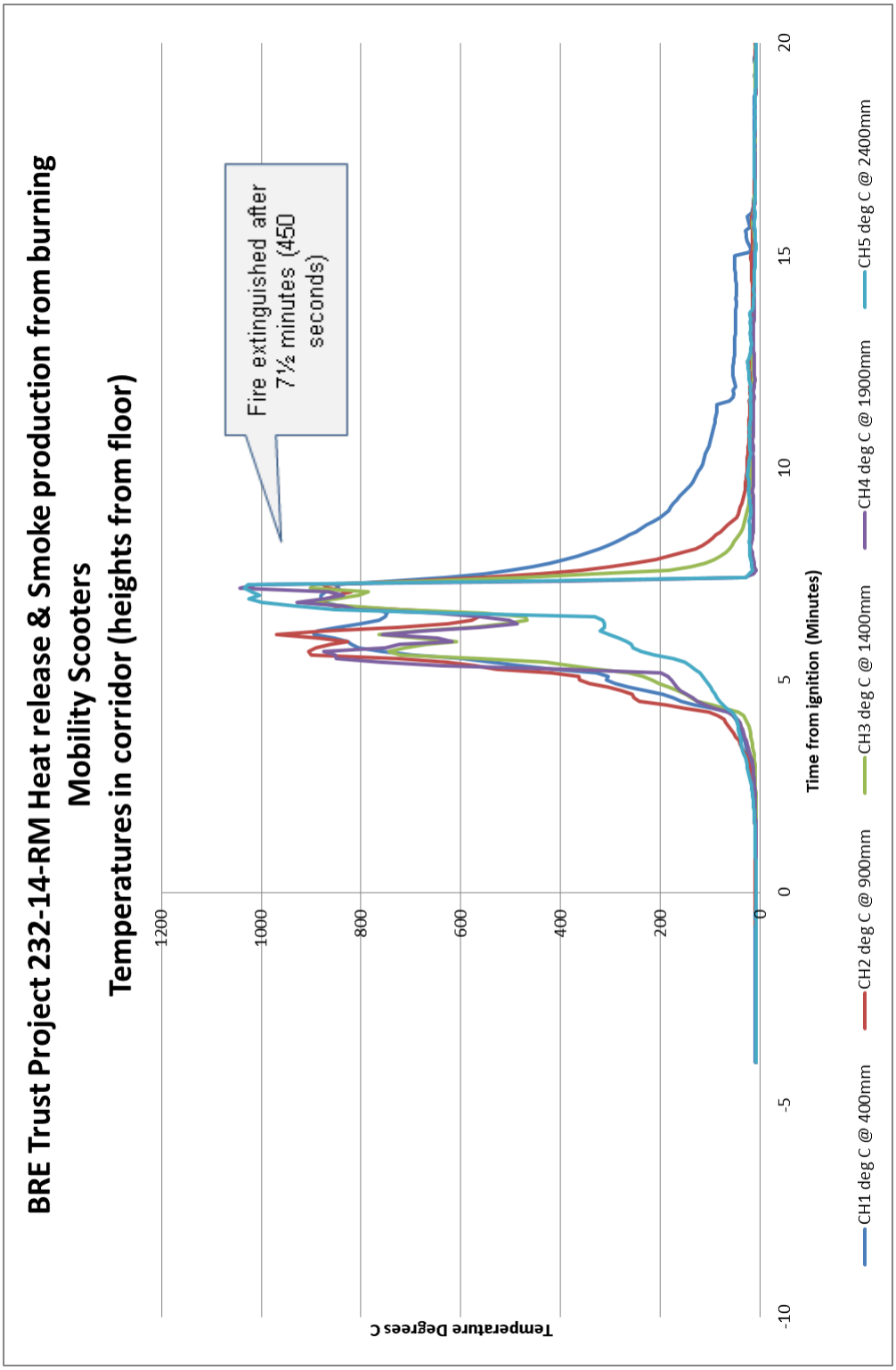
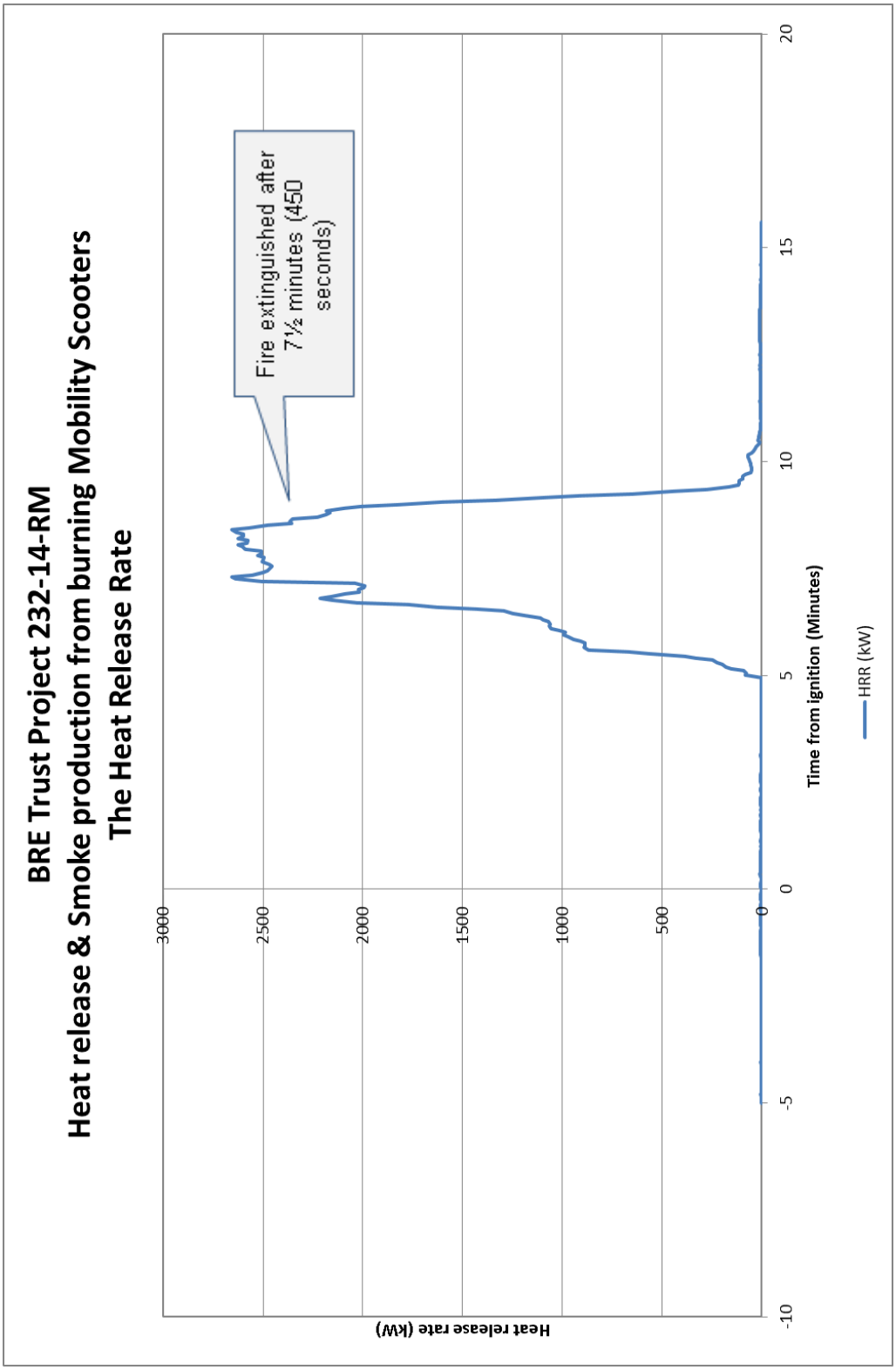


Figure 12. Heat release rate as a function of time.





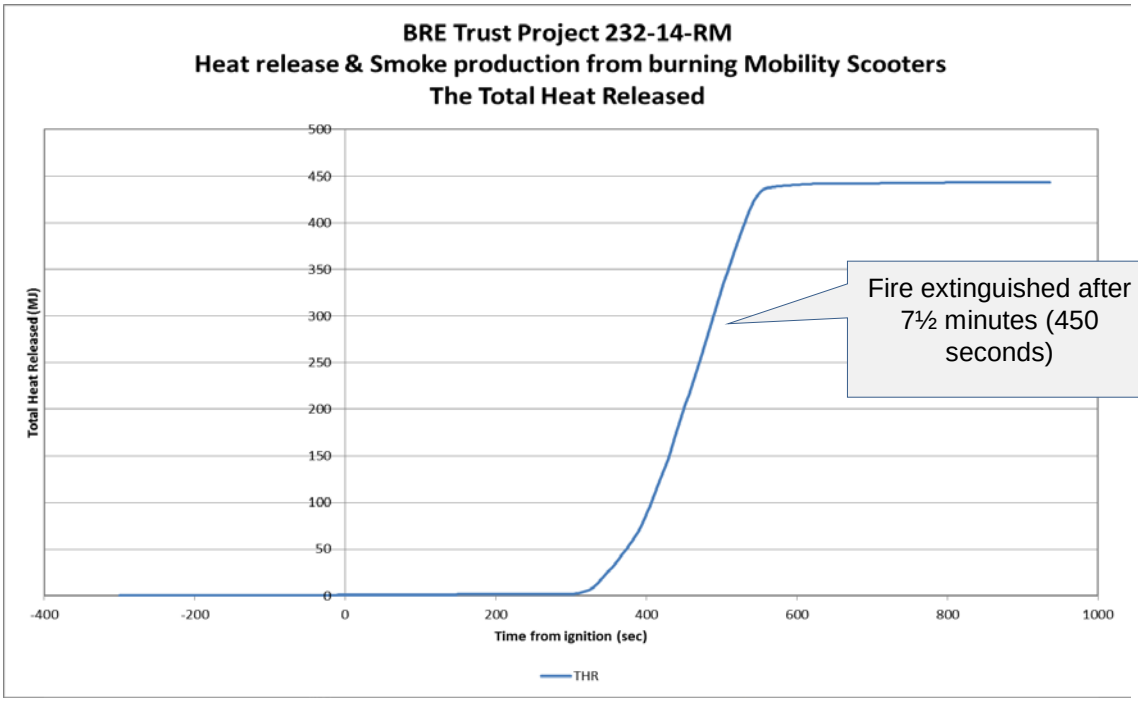


Figure 15. Total heat released.

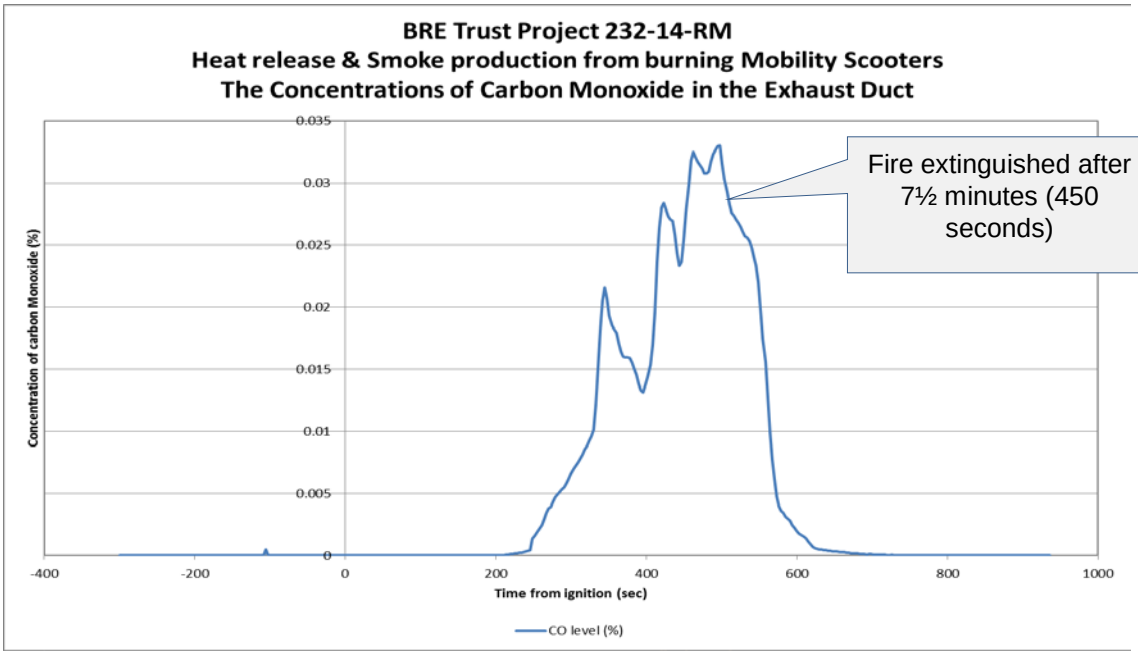


Figure 16. Volume concentration of Carbon Monoxide as a function of time (secs)

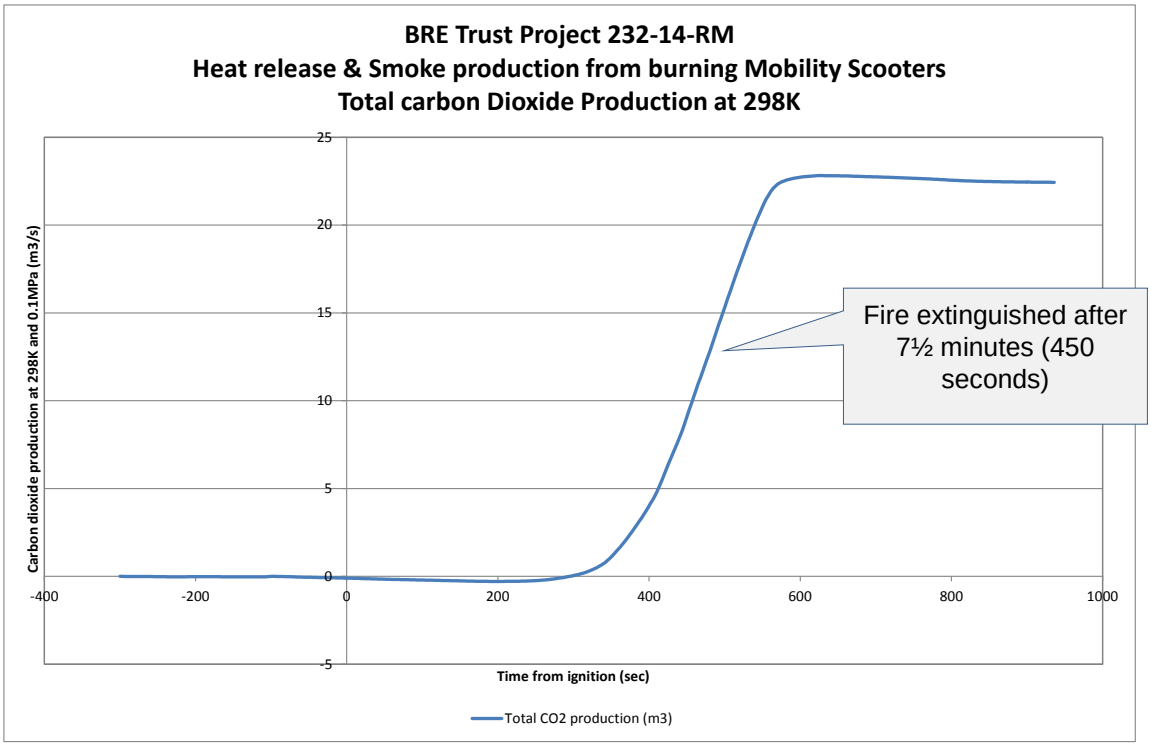


Figure 17. Total carbon monoxide produced as a function of time (secs.)..

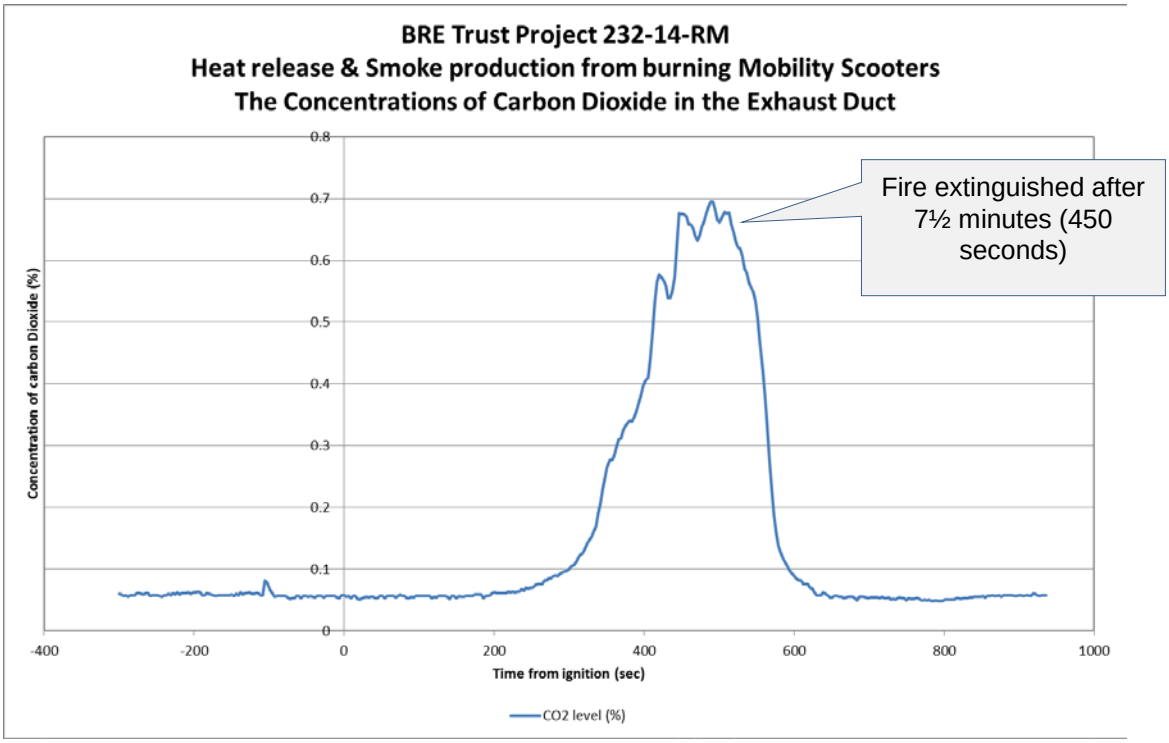


Figure 18. Volume concentration of carbon dioxide as a function of time (secs).

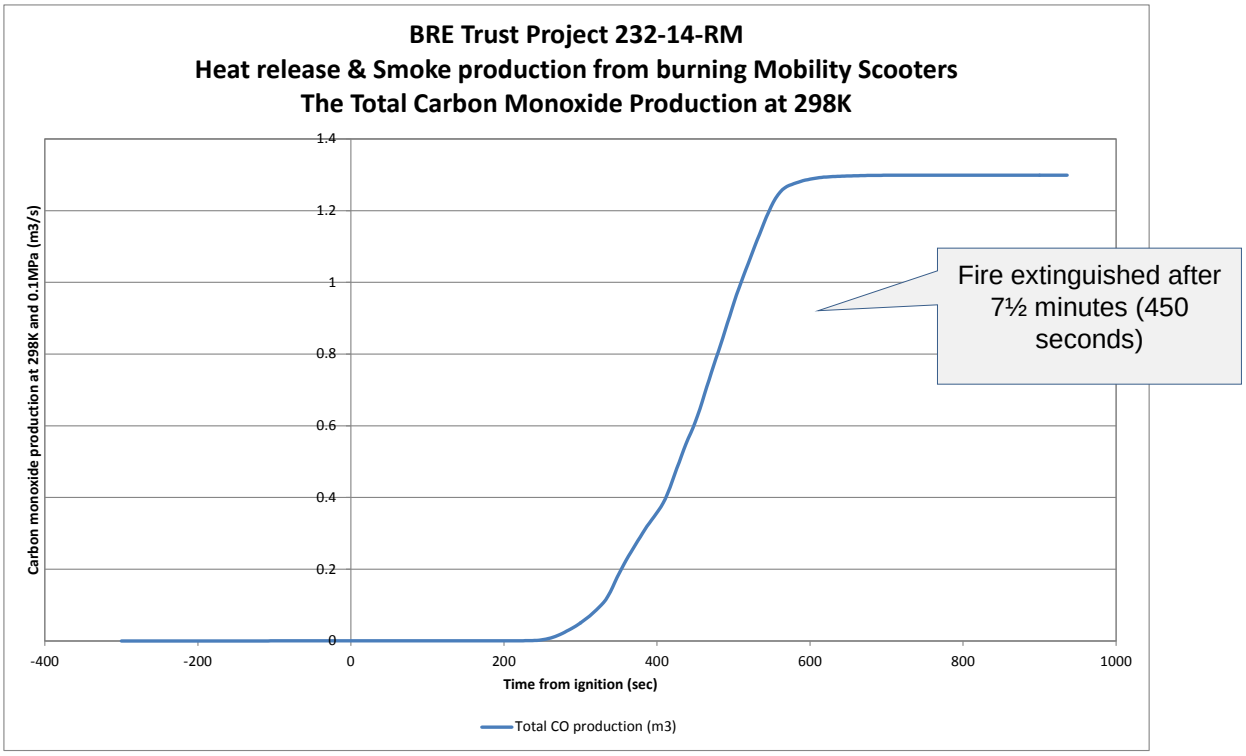


Figure 19. Total carbon dioxide produced as a function of time (secs).

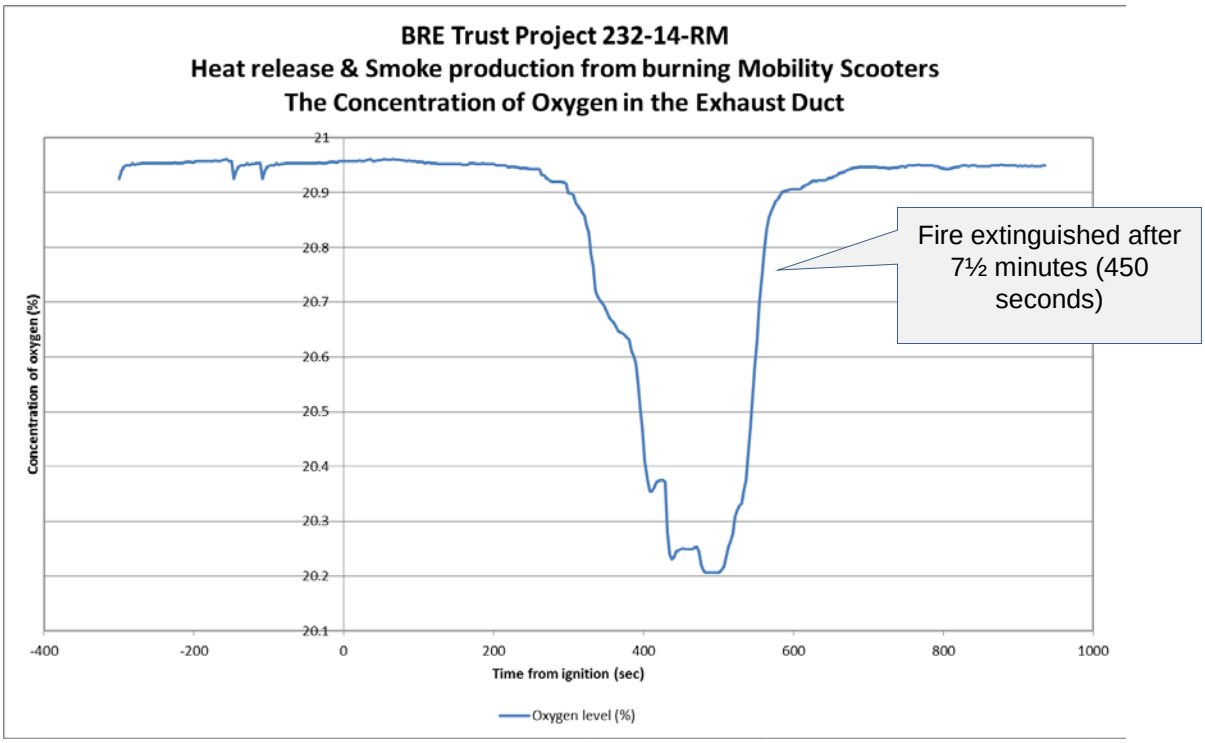


Figure 20. Volume concentration of oxygen as a function of time (secs)

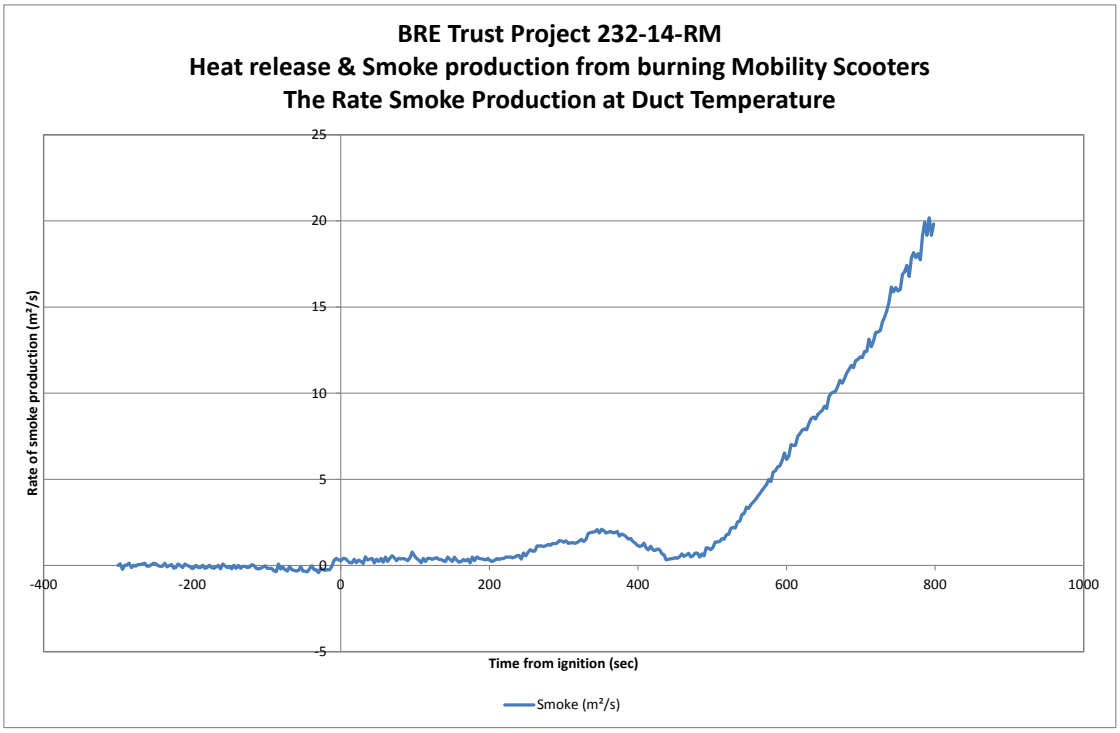


Figure 21. Rate of Smoke Production as a function of time (secs)

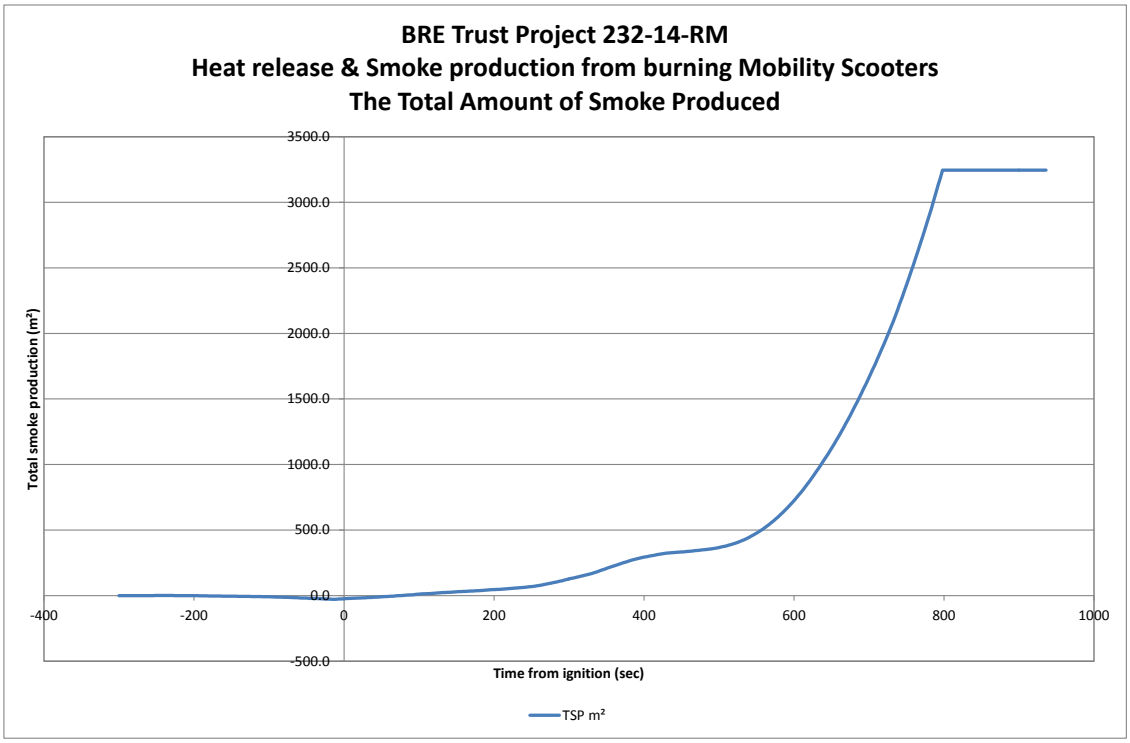


Figure 22. Total smoke produced as a function of time (secs).

Conclusion and recommendations

The experiment carried out on the two mobility scooters demonstrated the ease with which a mobility scooter fire in a corridor might spread to nearby scooters.

In this situation, where a number of scooters are burning simultaneously, the fire is exacerbated by heat-feedback and heat release rates in excess of 2½ MW might be achieved from two or three quite small scooters.

In the experiment, scooter 1 burned slowly for about 3 minutes and then scooter 2 became involved. However, temperatures and heat release then rapidly rose. A substantial quantity of smoke was produced.

It is evident that a fire involving mobility scooters, within the confines of a corridor or stairway, will create a substantial risk to occupants since the smoke and heat will make such routes impassable and put at risk any occupants who open their doors.

The findings from this research, 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. It follows that bigger scooters (or a greater number of scooters) are likely to lead to far more severe fires and quantities of smoke. Further work to examine a range of types of scooter would be of value.

References

1. Welwyn Garden City Housing Association
   http://www.wgchaltd.co.uk/
   Accessed on: 19 December 2014
2. The BRE Trust
   http://www.bre.co.uk/bretrust/
   Accessed on: 04 February 2015
3. Mobility scooters and powered wheelchairs: the rules
   https://www.gov.uk/mobility-scooters-and-powered-wheelchairs-rules/overview
   Accessed on: 17 December 2014
4. Mobility scooters: a market study, May 2014 by Research Institute for Consumer Affairs (Rica)
   https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/362989/Rica_Mobility_scooter_market_study_final.pdf
   Accessed on: 17 December 2014
5. Britain is mobility scooter capital of Europe: 300,000 on our roads and streets as obesity and number of pensioners soar
   By Paul Bentley for the Daily Mail
   Published: 01:53, 12 May 2012 | Updated: 01:53, 12 May 2012
   http://www.dailymail.co.uk/news/article-2143307/Britain-mobility-scooter-capital-Europe-300-000-roads.html
   Accessed on: 17 December 2014
6. Mobility scooter 'danger' campaign goes to Downing Street
   http://www.bbc.co.uk/news/uk-england-derbyshire-21551894
   27 February 2013 Last updated at 09:08
   Accessed: 16 December 2014
7. Disabled mother forced to sell home to pay compensation after mobility scooter injures supermarket worker's knee
   http://www.dailymail.co.uk/news/article-1263925/Disabled-mother-forced-sell-home-pay-compensation-mobility-scooter-injures-knee-supermarket-worker.html
   By Daily Mail Reporter
   Updated: 01:35, 7 April 2010
   Accessed: 16 December 2014
8. Mobility scooter 'may have caused St Austell flats fire'
   From the BBC News website: 31 May 2014 Last updated at 16:38
   http://www.bbc.co.uk/news/uk-england-cornwall-27647672
9. 'I was almost barbecued': Pensioner pulled to safety seconds before his mobility scooter EXPLODED
   By Daily Mail Reporter
   UPDATED: 14:14, 5 August 2011
   From:
   http://www.dailymail.co.uk/news/article-2022383/Aiden-Cassidy-77-pulled-safety-seconds-mobility-scooter-EXPLODED.html#ixzz1UAcc7SKP
   Accessed on: 10 December 2014

10. Mobility scooter caused fatal fire
From the Banbury Guardian website:
http://www.banburyguardian.co.uk/news/local-news/mobility-scooter-caused-fatal-fire-1-1621502
Accessed on: 10 December 2014
11. Pensioner couple die in house blaze after mobility scooter is torched
http://www.dailymail.co.uk/news/article-1254584/Pensioner-couple-die-house-blaze-mobility-scooter-torched.html
By Fay Schlesinger and James Tozer for the Daily Mail
Updated: 18:08, 2 March 2010
Accessed: 16 December 2014
12. From the Leicestershire Fire and Rescue Service website:
http://www.leicestershire-fire.gov.uk/your-safety/domestic-fire-safety/safety-campaigns/safety-advice-for-the-elderly/mobility-scooters
Accessed: 10 December 2014
13. Mobility Scooter Charging Advice
From Dorset Fire and Rescue Service Website, at:
http://www.dorsetfire.gov.uk/safety/fire-road-safety/fire-safety-your-home/how-prevent-fires/mobility-scooters-in-shared-accommodation/
Accessed on: 10 December 2014
14. Fire safety advice for landlords, managing agents, private dwellings, blocks of flats and owners of houses in multiple occupation and social housing.
Devon and Somerset Fire and Rescue Service (DSFRS) provide guidance and advise to Landlords, managing agents and owners at:
http://www.dsfire.gov.uk/YourSafety/SafetyAtWorkandotherplaces/Adviceforlandlordsandlettingagents/documents/Firesafetyadvicetolandlords.pdf
Accessed on: 10 December 2014
15. List of reasons why we and fire brigades think mobility scooters can be a fire hazard
From the Bristol City Council website:
http://www.bristol.gov.uk/sites/default/files/documents/housing/council_housing/housing_repairs/List%20of%20reasons%20why%20we%20and%20fire%20brigades%20think%20mobility%20scooters%20can%20be%20a%20fire%20hazard_0.pdf
Accessed: 10 December 2014
16. Black Museum - Mobility Scooter
From the East Sussex Fire & Rescue Service website:
http://www.esfrs.org/blackmuseum/mobilityScooter.shtml
Accessed: 10 December 2014
17. South Yorkshire Fire and Rescue Freedom of Information Request Reference No: FOIA 701
http://www.syfire.gov.uk/Documents/FOIA_701_response.pdf
Accessed: 16 December 2014
Freedom of Information Request Reference No: FOIA 701
Thank you for your email of 22/05/13 requesting information about mobility scooters.
18. Bristol pensioner's fury over 'ridiculous'' letter asking her to shift mobility scooter
Bristol Post website, March 01 2012:
http://www.bristolpost.co.uk/Bristol-pensioner-8217-s-fury-ridiculous-8217/story-15360635-detail/story.html
Accessed: 10 December 2014
19. The Building Regulations 2010 (SI 2010/2214)

20. Approved Document B (Fire safety) – Volume 2 - Buildings other than dwellinghouses (2006 edition incorporating 2010 and 2013 amendments)
21. The Regulatory Reform (Fire Safety) Order 2005 (SI 2005/1541)
22. "Fire Safety Risk Assessment - Sleeping Accommodation". DCLG. Published 5 June 2006.. https://www.gov.uk/government/publications/fire-safety-risk-assessment-sleeping-accommodation
Accessed on 04 February 2015.
23. Local Government Association guide "Fire safety in purpose-built flats.
Fire safety in purpose-built flats published by LG Group 30 July 2011 - See more at: http://www.local.gov.uk/publications/-/journal_content/56/10180/3369777/PUBLICATION#sthash.lJuwdoZi.dpuf
http://www.local.gov.uk/publications/-/journal_content/56/10180/3369777/PUBLICATION
Accessed on 04 February 2015.
24. "Fire Safety Risk Assessment - Residential Care Premises" [ref].. DCLG. Published 6 July 2006..
https://www.gov.uk/government/publications/fire-safety-risk-assessment-residential-care-premises
Accessed on 04 February 2015.

Acknowledgments

Particular thanks go to Reg Bek and Graham Lale of Welwyn Garden City Housing Association for their support and contribution to this project.

The laboratory work was funded by the BRE Trust.

The experimental team comprised Phil Clark and Harry Granados, BRE Global, Fire Safety Group.

Report Ends