



Report

Project	Royal Heights, Reading
Report Title	Fire Strategy
Our Ref	CL6014/R1 Issue 5

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1.0 INTRODUCTION

1.1 Description of building

The scheme is a single stair residential development. When complete the building will comprise six floors of residential apartments. The building has a single basement level.

The top floor of the building is 16.8m above Ground Floor.

1.2 Purpose of Report

This report describes the fire strategy for the development. The fire strategy draws from BS 9991: 2015 *Fire safety design in design, management and use of residential buildings* and the Approved Document B. The proposed development includes some areas which don't comply with the recommendations of standard code guidance and where this occurs, fire engineered solutions are proposed which are set out within this report

The report is for submission to the approving authorities as part of the Building Regulations submission

2.0 ACTIVE FIRE SAFETY SYSTEMS

2.1.1 Sprinklers

At the time of application, Building Guidance recommended that residential buildings which have top floors that are more than 30m above ground level should be provided with sprinklers. The top floor of the building is 16.8m above ground level so did not need sprinklers to comply with Building Regulations guidance.

However, sprinklers are proposed in any case to provide flexibility in apartment design and support extended common corridor escape distances. Sprinklers will be designed and installed in accordance with BS 9251:2014.

2.2 Automatic Fire Detection and Alarm

An automatic fire detection and alarm system designed to an LD1 standard will be provided in the apartments to support the open plan design. Smoke detection will be designed and installed to BS5839-6 2004.

Smoke detection will be provided in the residential corridors and the lobbies in order to operate smoke extract shafts and automatically opening vents.

For private terraces, where internal sounders are not sufficiently audible on the terrace, a sounder will be provided on the balcony linked to detection in the adjoining room. Alternatively, a flashing beacon installed on the wall or the ceiling, visible from all parts of the balcony will be provided.

An L2 standard of smoke detection will be provided at basement level with sounders at that level only. This is to deal with the inner room situation discussed later in this report. There will be no link to detection or sounders elsewhere in the building.

2.3 Emergency Lighting

Emergency lighting will be provided in accordance with BS 5266-1 to illuminate escape routes in the event of mains failure.

Signage in accordance with BS 5499-1: 2000 will be provided on common escape routes.

3.0 APARTMENTS

3.1 Evacuation Strategy

The building has been designed based on a defend-in-place escape strategy.

Internal Apartment Layouts

The majority of the apartments are one bedroom apartments. However there are two no. two bedroom apartments at Fifth Floor.

Each apartment will be open plan, with bedrooms accessed from the living space. These are acceptable based on the provision of sprinklers and an LD1 standard of smoke detection in each apartment.

3.2 Apartment Dimensions

BS 9991 states that open-plan apartments should not be larger than 16m x 12m in size. All apartments are less than the maximum recommended 16m x 12m dimension.

Kitchens should be enclosed in apartments larger than 8m x 4m to comply with BS9991. Open plan kitchens are proposed in each apartment. The majority are only marginally over the recommended limit at 6m x 5m. However, at Fifth Floor the apartments are up to 16m x 8m.

The floor to ceiling heights in the apartments will be approximately 2.775m, which exceeds the minimum recommended 2.25m.

3.3 Discussion

The recommendations on maximum apartment dimensions in BS9991 come from research carried out by the Building Research Establishment on behalf of the NHBC Foundation. The research involved a number of studies of apartments of varying size, using computational fire modelling to compare code compliant layouts in unsprinklered apartments with open-plan layouts in sprinklered apartments. The code compliant apartments were designed following the guidance of the Approved Document B (ADB) and had rooms accessed from a protected hallway.

The studies only covered apartments up to 16m x 12m, and kitchens were open to the living area in smaller apartments up to 8m x 4m, but enclosed in larger apartments. The conclusion of the studies was that sprinklers provided better conditions for apartment occupants than an ADB-compliant layout, but that further work was required to study the effect of larger apartment dimensions and the design of kitchens. The research did not conclude that open kitchens in larger apartments would present an additional danger to occupants, because that was not covered by the research carried out.

As this issue was not specifically addressed additional research has been referenced in the development of the fire strategy for Royal Heights, this is described in Appendix A.

3.3.1 Hob Location

In the apartments the kitchen hob will be located at least 1.8m from the escape route to the apartment entrance. This should be sufficient to allow occupants escape past the hob fire and ensure that radiant heat does not exceed 2.5kW/m² and hence maintaining tenable conditions for occupants to escape past a hob fire. This is discussed in more detail in Appendix B.

3.4 Independent Evacuation

BS9991 recommends that open-plan apartment layouts should not be provided for accommodation where the occupants are not capable of independent evacuation.

It is not clear exactly what this is meant to achieve and in practice this recommendation is impossible to apply. There is no control over whom may occupy an apartment. Able bodied residents could find themselves less physically able due to changes of circumstances i.e. a broken leg or old age. Alternatively, an occupant's mobility could be impaired due to long term disability or could be due to medication, alcohol etc. Clearly, a more considered approach is needed.

The standard of safety in the sprinklered apartments is much better when compared to a conventional apartment.

If the resident were not physically able to reach the front door then in an Approved Document B compliant flat they would rely on the passive measures to protect them until they could be rescued.

In some cases, the walls and doors will be fire resisting and will provide some protection against fire and smoke. However, small one or two bed apartments would not normally need any fire separation between the rooms or the corridor, nor would it need sprinklers to satisfy code guidance. The resident may also not be aware of the fire until smoke is detected in the hallway by which time the fire could have been burning for a long time. Conditions on the escape route could already be untenable.

In contrast, the Royal Heights open plan apartments will have an LD1 smoke alarms providing early warning of a fire to the occupant as there will be detection in every room. This will provide more time for them to call for assistance. The operation of sprinklers in the fire room will control the rate of fire growth and reduce the amount and temperature of smoke produced. Evidence from the BRE research demonstrated that conditions in sprinklered apartments would be significantly better than those in unsprinklered apartments. This is discussed in Appendix A. Therefore, this provides a much higher standard for mobility impaired occupants than in a code compliant apartment.

4.0 RESIDENTIAL COMMON CORRIDORS AND STAIRS

4.1 Corridor Escape Distances

Guidance in BS9991 recommends that escape distances in a single direction in common corridors should not exceed 15m where the flats are sprinklered and the corridor is smoke vented.

Escape distances in the corridor between the stair are up to 27m at First – Fourth Floors, and 23m at Fifth floor. To support the layout with travel distances greater than 15m, an enhanced smoke venting system will be provided in the corridors. This is described in the following section.



Figure 1 – First to Fourth Floor Corridor Escape Distance

4.2 Corridor Smoke Venting Provisions

To support the extended travel distances, two mechanical smoke shafts will be provided, one at each end of the corridor. The corridor at the end of the corridor remote from the stair will provide smoke extract. The shaft adjacent to the stair will provide inlet. The smoke extract shaft adjacent to the stair will be reversible so that it can also provide extract. This is proposed as part of the basement strategy, discussed later in this report.

Upon smoke detection in the corridor the fans at the head of both shafts will operate to flush smoke to the end of the corridor, from where it will be extracted.

A Computational Fluid Dynamics (CFD) smoke modelling study has been carried out to validate the proposals. This has been carried out in a separate report which was not prepared by Jensen Hughes.

Mechanical smoke shafts typically have a cross-sectional area of 0.6-0.8m² with an extract rate of 3-5m³/s. This will need to be confirmed by a specialist supplier.

Additionally a 1m² automatically opening vent will be provided at the head of the stair.

4.3 Final Exit from the Stair

4.3.1 Building Regulations Guidance

Building Regulations guidance recommends stairs which form the only escape route from a residential building should discharge directly to outside or by way of a protected corridor.

Ancillary accommodation, such as plant rooms, should not be accessed via a corridor which is part of the only escape route in residential buildings.

4.3.2 Proposed Arrangement

The proposed arrangement is for the stair to exit at ground floor into a protected Communal lobby which then exits to outside. The Communal lobby will be fire sterile with the exception of fire rated letterboxes.

The Communal lobby is separated from the residential common corridor by an FD30S fire door. The arrangement is shown in Figure 2 below and complies with Building Regulations guidance:

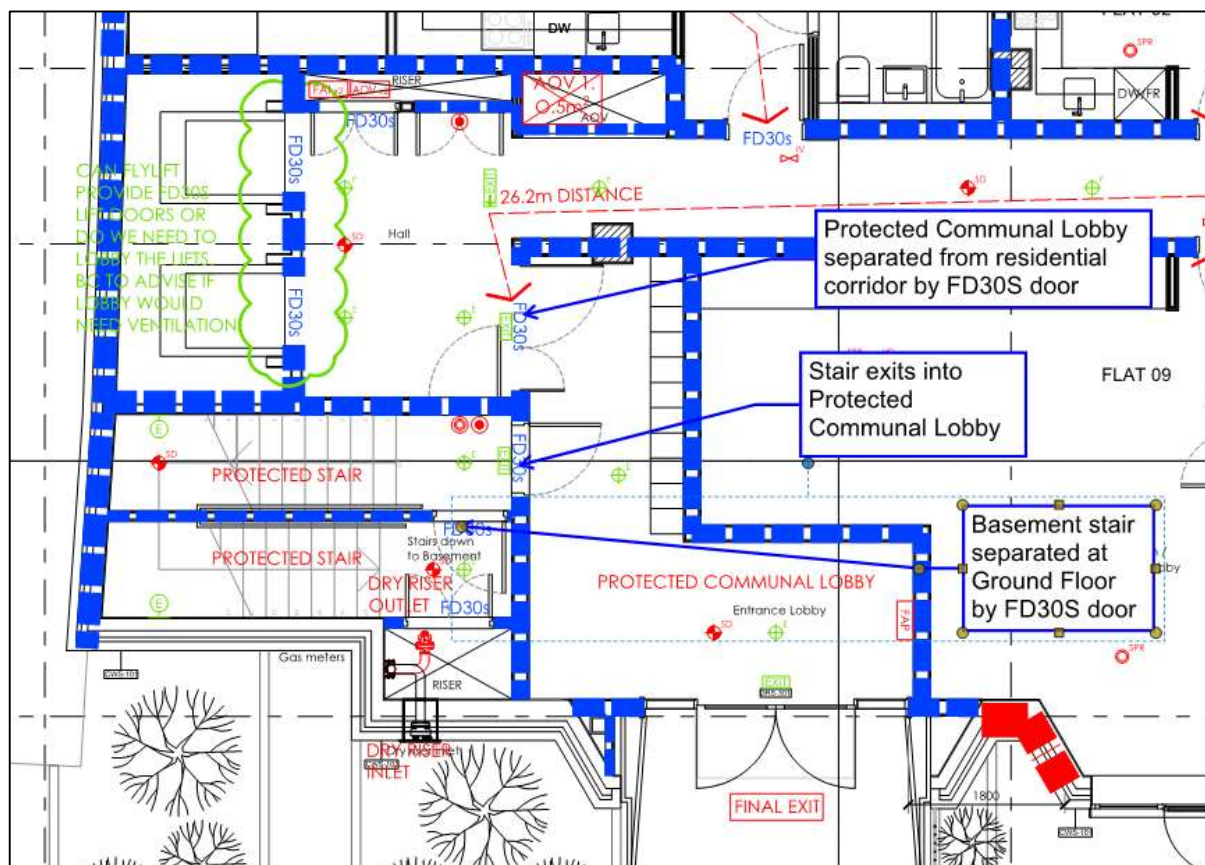


Figure 2 – Exit at Ground Floor

4.4 Stair Connection to Basement Level

Building Regulations guidance recommends that where a residential stair forms the only escape route from a building, that the stair should not continue down to serve basement level.

However, it is proposed that that the stair will extend to serve the basement. This is to provide resident access to the communal gardens at the rear of the building.

This is proposed based on the following:

- The basement section of stair will be separated at ground floor from the stair serving the above ground levels by an FD30S fire door.
- The stair will be protected from any fire risks at basement level by a double lobby, i.e. three fire doors.
- The mechanical smoke extract shaft adjacent to the stair which serves the residential levels will be extended to basement level and will provide smoke extract from the lift lobby.
- The second smaller lobby in front of the stair means that the level of protection to the stair at basement level is higher than the level of protection at the residential levels. The fire load in the Plant rooms is anticipated to be much lower than in a standard residential apartment which would contain items such as clothing, upholstered furniture, curtains, furniture etc.

- Fire fighters can access the basement via the external stair from the communal gardens. This means that for fire fighting there would be no reliance on access via the residential stair, so doors would not need to be propped open.
- The fire risk areas (plant room and electrical intake room) will be enclosed in 1 hour fire resisting construction.
- Continuing the stair to serve the basement isn't expected to be an issue for occupants becoming disorientated as it will be a familiar route given that it is to access the communal gardens. Fire exit signage can be provided in the stair to advise occupants of the primary and secondary escape routes.

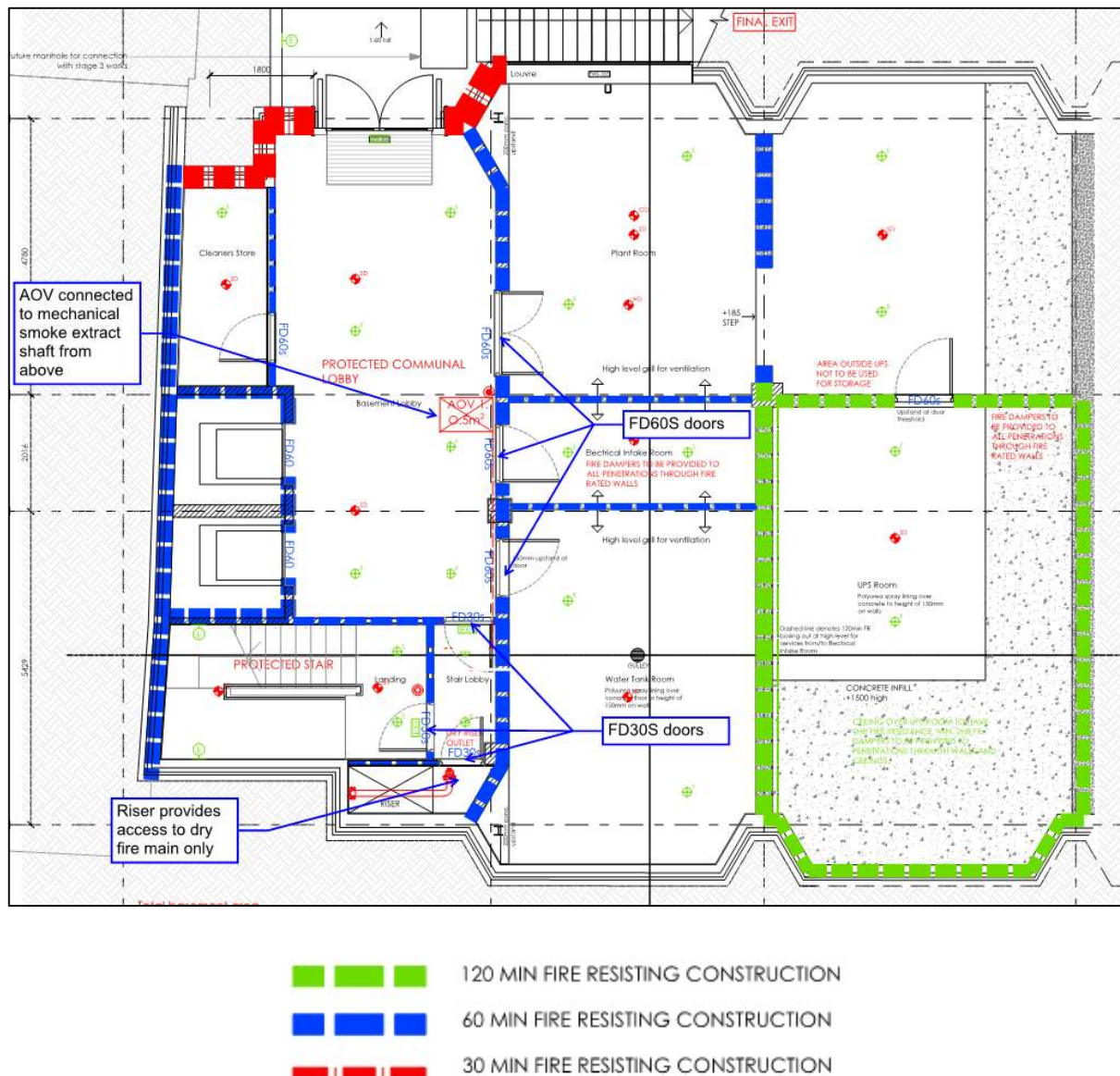


Figure 3 – Protection to Residential Stair at Basement Level

4.5 Plant Room Escape

Escape distances in plant rooms will be within 9m. Once occupants reach leave the plant room at basement level they will have two directions of escape. The overall escape distance will be within 35m.

The UPS room will be an inner room to the adjacent Plant Room. The area outside the UPS room will be kept clear at all times and will not be used for storage. Smoke detectors will be provided in each room.

5.0 STRUCTURE & COMPARTMENTATION

5.1 Fire Resistance of Structure

Structure will achieve 1 hour fire resistance.

5.2 Compartmentation

5.2.1 General

Each floor will be a compartment floor achieving 1 hour fire resistance.

The following will be constructed to achieve at least 1 hour fire resistance:

- Service risers (FD30 doors)
- Stair enclosure (FD30S doors)
- Lift shafts (FD30 doors)
- Walls surrounding plant rooms (FD60S doors)
- Walls between flats;
- Walls between flats and common corridors (FD30S doors);
- Walls enclosing ancillary accommodation (FD60S doors);
- Walls within the apartments do not need to be fire rated given the provision of sprinklers and an LD1 standard of smoke detection.

Walls enclosing the UPS room will achieve 2 hours fire resistance.

5.2.2 Riser within Stair Enclosure

It is proposed to provide a riser shaft within the stair enclosure. However, the riser will contain only the dry fire main and residential water mains. Therefore there is no fire risk to the stair.

5.2.3 Lifts Extending to Basement Level

The two passenger lifts which serve the residentials extend down to serve basement level. There is nothing in Building Regulations guidance which precludes this arrangement. The lifts are accessed from a protected lobby at each level. Therefore their location will not affect escape from any level.

5.3 Cavity Barriers

Cavity barriers and fire stopping will be provided in concealed spaces such as floor and ceiling voids and external walls to comply with Section 19 of BS 9991.

Cavity barriers will be provided in any external wall cavity as per the recommendations of guidance in the following locations:-

- At the junction between an external cavity wall and every compartment floor;
- At the junction between an external cavity wall and every compartment wall;
- To close the edges of the cavity wall including around any window openings and at the top of the external wall cavity;
- To limit the dimension of any extensive concealed spaces to a maximum of 20m in any direction.

The cavity barrier product will achieve a minimum 30 minutes fire resistance for integrity and 15 minutes for insulation.

5.4 Protection of Openings & Fire Stopping

Fire stopping will be provided to maintain the integrity of the fire separating elements in accordance with the recommendations of BS 9991. It will be provided where cables, conduits or pipes pass through cavity barriers or other fire resistant construction.

5.5 Internal Linings

Internal wall and ceiling linings will achieve the following minimum classifications: -

Location	Surface spread of flame Classification
Communal Circulation Spaces, i.e. common corridors and stairs.	Class 0 (national) or Class B – s3,d2 (European)
Dwelling Circulation Spaces, All other rooms. Small rooms not exceeding 4m ²	Class 1 (national) or Class C – s3,d2(European) Class 3 (national) or Class D – s3,d2 (European)

Table 1 – Internal Lining Ratings

5.6 Roof Linings

Roof linings will comply with Section 18.6 of BS9991 for a minimum distance to the relevant boundary of at least 6m.

6.0 FIRE FIGHTING

6.1 Fire Fighting Facilities

The building is less than 18m in height so does not require a fire fighting core.

To ensure that all areas are within adequate hose coverage, a dry fire main will be provided within the stair enclosure with an outlet at every level. This will provide hose coverage within 45m to all areas of the building.

The fire main inlet will be within 18m and in sight of the fire appliance parking position.

A fire hydrant will be within 90m of the fire main inlet.

6.2 Water Supplies

Fire Hydrants will be provided within 90m of the entry point of the building and not separated by more than 90m between hydrants.

6.3 Basement Smoke Venting

Dedicated basement smoke venting is not needed where there is a door or window provided direct to outside. This will be provided via the door to the access route up to the residential communal gardens.

However, the mechanical smoke extract shaft which serves the residential levels will be extended down to serve the basement lift lobby. Based on a typical extract duty of $\sim 3\text{m}^3/\text{s}$ (to be confirmed by the specialist supplier), the extract rate provided will be broadly equivalent to a duty of 10 air changes per hour. This provides an additional level of safety not needed to comply with Building Regulations guidance where there is a door direct to outside.

7.0 EXTERNAL FIRE SPREAD

7.1 External Wall Construction

There are currently no restrictions in Building Regulations guidance on the use of combustible materials in the external wall build up of residential buildings of this height.

However the materials used are largely A1 or A2-s1, d0, albeit there is a limited proposed use of combustible insulation at Fifth Floor only.

7.2 Unprotected Areas

There is no glazing proposed to the west elevation. This elevation will be entirely fire resisting.

Glazing is proposed to the North, South and East elevations. The building is at least 1.9m back from either the site boundary or centre line of the surrounding roads.

The closest distance to the site boundary is on the east elevation, where the distance is approximately 1.9m from the site boundary.

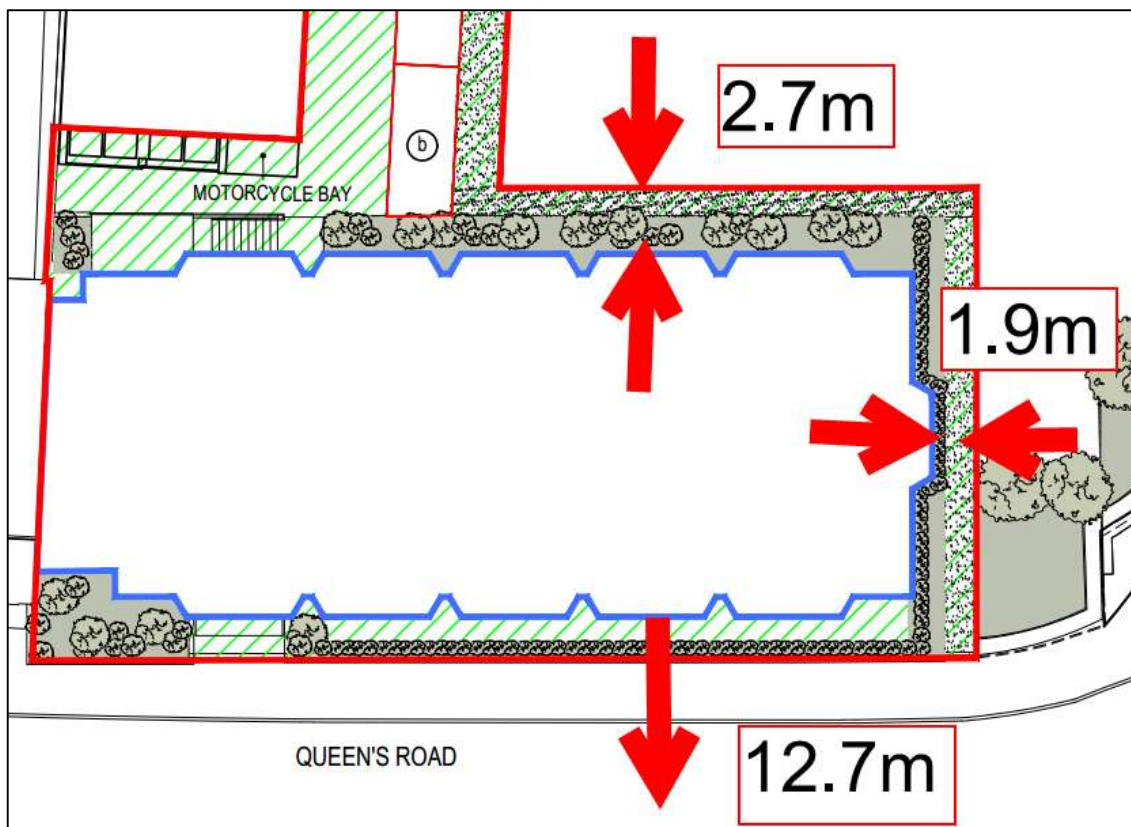


Figure 4 – Site Boundary / Notional Boundary Distances

Calculations below for the largest apartment facing east show that given the provision of sprinklers in the apartment, there is no restriction on the extent of glazing to the elevation.

BR187 Table Lookup
ALL VALUES SHOULD BE ENTERED ON THIS SHEET ONLY.

Input values in the yellow boxes

Project : Royal Heights, Reading
Project number: CL6014
Elevation: East Elevation
Date: 20/12/18
Checked by (initials, date): MN

Residential, office or assembly? (Yes/No)	Yes
Sprinklered? (Yes/No)	Yes

	Input	Enclosing rectangle
Height of compartment (m)	2.80	3
Width of compartment (m)	3.60	6
Distance to boundary (m)	1.90	3.80
Area (m ²)	10.08	18.00
Permitted unprotected percentage of area	100.0%	100.0%
Permitted unprotected area (m ²)	10.08	

Figure 5 – Elevation Calculations for East Facing Apartment

Non glazed areas will achieve at least 1 hour fire resistance for integrity, 15 minutes for insulation.

7.3 Apartment Elevation Recesses

The apartment elevations have recesses between each apartment from Ground to Fourth Floor. This provides potential for fire spread between apartments. To prevent this the elevation on one side of the recess will be fire rated for 1 hour from each side separately as shown below.



Figure 6 – Apartment Recesses

8.0 FIRE SAFETY MANAGEMENT

8.1 General

Once the building is occupied, it is the responsibility of the management to ensure that all fire safety systems are tested and maintained to ensure their continuous effectiveness. The management should: -

- Be aware of all the fire safety features provided and their purpose
- Liaise with and seek the advice of the fire authority

8.2 Staff

Staff should be trained by competent persons. The training should be at regular intervals and should ensure that all staff know what to do if a fire is discovered; the correct response on hearing a fire alarm, and the correct escape procedures from every part of the building.

A management structure should be provided to ensure that in the case of fire staff are aware of their responsibilities, which should be clearly defined. A chain of command should be provided with clear lines of responsibility, authority and accountability.

8.3 Fire Safety Manual

Before a building is occupied, a fire safety manual should be completed. The purpose of the manual is to clearly define the nature of the fire safety systems provided for the building. It should include: -

- An explanation of the overall fire safety strategy
- Evacuation procedures
- Design documentation to describe the use of each fire safety system
- Staff roles in the event of a fire: their responsibility, authority and accountability
- A detailed maintenance routine

The Fire Safety Manual should be reviewed periodically and when any alterations are made to the building. Details of the suggested contents of the fire safety manual are provided in Section 19 of the Approved Document B and Annex H of BS 9999 Code of practice for fire safety in the design management and use of buildings.

8.4 Maintenance and Housekeeping

It is the role of management to ensure that maintenance is carried out in accordance with the relevant British Standards, so that all fire safety systems are operational in the event of a fire. It is also important that good housekeeping practices are followed. The building management should be aware of any hazardous substances or practices within the building, which increase the risk of fire.

8.5 The Regulatory Reform (Fire Safety) Order 2005

This Order places a duty on the 'responsible person' to ensure, 'as far as is reasonably practical' the safety of his employees and to take such general fire precautions as may be reasonably required to ensure that the premises are safe [i.e. for non-employees].

Under the Order, there is a requirement to carry out and continually update an assessment of the risk of fire to people in and around the premises/building, and to assess and maintain the measures to reduce those risks to an acceptable level. Where there are five or more employees, the risk assessment must be recorded.

A Fire Risk Assessment should be carried out:-

1. On completion of the building fit out, and strictly before first occupation of the building.
2. Regularly, particularly where any changes occur such as changes in the use of the building, the number or nature of occupants, or building works.
3. We would recommend that a fire risk assessment is carried out at least annually.

Other legal duties include: -

1. Keeping a record of the Fire Safety Arrangements. These are the preventative and protective measures for the building.
2. A person must be nominated for any special role identified in an emergency plan.
3. Employees must be consulted about nominations to perform special roles, and about any proposals for improving the fire precautions.
4. Other employers in the building must be informed about any significant risks, which might affect the safety of their employees, and there must be co-operation with them in measures to reduce the risk.
5. Those having control over the workplace have a responsibility to ensure compliance with the regulations in those parts of the building over which they have control.
6. A suitable and readily available method of calling the emergency services must be established.
7. Employees are required to co-operate in ensuring that the workplace is safe from fire.

The order also adopts 'Principles of Prevention'. These include:-

- Avoiding risks;
- Evaluating the risks which cannot be avoided;
- Combating the risks at source;
- Adapting to technical progress;
- Replacing the dangerous by the non-dangerous or less dangerous [particularly with respect to hazardous substances];
- Developing a coherent overall prevention policy which covers technology, organisation of work and the influence of factors relating to the working environment, and;
- Giving appropriate instructions to employees.

9.0 INFORMATION, LIMITATIONS AND ASSUMPTIONS

The information limitations and assumptions used in the preparation of this report are noted below: -

Drawings

This report is based on drawings issued to us. Dimensions have been taken from these drawings. The following drawings were used: -

Job No.	Code	Sheet No.				
1596	900 Series	1	Day of Issue	08	10	13
	Fire		Month of Issue	03	03	05
			Year of Issue	21	21	21
Dwg No	Title	Date	Type	Scale/Size	Revision :	
900	Basement Fire Strategy	Mar 21	dwg	1:50@A1L	E C N E	-
901	GF Fire Strategy	Mar 21	dwg	1:50@A1L		-
902	1F- 4F Fire Strategy	Mar 21	dwg	1:50@A1L		-
903	5F Fire Strategy	Mar 21	dwg	1:50@A1L		-
904	Fire Strategy Elevations	Mar 21	dwg	1:100@A1L		-

Survey (Existing Building)

This building has not been surveyed by Jeremy Gardner Associates Limited.

Building Regulations

This report considers building regulations, which deal with life safety. Property protection and insurance issues are not addressed in this report. Guidance on property protection and insurance requirements can be found in the document *Approved Document B: Fire Safety (Volume 2) – Buildings other than dwellinghouses Incorporating Insurers' Requirements for Property Protection*, RIBA Publishing 2015.

Other Limitations

Complying with the recommendations of this report will not guarantee that a fire will not occur.

Unless otherwise described in this report, the fire strategy assumes that the building design, the mechanical and electrical systems, construction methods and materials specifications will comply with current Building Regulations guidance, and relevant British Standards and Codes of Practice. The design of mechanical and electrical systems such as fire alarm and sprinklers is a specialist area. Fire Strategy recommendations are given in this report, however, the design and specifications need to be developed at the appropriate stage in consultation with the specialist designers of these systems.

This report has been prepared for the sole benefit, use and information of Urban High Developments and the liability of Jeremy Gardner Associates Limited, its directors and employees in respect of the information contained in the report will not extend to any third party.

APPENDIX A RESIDENTIAL SPRINKLER RESEARCH

Tenable Conditions

The table below summaries the recommended tenability criteria given in BS 7974-6:

Combustion Product	Period of Exposure	Extent of exposure
Temperature	>30 minutes	<60°C (100% saturated)
Temperature	8 minutes	100°C (<10% H ₂ O)
Temperature	6 minutes	110°C (<10% H ₂ O)
Temperature	4 minutes	120°C (<10% H ₂ O)
Temperature	3 minutes	130°C (<10% H ₂ O)
Temperature	2 minutes	150°C (<10% H ₂ O)
Temperature	1 minute	180°C (<10% H ₂ O)
Carbon Monoxide	5 minutes	800ppm
Carbon Monoxide	30 minutes	125ppm

Table 1: Tenability Criteria (Temperature and CO)

BS7974 recommends a limit of 5m visibility for small compartments and 10m for large compartments. These figures do not consider familiarity and are therefore conservative in a residential building.

BRE Project Report 204505

In 2004 the Building Research Establishment carried out a study into residential sprinkler systems and published the report '*Effectiveness of Sprinklers in Residential Premises: BRE Project Report 204505*'.

The pilot study carried out by the BRE as part of this project concluded that the combination of sprinklers and linked smoke alarms in the rooms and circulation spaces would reduce deaths by 83% and injuries by up to 85%.

The report describes experiments carried out by the BRE on eight sprinklered and unsprinklered lounge fires in a two-storey dwelling house with a loft conversion. The duration of each house fire test was 30 minutes.

The experiments demonstrated the following:

Unsprinklered lounge fire

- Without sprinklers, conditions in the lounge became unsurvivable within 15 to 20 minutes.
- Visibility in the room of origin was reduced to less than 2m within 5 to 7 minutes.
- With an open plan lounge, or a standard lounge with the doors open, fires without sprinklers would eventually cause untenable conditions in all open spaces throughout the house.

Sprinklered lounge fire

- The sprinklers controlled all fires.
- The sprinklers extinguished some of the fires.
- For sprinklered fires, the fire-damaged area was less than when unsprinklered.

With sprinklers, the fire gases were cooled sufficiently so that the occupants of the room of origin would not have experienced extreme pain due to convected heat.

- Sprinklers significantly reduced the Fractional Effective Dose (FED) in the room of origin. In all but one test sprinklers maintained tenable conditions in the room of fire origin in terms of toxic effects. In the other test unconsciousness due to asphyxiants was estimated to have occurred approximately 25 minutes after ignition.
- Visibility in the room of origin was reduced to less than 2m within 5 minutes.
- Tenable conditions (apart from visibility) were achieved throughout the house in the sprinklered tests.

These tests demonstrate that sprinklers are effective in providing more time for occupants to escape. Not only would tenable conditions be maintained within the remainder of the house but also occupants of the room of fire origin would not have died.

As part of the same research project the BRE carried out 29 further fire tests considering a series of three adjacent compartments. Fires in beds, sofas, televisions and tables were modelled. The conclusions from these fires are broadly similar to those from the house fire tests:-

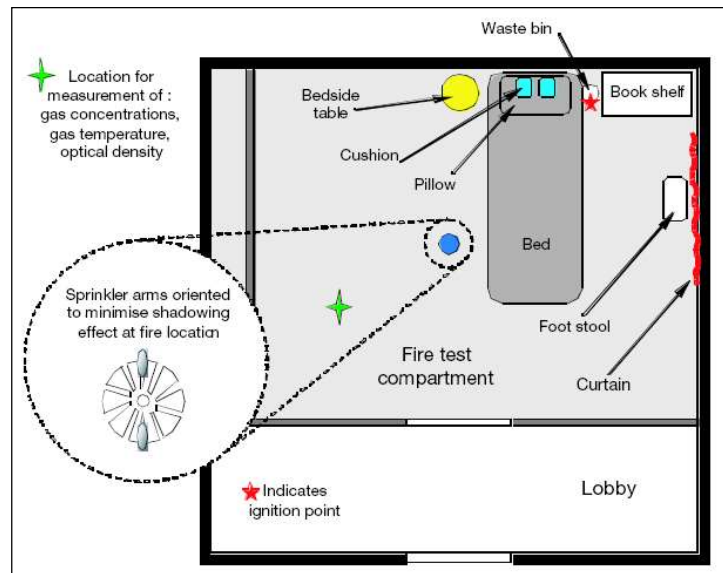
- Conditions became unsurvivable in all unsprinklered tests.
- Sprinklers significantly reduced temperature in the room of fire origin.
- Sprinklers maintained tenable conditions in terms of toxic effects for television and bed fires.
- Untenable conditions in terms of toxic effects did occur in the sprinklered table fires. The time to unconsciousness varied between 5 and 10 minutes. Sprinklers reduced temperatures such that these were tolerable for a significant period of time (>30 minutes). In contrast, in the unsprinklered tests occupants would have experienced extreme pain after 2.5 to 3 minutes.

DCLG Fire Research Technical Report 2/2007

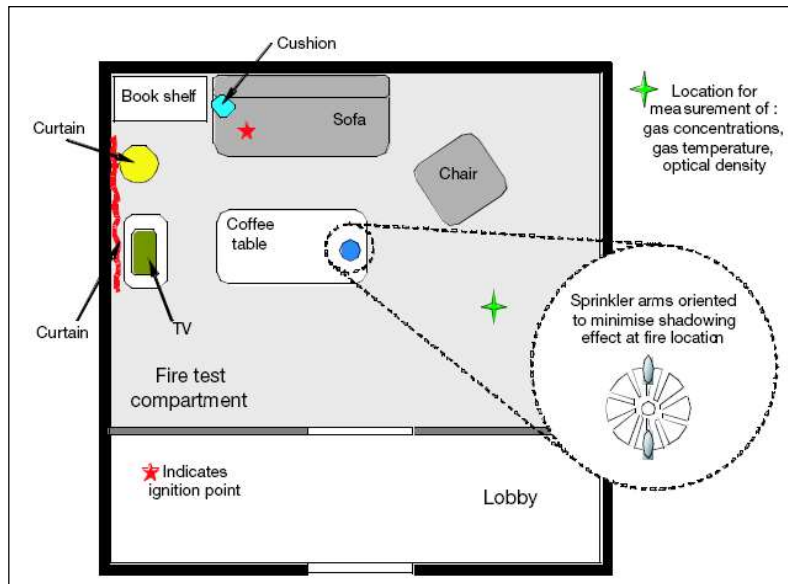
The FPA were commissioned to carry out research into providing a low cost residential fire suppression system for the UK housing sector. As part of this project a series of practical fire trials were carried out to demonstrate and assess the effectiveness of sprinkler systems under realistic conditions.

Bedroom & Lounge Fires

The bedroom tests were based on a fire occurring in a wastepaper bin adjacent to the bed and bookcase, which contained books and other combustibles. The arrangement of the fuel in relation to the fire was intended to encourage rapid fire spread to challenge the sprinkler system.



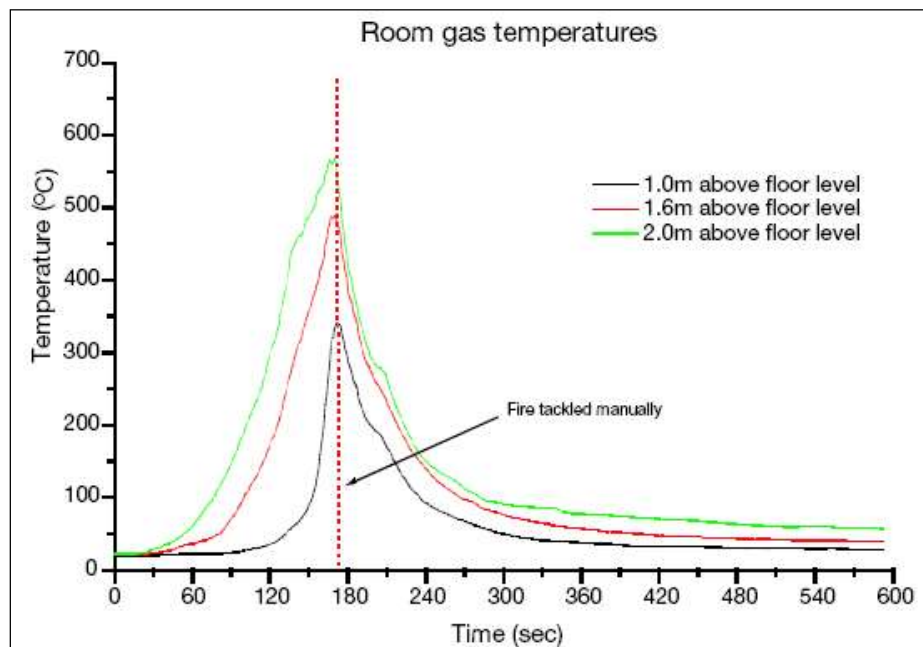
In the lounge the fire started on a sofa immediately adjacent to a bookcase. The sofa padding was constructed from non-modified foam.



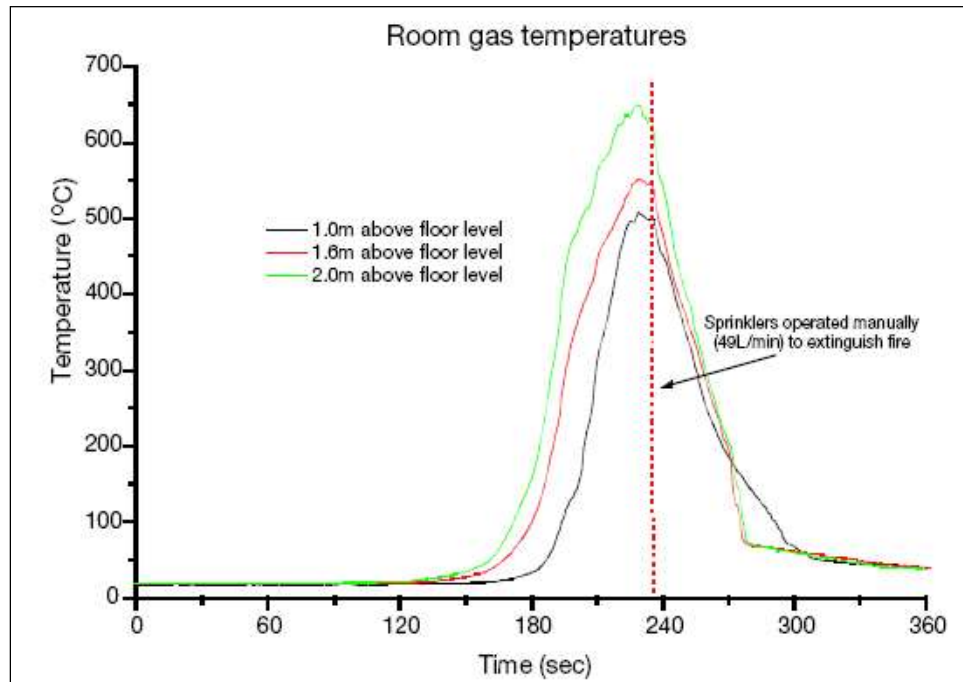
A concealed sprinkler was used in the tests. The results are summarised below:-

Unsprinklered Rooms

- Rapid fire development occurred in the unsprinklered bedroom and lounge.
- Flashover occurred after 2 mins 30 secs in the bedroom and 3 mins and 15 secs in the lounge.



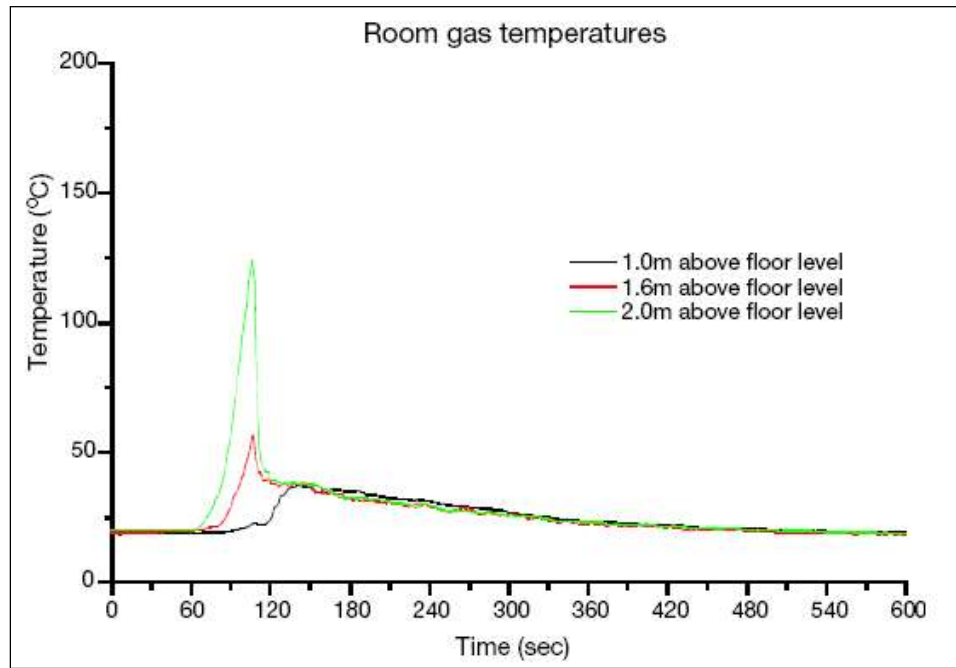
Unsprinklered bedroom fire



Unsprinklered lounge fire

Sprinklered Bedrooms

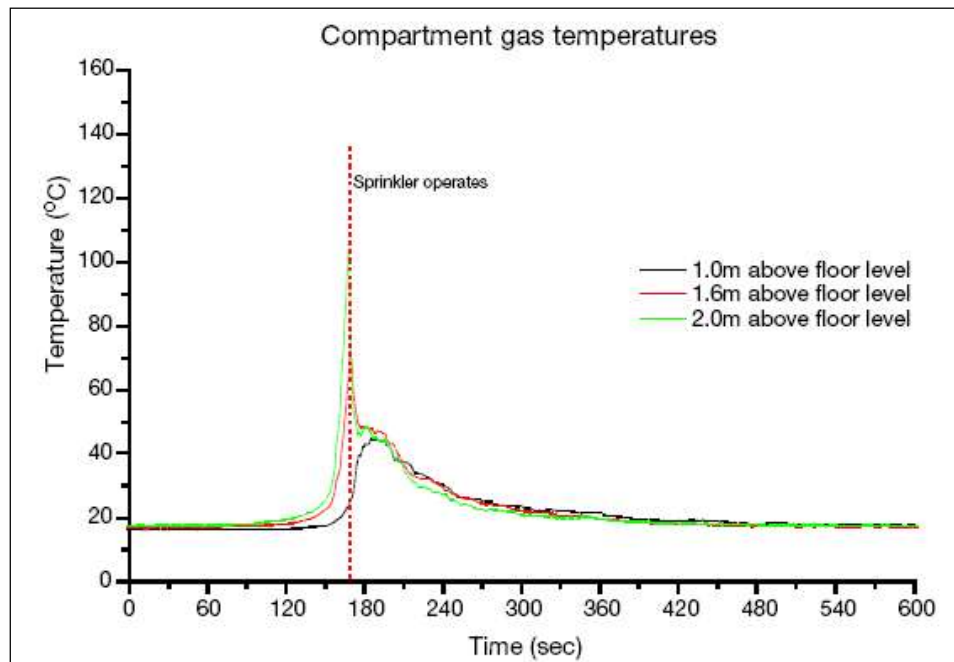
- In both sprinklered bedroom tests the sprinklers activated after approximately 2 minutes.
- Fire was controlled and mostly suppressed although there is still some limited burning on the shelves.
- Room gas temperatures peaked at 125 deg C at 2m above floor level. At head height temperatures in the room were a maximum of approximately 60 deg C.



Sprinklered bedroom fire

Sprinklered Lounge

- In both sprinklered tests the sprinklers operated after approximately 3 minutes.
- The fires were controlled and mostly suppressed although there was some residual burning on the sofa cushions.
- Temperatures in the room peaked at approximately 120 deg C (2m above floor level) prior to sprinkler activation. At head height temperatures of up to 90 deg C occur. These were quickly reduced once sprinklers activated.

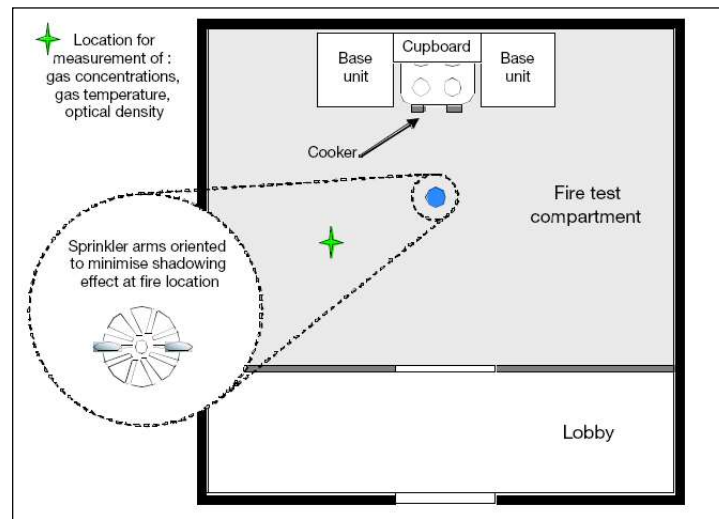


Sprinklered lounge fire

Kitchen Fire Scenario

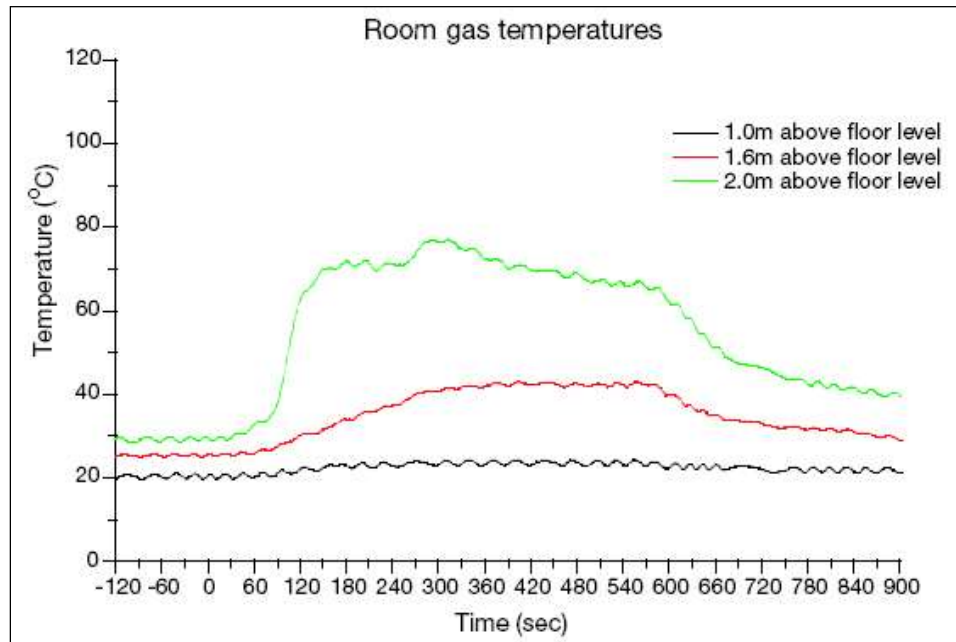
The kitchen fire tests were based on a chip pan fire. A two litre pan was used filled with one litre of pure vegetable oil. Several tea towels were draped over the top of the cooker grill pan to provide an

opportunity for flame spread from the chip pan (layout shown below). The pan was left on a lit stove to reach its auto ignition temperature. This occurred after approximately 50 minutes.



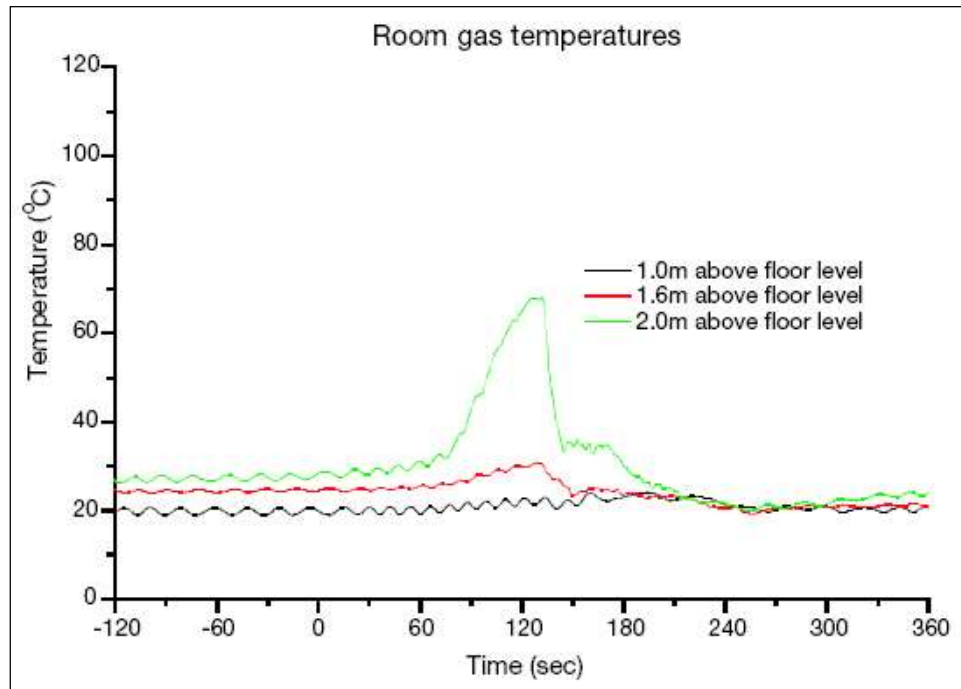
Test observations and results for the unsprinklered test are shown below: -

Table 44 Test details and observations for 1st kitchen test		
Test No		K1
Scenario		Kitchen
Sprinklered?		No
Test details		Chip pan heated on gas cooker until 1 minute after auto-ignition of oil occurs. Tea-towels paced on cooker hood, above chip pan to propagate flames.
Time		Event
Minutes	Seconds	
-24	0	Lobby smoke alarm activated
0	0	Ignition (@ oil temperature of 361°C)
1	12	Towels ignite
1	33	Front towels fully burning
3	09	Burning of front of towels decreases
3	43	Side towels start burning
5	09	Burning of front of towels ceases
6	48	Sporadic flaming of towels ceases
Post test damage assessment		
Cooker		Grill pan cover scorched
Tea towels		All towels fully burned
Cupboards		Smoke damage and some charring of underside of cupboards
Work surfaces		No damage



Test observations and results for the sprinklered test are shown below: -

Table 45 Test details and observations for 2nd kitchen test		
Test No	K2	
Scenario	Kitchen	
Sprinklered?	Yes @ 60Lpm	
Test details	Chip pan heated on gas cooker until 1 minute after auto-ignition of oil occurs. Tea-towels paced on cooker hood, above chip pan to propagate flames.	
Time		Event
Minutes	Seconds	
0	0	Ignition (@ oil temperature of 355°C)
1	08	Tea-towels ignite
1	17	Tea-towels fully burning
2	12	Sprinkler operation
2	58	Flames extinguished
Post test damage assessment		
Cooker	Grill pan cover scorched Main cooker surface covered with water and blackened cooking oil.	
Tea towels	Front facing towels partially burnt, side towels slightly charred	
Cupboards	Smoke damage to wall cupboards.	
Work surface	Spattered with water and blackened oil	



Other Research in the USA

BFRL, with support from the US Fire Administration, conducted experiments to quantify the effectiveness of residential sprinkler systems designed in accordance with NFPA 13D.

An example of these experiments is the following comparison of a “living room” fire, with and without residential sprinklers. Two rooms, each 3.7m X 2.4m high, were built in the Large Fire Research Facility at NIST (National Institute of Standards and Technology in the US). Both of the “living rooms” were furnished with a sofa, love seat, end table, lamp and carpeting. Room A had a smoke detector installed and Room B had both a smoke detector and a residential sprinkler system. A match was used to ignite the sofa.

Within 40 seconds after ignition, the smoke detectors in each room activated. The fires in both rooms continued to grow. At 85 seconds the residential sprinkler activated in Room B. As a result of the water spray from the sprinkler in Room B, the fire was suppressed and safe conditions were maintained. The fire in Room A continues to grow. Flashover occurs in Room A, 195 seconds after ignition, with temperatures exceeding 600 °C.

Statistics

The installation of residential sprinklers in Europe is relatively new, but there are studies in North America which highlight their effectiveness. Many jurisdictions in the USA and Canada now require sprinklers to be provided in new residential buildings. These are:-

1. San Clemente, California, 1978
2. Cobb County, Georgia USA
3. NAPA, California
4. Prince George's County, Maryland, 1992
5. Scottsdale, Arizona, 1986
6. Port Angeles, Washington, 1986
7. City of Vancouver, Canada, 1990

There has not been a single fire fatality in either Napa, California or Cobb County since the inception of those programs.

There has not been a single fire fatality in Prince Georges County in a residential building fitted with a sprinkler system.

In Scottsdale, more than 50% of homes have sprinklers. During a fifteen year period (between 1986 and 2001) there were 49 fires in sprinklered homes. There were no fatalities in sprinklered homes. During the same period there were 549 fires in unsprinklered homes with 13 fatalities.

In Vancouver, annual fire deaths in the City have fallen from 7 fatalities per 100,000 population in the early 1970's to 1 fatality per 100,000 in the 1990's.

In 1984, a report by NIST estimated that the effect of adding sprinklers when smoke detectors are already present could reduce the number of fire deaths by 63%.

A NFPA analysis of national US data, collected from 1983 to 1992, indicates the number of fire deaths per 1,000 fires was reduced by 57% in homes with sprinklers.

APPENDIX B KITCHEN LAYOUT

The analysis is for a sprinkler controlled fire that limits the fire to the cooking pan, which is in line with results of BRE sprinklered test. The time for occupants to escape past the hobs is solely that for movement past the hob, in order to demonstrate that occupants would not be harmed in passing the hob.

BS 7974 “Applications of Fire Safety Engineering Principles to the Design of Buildings” states that at a point where the radiant heat flux is 10 kW/m^2 tenable conditions are maintained for 4 seconds and where the radiant heat flux is 2.5 kW/m^2 they are maintained for 30s. This is a reasonable time to escape from a flat. The radiant heat flux is a function of the heat release rate of a fire and the distance from the fire (see Figure 1).

A research study carried out by lit Gandhinagar and Underwriters Laboratory Inc. (“Report of research on detection of kitchen fire”, 8 July 2010) shows that the peak heat release rate of a cooktop fire is 86.9 KW. Another research study carried out by Hyeong-Jin Kim and David G. Lilley and published by the American Institute of Aeronautics and Astronautics (“Heat release rates of burning items in fires”, January 2000) gives a heat release rate for a 12 inch pan fire of 116KW. Both of these fire sizes were not controlled by sprinklers and represent the worst case scenario as the fire was fed by constantly burning oil.

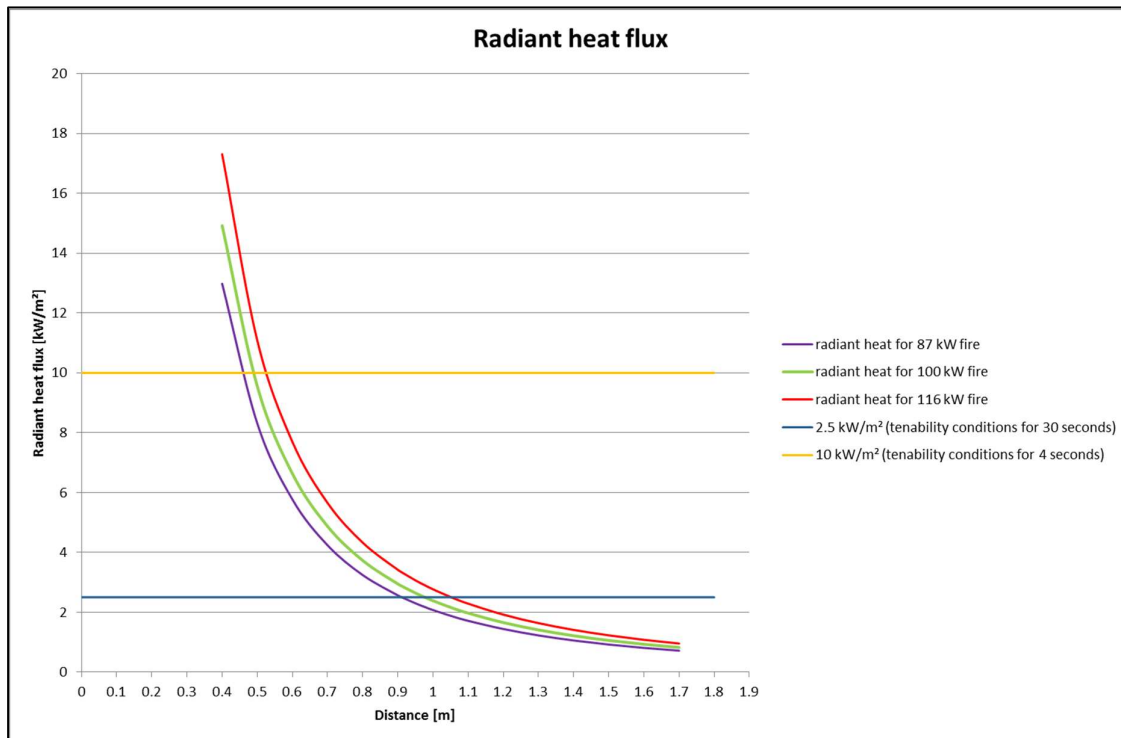


Figure 1: Radiant Heat Flux

The hob fire sizes within a range between 87kW and 116kW are modelled, as shown in the figure above. To keep tenable conditions for 30 seconds the distance from the hob fire should not be less than 1.1m. To keep tenable conditions for 4 seconds the distance from the hob fire should not be less than 0.53m.

Provided that the minimum distance between the hob and the opposite wall in the open-plan flats is approximately 1.8m and assuming occupants have shoulder width of 0.5m, they would be at least 1.1m from the hob fire. Therefore, the radiant heat flux in the proposed open-plan flats does not exceed 2.5 kW/m^2 and tenable conditions remain to allow occupants to escape past the hob fire.

The analysis takes no account of the effect of sprinklers in controlling the hob fire, or of the radiation absorption and cooling of the occupants' skin by the water spray. Therefore, in the event of a hob fire occupants should be able to escape safely from the flat.

A method of calculating the separation between a fire and a combustible material is described in NFPA92b and the SFPE Handbook, which assumes a point source, and measures the separation distance from this point.

The method relates the radiant heat flux (RHF), q , at a distance r from the centre of a fire to the total of heat release rate (HRR) of the fire, Q_t .

The equation is:

$$q = \frac{0.3Q_t}{4\pi r^2}$$

Where 0.3 is the fraction of heat emitted as radiation.

The distance, r , from the centre of fire can be calculated from the following equation:

$$r = \sqrt{\frac{0.3Q_t}{4\pi q}}$$

Therefore, the distance for 2.5kw/m² RHF at 116kW HRR would be:

$$r = \sqrt{\frac{0.3 \times 116}{4\pi \times 2.5}}$$
$$r = 1.1m$$

The distance for 10kw/m² RHF at 116kW HRR would be:

$$r = \sqrt{\frac{0.3 \times 116}{4\pi \times 10}}$$
$$r = 0.53m$$

OFFICES AND CONTACT INFORMATION

Should you have any queries with this report please contact our London Office.

London Office:

209-215 Blackfriars Road
London
SE1 8NL
Tel: +44 (0)20 7202 8484
london-jga@jensenhughes.com

OTHER JH OFFICES AT:

Manchester Office:

2nd Floor
Swan Buildings
20 Swan Street
Manchester
M4 5JW
Tel: +44 (0)1612366527
manchester-jga@jensenhughes.com

Edinburgh Office:

22 Hanover Street
Edinburgh
EH2 2EP
Tel: +44 (0)131 226 1661
edinburgh-jga@jensenhughes.com

Dublin Office:

9 Upper Baggot Street
Dublin 4
D04 A6W7
Tel: +353 (0)1 661 4925
dublin-jga@jensenhughes.com

Galway Office:

Office 3, Monterey Court
Salthill, Galway
Ireland
Tel: +353 (0)91 528 342
galway-jga@jensenhughes.com

Birmingham Office:

Suite 205, Cheltenham House
16 Temple Street
Birmingham
B2 5BG
Tel: +44 (0) 121 281 4513
birmingham-jga@jensenhughes.com

Glasgow Office:

30 Gordon Street
Glasgow
G1 3PU
Tel: +44 (0)141 847 0446
glasgow-jga@jensenhughes.com

Belfast Office:

Victoria Place
Wellwood Street
Belfast
BT12 5GE
Tel: +44 (0)2890 230 300
belfast-jga@jensenhughes.com

