Brill Place

Detailed Fire Strategy

07th May 2021

Omega Fire trading as BB7

BB-DFS-10634-OF-01-RevC

Revision History

Version	Date	Author	Comments
01	16/12/2020	Ellis White	Initial Issue
Rev A	25/01/2021	Ellis White	Revised following building control comments.
Rev B	27/04/2021	Conor McBride	Revised following design team review
Rev C	07/05/2021	Conor McBride	Revised following design team review

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Contents

1. Design Principles Summary

1.1 Introduction

1.1.1 BB7 Fire has been commissioned by Henry Construction to produce a Detailed Fire Strategy for the proposed Brill Place development, London. Brill Place is a proposed new build tower, primarily consisting of residential accommodation and a ground floor commercial unit.

1.1.2 This report outlines the recommendations for fire safety features to satisfy the functional requirements of Part B of the Building Regulations on the basis of fire engineering principles.

1.2 Legislation

1.2.1 Under the Building Regulations a building owner is required to provide an adequate level of life safety to the building by providing suitable means of escape, means of warning occupants of a fire, limiting internal fire spread, protecting adjacent property from fire, and facilitating Fire Service operations. This can be achieved by the adoption of standard guidance as documented within Approved Document B (ADB Volume 1/2) 2019 Edition (May 2020 update). However, ADB further recognises that alternative solutions may provide a more appropriate design. The use of an alternative approach is detailed in ADB, Use of Guidance page 3/4:

"The fire safety requirements of the Building Regulations will probably be satisfied by following the relevant guidance in this approved document. However, approved documents provide guidance for some common building situations and there may be alternative methods of complying with the Building Regulations' requirements.

If alternative methods are adopted, the overall level of safety should not be lower than the approved document provides. It is the responsibility of those undertaking the work to demonstrate compliance.

If other standards or guidance documents are adopted, the relevant fire safety recommendations in those publications should be followed in their entirety. However, in some circumstances it may be necessary to use one publication to supplement another. Care must be taken when using supplementary guidance to ensure that an integrated approach is used in any one building."

1.2.2 The Brill Place development will adopt "BS 9991 – Fire safety in the design, management and use of residential buildings" will be used as the basis of the fire safety design of the residential accommodation. BS 9991 superseded BS 5588-1 in December 2011.

1.2.3 This report provides the minimum level of protection required regarding compliance for Part B of the Building Regulations. If additional items are required due to property protection, this will need to be advised as soon as possible because changes may be required to the fire strategy.

1.2.4 Where no reference is made within this report with regards to a certain element, all aspects of the building are to be in full accordance with the recommendations of BS 9991 and/or the appropriate British Standard. Where the design deviates from BS 9991 a fire engineered approach will be used.

1.2.5 The draft London Plan Policy D12(B) and D5(B)(5) have also be considered within this outline report.

1.3 Important Information

1.3.1 This report provides the minimum level of protection required regarding compliance for Part B of the Building Regulations. If additional items are required due to property protection or due to the nature of the building, this will need to be advised as soon as possible because changes may be required to be made to the fire strategy.

1.3.2 Unless explicitly stated otherwise in this report, all aspects of the building are to be in full accordance with the recommendations of BS 9991 and/or the appropriate British Standard.

1.3.3 The validity of this report is dependent upon the recommendations being implemented in full and as described. Any subsequent changes to the design by any party which are not agreed with BB7 invalidate the report.

1.3.4 It should be noted that all recommendations made in this report are of equal critical importance for life safety and compliance and the report should be read in its entirety. If you have any queries or do not understand anything within this report, please contact us.

1.3.5 This report is developed on the basis traditional construction methods i.e. conventional steel or concrete structure being used.

1.3.6 Any proprietary systems or product used should be confirmed by the manufacturer and installer as appropriate for the use in the application to meet the performance specification of this report.

1.3.7 On-going maintenance is critical to life safety systems and all systems referenced in this performance specification should be maintained in full accordance with the manufacturers' recommendations.

1.3.8 It is considered that the recommendations in this report will provide sufficient guidance to obtain approval from the relevant authorities and achieve a satisfactory level of safety commensurate with the risks of the occupied premises.

1.3.9 This report will be based on compliance with Part B to the Building Regulations as of the date of this report and does not intend on advising on possible changes to the Building Regulations.

1.3.10 This report has not yet been approved and should not be used for construction until it is fully approved by the relevant approval bodies. It should be noted that the principles detailed in this report must be discussed and agreed with Building Control and the Fire Service.

1.4 Building Description

1.4.1 The Brill Place development comprises of primarily residential accommodation over 25 stories with a height of c.71m when measured from the lowest adjacent ground to the topmost occupied storey. The development consists of a basement level, ground & mezzanine, and first to 23rd storeys.

Figure 1. Brill Street Concept Image12

1.4.2 The basement level consists of;

- Chillers & BCWS
- Main Comms Room
- LS Room
- Accessible WC
- Main LV Switch room
- Bin Store
- Bike Store
- LTHW Pump Room
- Generator Room
- Wet Riser Plant Room
- Sprinkler Plant Room
- Goods lift

1.4.3 The Ground and Mezzanine Floors consist of;

- Commercial Unit
- Residential Lobby
- Stair Lobby
- Goods lift
- Substation

1.4.4 The first to twenty second floors contain residential accommodation. However, there is a small plant room on the seventeenth floor and a BMU garage on the 21st – 23rd(roof) levels.

1.5 Very Tall Buildings

1.5.1 Due to the increased design demands on structural integrity, services, fire safety systems, means of fire-fighting and evacuation generated by buildings in excess of 50 m high might mean that specific evaluation of all fire safety provisions is needed using a qualitative design review (QDR) in accordance with BS 7974. This is to determine whether the recommendations in BS 9991 are appropriate, or whether a full fire engineered solution is required. The QDR has been produced by BB7 as a separate document and is included in Appendix 3 for information..

1.6 Project Information

1.6.1 Table 1.1 provides a summary of the information that has been considered to develop this fire strategy. Where the design of the building is referred to in this report, it is based on the drawings listed below only.

Table 1.1 Drawing Schedule

Architect	Drawing Number	Description	Revision
Stiff & Trevillion	4451-ST-XX-B1-DR-A-37-099	Basement Plan	3C
	4451-ST-XX-00-DR-A-37-100	Ground Floor Plan	3D
	4451-ST-XX-0M-DR-A-37-100M	Mezzanine Floor Plan	3C
	4451-ST-XX-01-DR-A-37-101	First Floor Plan	3C
	4451-ST-XX-02-DR-A-37-102	Second Floor Plan	3C
	4451-ST-XX-03-DR-A-37-103	Levels 03,05,07,09,11,13 Plans	3C
	4451-ST-XX-04-DR-A-37-104	Levels 03,06,08,10,12,14 Plans	3C
	4451-ST-XX-15-DR-A-37-115	Fifteenth Floor Plan	3C
	4451-ST-XX-16-DR-A-37-116	Sixteenth Floor Plan	3C
	4451-ST-XX-17-DR-A-37-117	Seventeenth Floor Plan	3C
	4451-ST-XX-18-DR-A-37-118	Eighteenth Floor Plan	3C
	4451-ST-XX-19-DR-A-37-119	Nineteenth Floor Plan	3C
	4451-ST-XX-20-DR-A-37-120	Twentieth Floor Plan	3C
	4451-ST-XX-21-DR-A-37-121	Twenty-first Floor Plan	3C
	4451-ST-XX-22-DR-A-37-122	Twenty-second Floor Plan	3C

2. Emergency Escape Strategy

2.1 Evacuation Principle

Apartments

2.1.1 The principal mode of evacuation for the residential accommodation is a 'safe to stay' evacuation strategy whereby only the occupants of the apartment of fire origin will evacuate. This standard approach reflects the high degree of compartmentation present and minimises the impact of false alarms - an important consideration in residential accommodation.

2.1.2 The means of escape from the apartments relies on automatic fire detection and fire protection measures incorporated in the common escape route design.

2.1.3 Further evacuation of apartments will not take place automatically and relies on the fire service, management or the independent action of the occupants.

Non-Residential Areas

2.1.4 The evacuation procedure within the non-residential areas will follow a simultaneous evacuation policy, whereby on fire alarm activation anywhere in the non-residential areas, the occupants of the non-residential areas will evacuate simultaneously, without the fire alarm sounding in the residential or commercial accommodation.

Commercial Unit

2.1.5 The evacuation procedure within the commercial unit will follow a simultaneous evacuation policy, whereby on fire alarm activation anywhere in the commercial unit, the occupants of the commercial unit will evacuate simultaneously, without the fire alarm sounding in the residential or non-residential accommodation.

2.2 Building Population

Apartments

2.2.1 Given that only a single apartment would be expected to evacuate at any one time, the maximum predicted number of occupants would be less than 60 including considerations for guests.

Non-residential Areas

2.2.2 The areas listed below are considered transient spaces, where a limited number of occupants would be present for a limited period of time or accounted for in other areas of the development. Thus, it is deemed acceptable additional occupancy is not accounted for in these areas.

- Bin Store;
- Bike Store;
- Stair Lobby

2.2.3 The areas listed below are considered as low occupancy, low use spaces which would only be used by maintenance personnel and therefore, will not be considered in the overall occupancy of the building.

- Plant rooms;
- Comms room;
- Switch rooms
- Substation
- Goods Lift
- Generator room

2.2.4 It is envisaged that the Residential lobby area will be occupied by a single concierge.

Commercial Unit

2.2.5 The commercial unit has an area of 60m^2, which equates to 30 people, when a floor space factor of 2m^2 per person is applied in accordance with a shop floor area.

2.3 Building's Automatic Fire Detection & Alarm System (AFDAS)

2.3.1 A summary of the fire detection and alarm recommendations for the building has been provided in Table 2.1 below, with details on each system listed below. Where referred to in this section, a "Category L" system is a life safety detection system designed in accordance with BS 5839-1 for use in non-domestic areas; a "Category LD" system is a life safety system designed in accordance with BS 5839-6 for use in domestic areas.

Table 2.1 Fire Detection and Alarm Systems

Occupancy	Alarm Performance	Design Standard	Sounders?	Manual Call Points?
Apartments	LD1	BS 5839-6	Yes	No
Common Corridors	L5	BS 5839-1	No	No
Non-Residential Areas	L2	BS 5839-1	Yes	Yes
Commercial Unit (shell & core only)	M	BS 5839-1	Yes	Yes

Residential

2.3.2 Due to the provision of open plan apartments, the residential accommodation is to be provided with a Grade D1 Category LD1 alarm system. This will permit a single sprinkler flow alarm per level, rather than one being required per flat.

2.3.3 A Category L5 detection and alarm system should be provided to the common corridors and stairs of the building. The system is provided to actuate the smoke ventilation only and will not act as a means of warning occupants of a fire. The system will consist of smoke detectors only, with no manual call points or sounders. The smoke detectors should be spaced along the corridor in accordance with the recommendations of BS 5839-1 in that all areas of the corridors must be no more than 7.5m from a smoke detector. Additionally, it should be ensured a detector on the corridor is provided within 1m of the apartment doorway that is closest to the escape stair. The detector should be located between the apartment doorway and the nearest stair.

Winter Gardens

2.3.4 The LD1 system within apartments from the 15th storey upwards that have a winter garden is to be extended to cover the winter garden , due to the semi enclosed nature of the area.

Non-residential Areas

2.3.5 A Category L2 detection and alarm system should be provided to the non-residential areas ground floor ancillary areas of the building.

2.3.6 The plant room on the seventeenth floor and the BMU garage on the on the 21st – 23rd(roof) levels should form part of the non-residential areas fitted with an L2 alarm system.

2.3.7 Manual call-points are to be located in the non-residential areas on escape routes and at all storey exits. All doors to fresh air should be provided with manual call points, including where exits are not specifically designed as fire exits. The distribution of the manual call points should be such that no occupant has to travel more than 45m to reach the nearest one. It should be noted that the activation of a manual call point should not trigger any sounders in the residential areas to facilitate the stay-put evacuation policy.

2.3.8 If the fire alarm is to interface with other systems e.g. plant shut down and lift installations these interfaces should be designed in accordance with BS 7273-6. Door release mechanisms, free-swing closers and hold open devices should be interfaced in accordance with BS 7273-4.

Commercial Unit

2.3.9 The commercial unit will be designed as shell and core only and are subject to separate Building Regulations applications upon fit out. The minimum alarm and detection required for such premises is a manual system containing no automatic detectors. The alarm system should be designed and installed in accordance with BS 5839-1.

Fire Alarm Control Panel

2.3.10 The fire alarm control panel (separated for the commercial and residential) should be located at an appropriate location for both key staff and firefighters. They should normally comprise an area on the ground floor close to the main entrance of building likely to be used by the Fire Service. It is recommended that the position of the fire alarm control and indicating panel is located in such a place that it can be easily and readily accessible to the Fire Service.

2.4 Directions of Escape

2.4.1 The directions of escape requirements have been highlighted in Table 2.2. These have been met throughout the development.

Table 2.2 Direction of Escape Requirements

Maximum Population	Directions of Escape Required	Door Opening Direction
60	1	No requirement
600	2	In direction of escape
More than 600	3	In direction of escape

2.5 Escape Widths

2.5.1 The escape widths should be in accordance with Table 2.3. This report only addresses the minimum in Part B of the Building Regulations and does not address Part M requirements. Conformance with other parts of Building Regulations should be confirmed by others (standard wheelchair users require doors of 850mm in width).

2.5.2 Where a single escape route is provided or the exit opens against the direction of escape, the occupancy will be limited to a maximum of 60 through that exit.

Table 2.3 Widths of Escape Routes and Exits

Maximum Number of Occupants	Minimum Escape Width (mm)
60	750
110	850
220	1050
More than 220	5mm per person

Residential

2.5.3 Due to the safe to stay evacuation policy, the maximum envisaged occupancy making an escape is below 60, therefore the residential exit widths are deemed acceptable.

Non-residential Areas

2.5.4 Due to the transient nature and small size of the non-residential areas the maximum envisaged occupancy making an escape is below 60, therefore the non-residential exit widths are deemed acceptable.

Commercial Unit

2.5.5 the maximum envisaged occupancy within the commercial unit is below 60, therefore the proposed exit widths are deemed acceptable.

2.6 Travel Distances

2.6.1 Recommendations for limitations on travel distances can be seen in Table 2.4.

Table 2.4 Travel Distance Limitations

Location	One direction	More than one direction
Apartments	9m*	N/A
Common Corridor	7.5m*	30m*
Bins Storage	9m	18m
Bike Storage	25m	45m
Plant Room	9m	35m
Commercial Unit	18m	45m

Note: * Where sprinklers are provided in accordance with BS 9251 in the apartments, the single direction travel distance within the ventilated common corridors can be increased to 15m and 20m within the apartments. Where there is an alternative direction of escape the common corridor travel distances can be increased to 60m.

Residential Apartment Layouts

2.6.2 Due to the height of the building and the provision of open plan apartments a BS9251 sprinkler system will be provided to the residential apartments. Travel distances in apartments fitted with sprinklers should be limited to 20m from the furthest point in the room to the apartment entrance door.

2.6.3 Due to the kitchen areas not being enclosed within the open plan apartments having an area exceeding 8m x 4m, Computational Fluid Dynamics (CFD) analysis has been undertaken to determine that the conditions within an open plan flat remain tenable in accordance with a code compliant layout. The CFD analysis has been produced within a separate report which can be read in Appendix 2 of this report

Residential Triplex Apartment

2.6.4 The travel distance in a Triplex apartment when measured from any point of the apartment to the head of a protected stair should be limited to 9.0m. This limit may be extended to 20m if a residential sprinkler system is incorporated into the design and a Grade D Category LD1 AFDA is also provided.

2.6.5 The stair and hallway within the Triplex apartment should be constructed of materials achieving a 30min fire rating and also doors should be FD30 rated.

Location of Cooking Facilities (Open-Plan Apartments)

2.6.6 The cooking facilities must be located such that they will not prejudice the escape from any point within the apartments. The cooking facilities are on the escape routes for open plan apartments, and so to ensure that their location is acceptable, an analysis has been undertaken to determine the likelihood of the egress route being affected by the radiant heat from a cooking fire. The analysis will seek to determine that an appropriate separation distance can be maintained between the cooking area and the egress route such that the escaping occupants are not exposed to excessive radiation, see Table 2.5.

2.6.7 The analysis will seek to determine that an appropriate separation distance can be maintained between the cooking area and the egress route such that the escaping occupants are not exposed to excessive radiation. In accordance with PD7974-6 (British Standards Institution, 2004) Table G.3 the tenability limits for received radiation are as follows.

- <2.5kW/m^2 for 5 over minutes
- 2.5kw/m^2 for 30 seconds
- 10kW/m^2 for 4 seconds

2.6.8 Generally, a tenability criterion of 2.5kW/m^2 will be adopted as a received radiant heat flux on the basis that any received thermal radiation less intense than that value is tolerable for over 5 minutes. Detailed calculations for the locations of the cooking facilities, and the impact that various fire protection devices have on the potential fire size have been provided in Appendix 1 of this report. A summary of the results has been provided below in Table 2.5.

Table 2.5 Calculated Definition of "Remote" for Means of Escape

Fire Protection System Provided	Dimension of R_0
None	Greater than 1250 mm[1]
Category B Cut-off Device (BS 50615)	Greater than 660mm

Note 1: This is based on a 2.5kW hob as a conservative estimate. Details on the specific cooking facilities are required to ensure this separation distance is accurate.

2.6.9 The "dimension of R_0" as given in Table 2.5 refers to the R_0 dimension indicated in Figure 2 below.

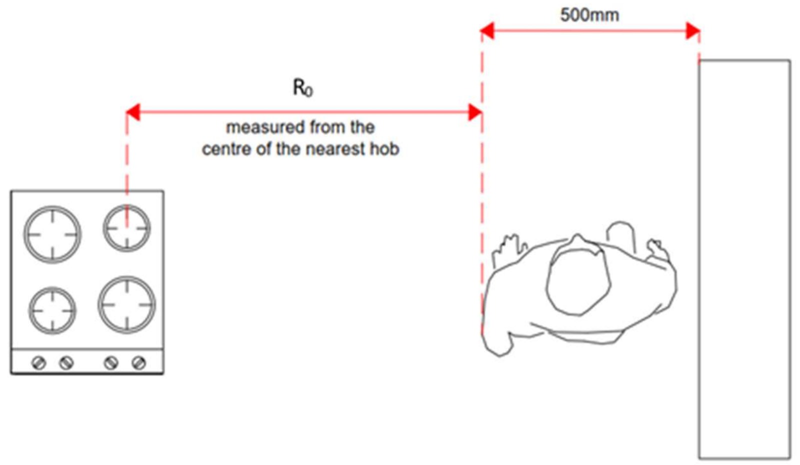

Figure 2. Separation distance from Hobs to Escape Route

2.6.10 The location of the cooking facilities within all open plan apartments should achieve the minimum separation distance stated in Table 2.5 and Figure 2. It appears that the cooking hobs in all apartments are located more than 1750mm from the escape route. Therefore, no additional fire protection system is required to the cookers.

Non-Residential Areas

2.6.11 The travel distances within the generator room (15.3m), wet riser plant room (14.8m) and BCWS plant room (13.8m) exceed the allowable limit of 9m. It is proposed these slight extensions are deemed acceptable due to the following;

- Provision of a BS9251 sprinkler system
- Provision of an L2 AFDA system
- They are all transient areas that would be usually unoccupied and locked and would only be accessed by maintenance personnel for a short period.
- The most onerous extension is 6.3m, which at a walking speed of 1.2m/s would take an additional 5.25 seconds.

2.6.12 The recommendations made in 2.6.11 is a deviation and would require Building Control and Fire Service approval and would remain a design risk until this is achieved.

Commercial Unit

2.6.13 Due to the small size of the commercial unit and alternative means of escape the travel distances within the commercial unit are compliant as per the limits set out in Table 2.4.

2.7 Common Corridors

2.7.1 Where a development is served by a BS 9251 sprinkler system, the recommendations of BS 9991 permit a travel distance of 15m in a single direction within a ventilated corridor, from an apartment door to the protected stair.

2.7.2 Additionally, under BS 9991 a travel distance of 7.5m is permitted in an unventilated corridor where the corridor provides direct access to a ventilated stair lobby, this configuration is used on floor 18 and 19.

2.7.3 It is proposed that the development is served by a mechanical smoke shaft for the purpose of smoke ventilation within the common corridors, the mechanical smoke shaft requirements are detailed in section 2.8.

2.7.4 The mechanical smoke shaft will serve all stories including ground and basement. Through the provision of the smoke shaft, the common corridor travel distances within the ground – 22nd floor are compliant.

Basement Common Corridor

2.7.5 The allowable 7.5m travel distance within the basement common corridor to the stair is exceeded in the areas highlighted in green in Figure 3. See section 6.4 for basement vent details.

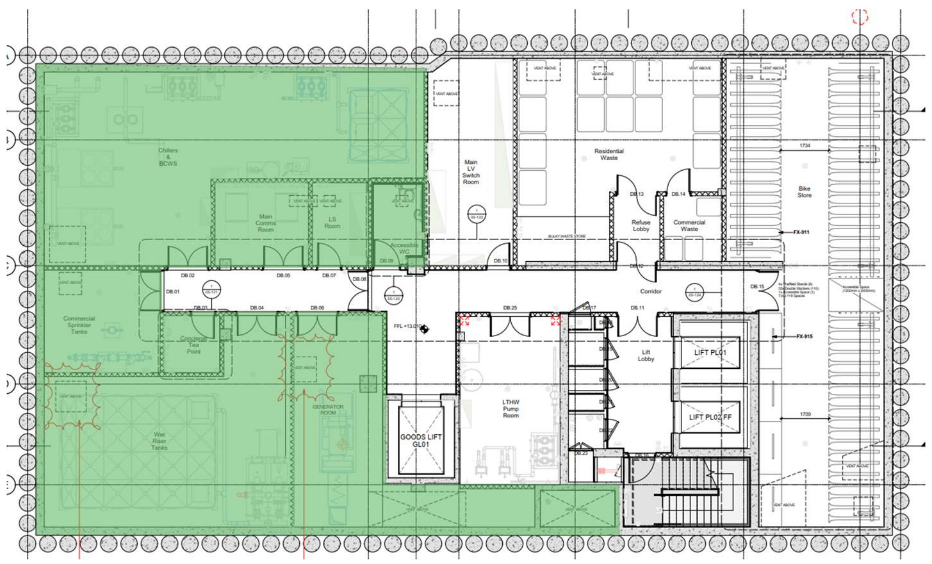

Figure 3. Basement Level Travel Distances

2.7.6 It is proposed that the extended travel distances within the BCWS plant room, generator room, wet riser plant, commercial sprinkler plant, tea room, WC, comms room and life safety mains room are acceptable based on the following;

- The lift lobby area is to be provided with a mechanical extract system;

- Provision of a BS9251 sprinkler system (except life safety mains room);
- Provision of an L2 AFDA system;
- They are all transient areas that would be usually unoccupied and locked and would only be accessed by maintenance personnel for a short period;
- The most onerous extension is 8m (23m from commercial sprinkler plant room), which at a walking speed of 1.2m/s would take an additional 6.7 seconds.

2.7.7 The recommendations made in 2.7.6 is a deviation and would require Building Control and Fire Service approval and would remain a design risk until this is achieved.

2.8 Ventilation Provisions

2.8.1 In buildings above 30m, where the common corridors/lobbies have travel distances within the recommendation in BS 9991, the ventilation can be achieved by either:

- An AOV of $1.0m^2$ in area which discharges into a vertical natural smoke shaft with a clear internal area of $1.5m^2$; or
- A $0.8m^2$ mechanical ventilation shaft with a pressure sensor in the corridor/lobby to prevent excessive depressurisation; or

Mechanical Smoke Shaft

2.8.2 The scheme is proposed to adopt a mechanical smoke shaft approach. The mechanically assisted smoke shafts should meet the following criteria:

- Have a minimum cross-sectional geometric free area of $0.8m^2$ and $1.0m^2$ geometric free area AOV into the corridor.
- The operation of the mechanical shaft would be upon a smoke detector activating in the corridor/lobby. The extract rate for the $0.8m^2$ mechanical shaft is to be confirmed by the smoke shaft designer.
- The smoke shafts are to be include duplicate fans (duty and standby) with alternative power supplies. The fans in the extract shafts are to be fire rated in accordance with the recommendations of BS EN 12101.

2.8.3 The mechanical smoke shaft extract fan will be required to be linked to pressure sensors in the common corridors to control the smoke extract rate. The sensor will control the ramp up of the fan extract rate when the stair door opens, for example, to ensure the pressure within the corridor isn't too great

2.8.4 Upon detection of smoke in the common corridor, the vents on the fire floor, the vents in the fire floor, the vent at the top of the smoke and the stair are to open simultaneously. The vents from the corridor/lobbies on all the other storeys will remain closed and locked shut i.e. they cannot open upon a second detector activating on another floor.

2.8.5 The smoke shafts should be constructed of materials classified as A1 in accordance with BS EN 13501-1:, or of materials determined to be non-combustible when tested in accordance with BS 476-4, or of any material which when tested in accordance with BS 476-11 does not flame or cause any rise in the temperature on either the centre of the specimen or the furnace thermocouples. It is proposed to skim the walls of the smoke shaft to ensure that the required fire rating is achieved.

2.8.6 As the smoke shafts penetrate compartment floors, as a minimum the shafts should maintain the fire rating of the respective compartment floor it runs through.

2.8.7 No services other than those relating to the smoke shaft should be contained within the smoke shafts.

2.8.8 Fans should be capable of handling gas temperatures of 300 °C for a continuous period of not less than 60 min and tested in accordance with BS EN 12101-3.

- Exhaust points outlets should be located not create recirculation with the stair "inlet vent".
- Smoke dampers configured to vent smoke from only one level at a time.

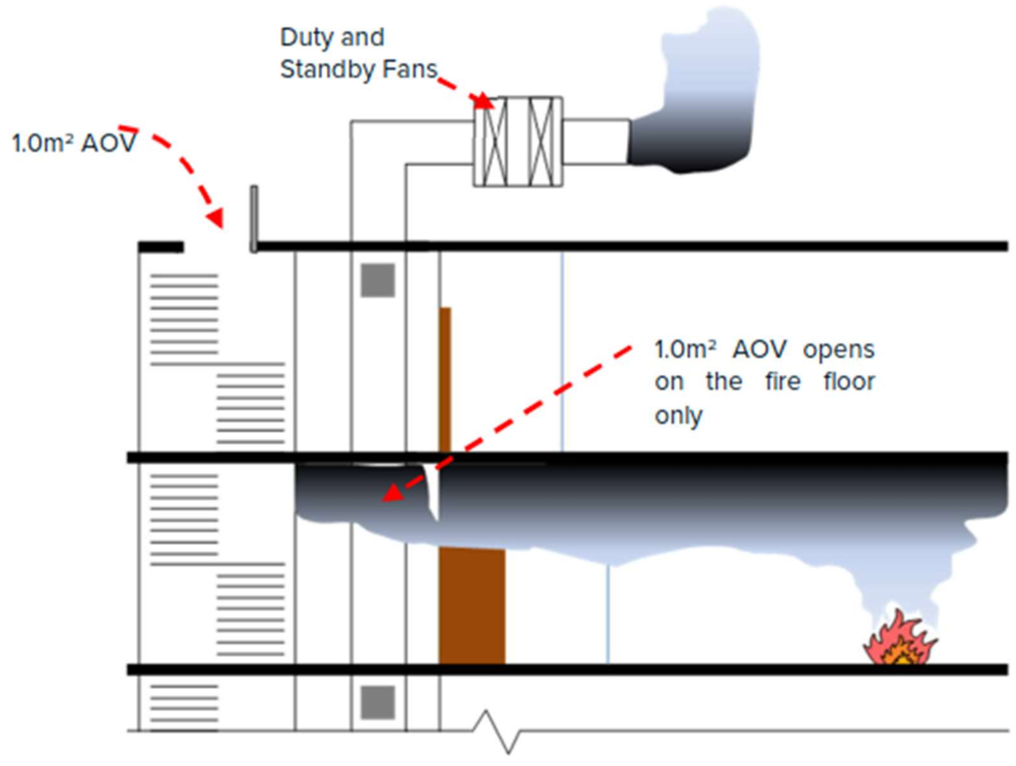

Figure 4. Mechanical Smoke Extraction System

2.8.9 The typical smoke shaft ventilation layouts have been highlighted in Figure 5 - Figure 9.

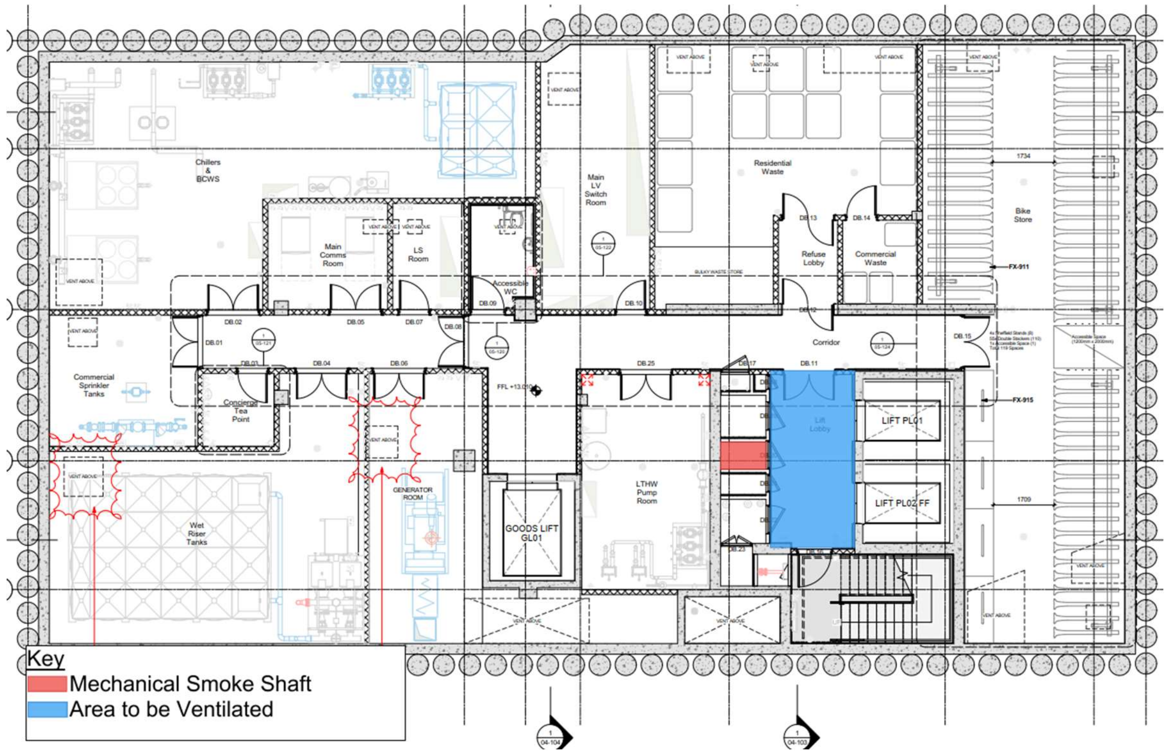

Figure 5. Basement Mechanical Smoke Shaft Arrangement

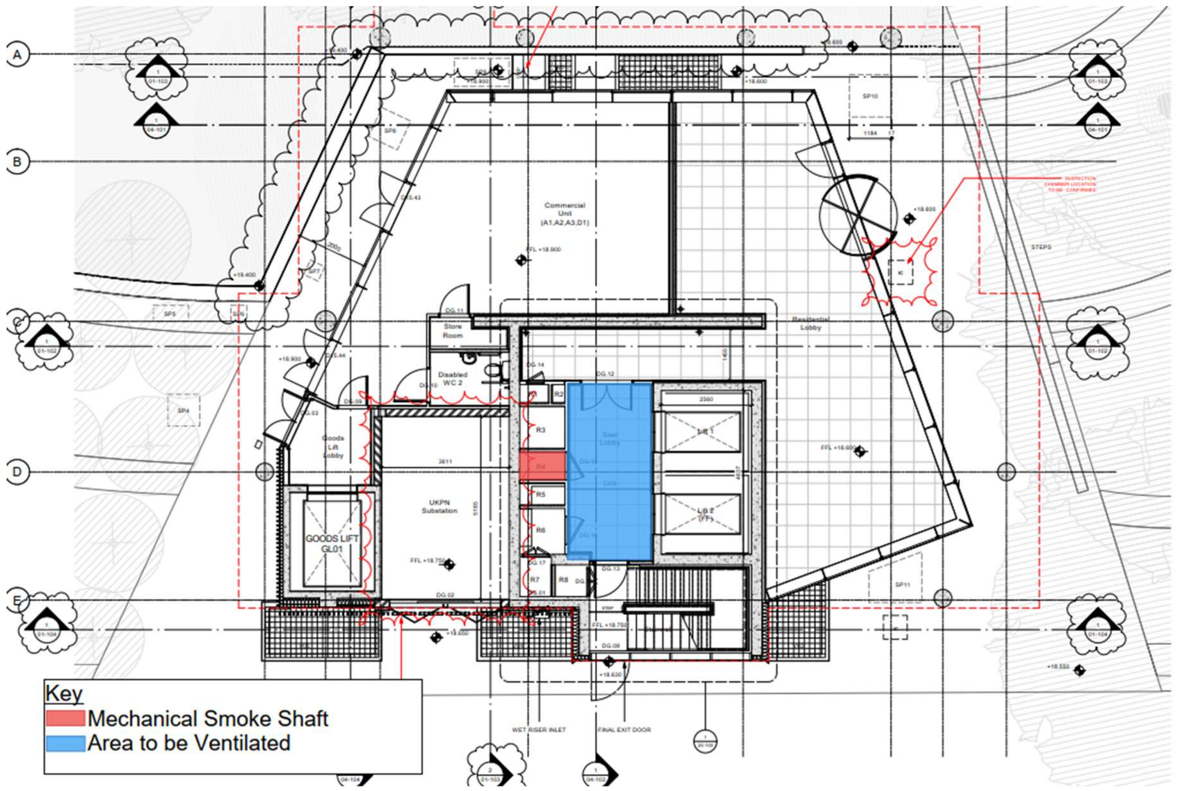

Figure 6. Ground & Mezzanine Floor Mechanical Smoke Shaft Arrangement

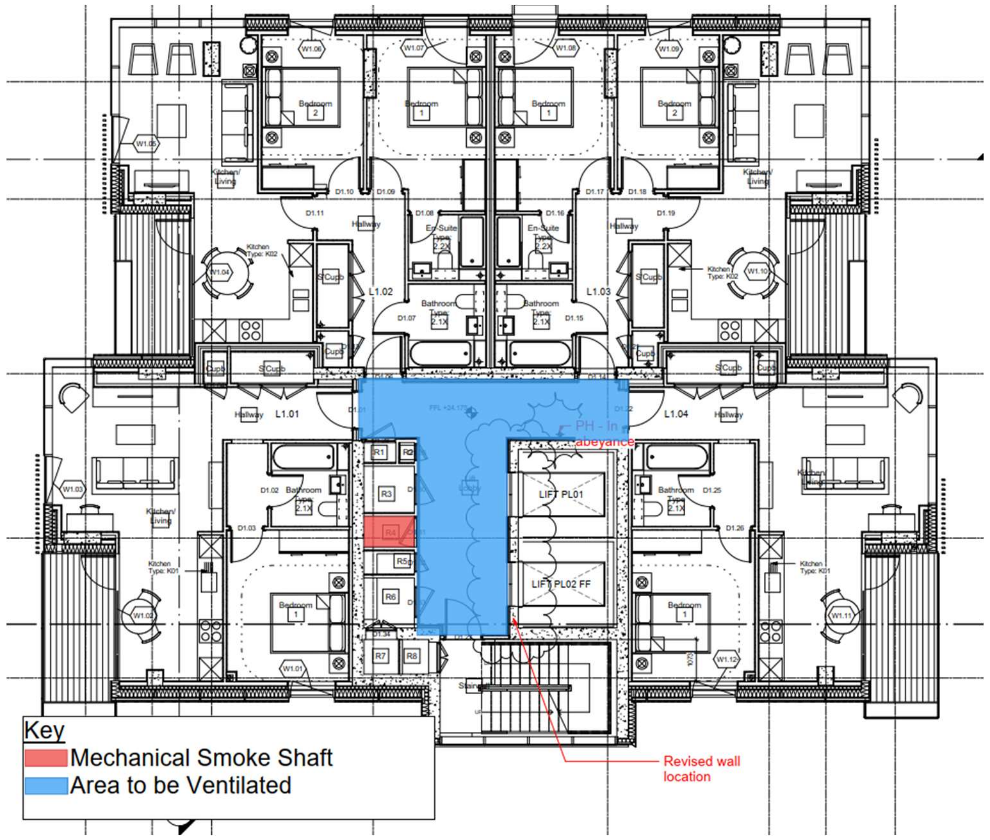

Figure 7. Typical Upper Floor Mechanical Smoke Shaft Arrangement

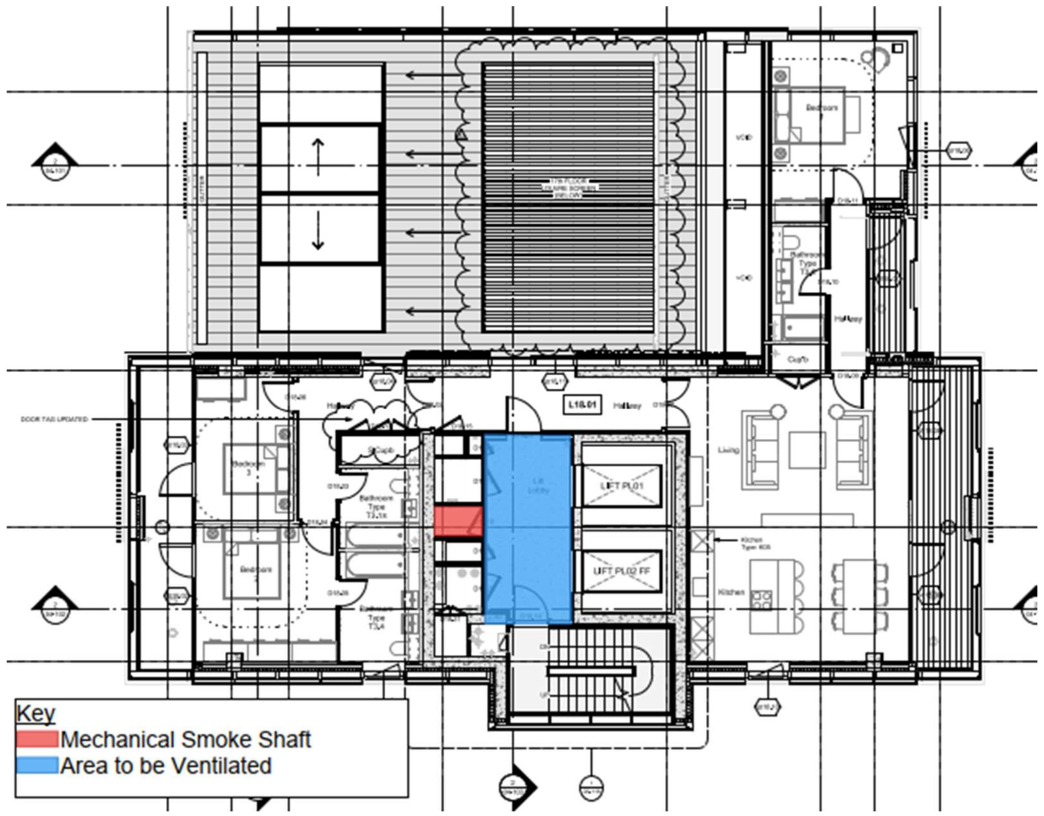

Figure 8. 18th – 19th Floor Typical Smoke Shaft Arrangement

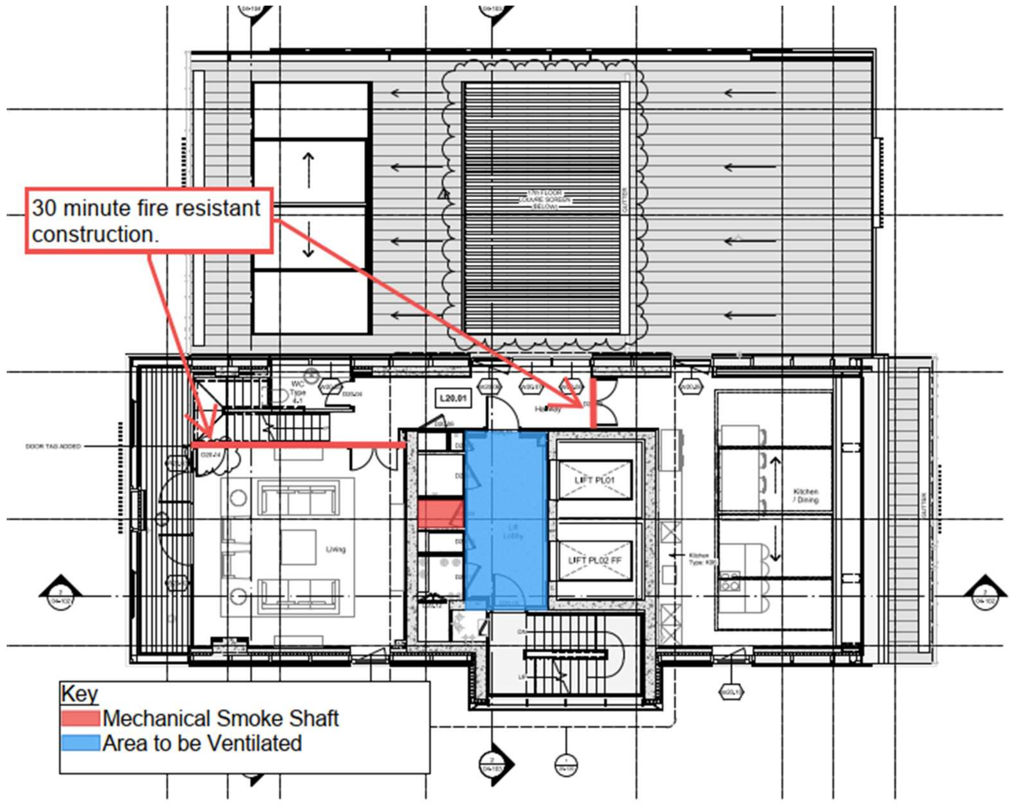

Figure 9. 20th Floor Smoke Shaft Arrangement

2.8.10 Additionally, a 1.0m^2 AOV should be provided at the head of the stair cores. AOVs should also be provided with a manual switch at ground floor level for use by the fire brigade.

2.8.11 The automatic openable vents (AOV's) play no part in the initial residential apartment evacuation but are intended to limit the spread of smoke to the stair. Additionally, the vents also aid in relieving smoke and heat from the common corridors during firefighting and allow firefighters to vent smoke. Vents designed to open automatically from the top storey of the stairs in buildings other than small single-stair buildings should be configured to operate upon smoke detection within any of the protected corridors or protected lobbies directly adjacent to the staircase enclosure.

2.8.12 The method to calculate the free area of the Automatic openable vents (AOV's) is highlighted in Figure 10. This is applicable for the AOV at the head of the head of the stair.

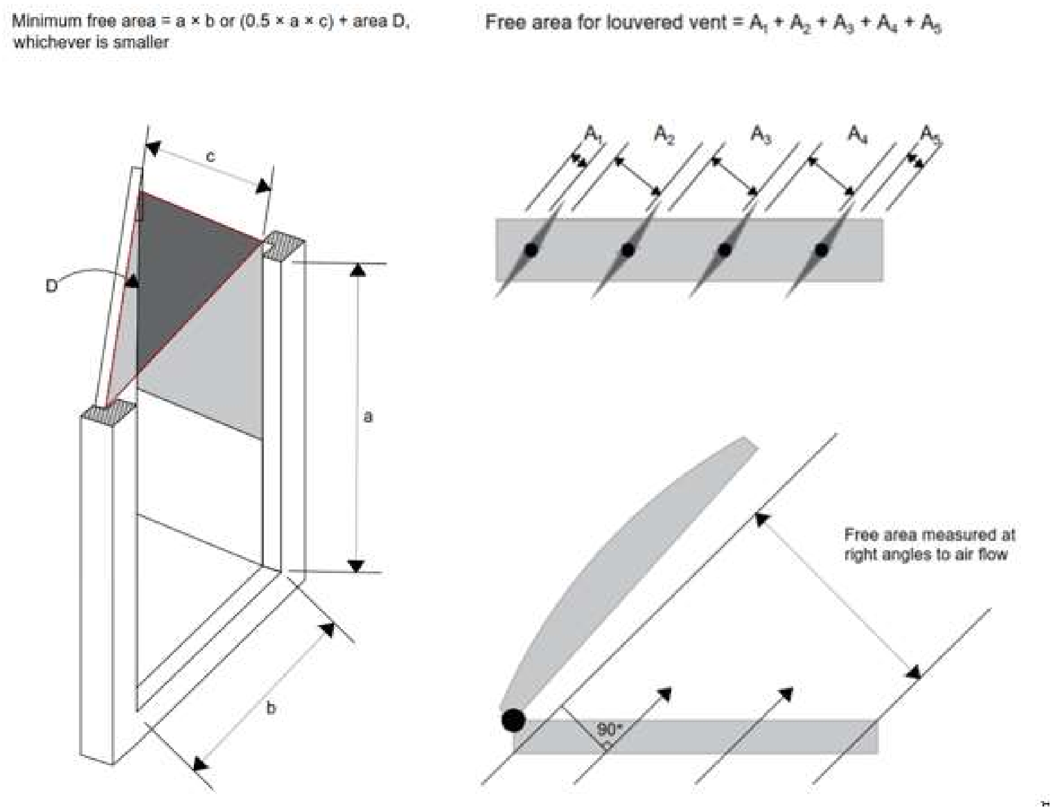

Figure 10. Free Area of Smoke Ventilation

2.9 Vertical Evacuation

2.9.1 BS 9991 states that a stair of acceptable width for everyday use will be sufficient for escape purposes from residential apartments. However, due to the height of the building, the stairs will be designed as firefighting stairs. Firefighting stairs will require to will have a minimum width of 1100mm (Note that this is the Part B requirement, and the Part M requirement may be greater). Further detail on the design of firefighting shafts can be found in Section 6.2.

2.9.2 The stair will be vented at the head via a 1.0m^2 AOV (Automatic Opening Vent).

2.9.3 Egress from the stair is provided direct to the external at the lowest adjacent ground level no extra provision are recommended as the final exit is in line with the recommendations of BS 9991.

2.9.4 Any final exit doors from the stairs would need to provide an equivalent clear width of the stair they serve. However, due to the stay put evacuation principal and low number (less than 60) of occupants escaping at any given time, it is proposed that the final exit widths could be reduced to a minimum of 850mm.This is to be discussed and agreed with Building Control.

2.10 Doors on Escape Routes

2.10.1 Access control measures incorporated into the design of the building which restrict access or egress from the building should not adversely affect the means of escape.

2.10.2 When the building is occupied, all electrically powered locking mechanisms are to return to the unlocked position on operation of the fire alarm system or loss of power. The door is also provided with a manual door release unit complying with BS 7273-4 in the side approached by people making their escape.

2.10.3 Exit widths are to be measured in accordance with Figure 11.

2.10.4 Doors on escape routes should:

- Be hung to open not less than 90 degrees
- Should be sufficiently recessed to prevent its swing from encroaching in the required egress route of the escape route or stair
- Provided with vision panels if they are provided to sub-divide corridors or where doors are hung to swing in both ways.
- Only fitted with lock or fastenings which are readily operated, without the use of a key and without having to manipulate more than one mechanism.

2.10.5 Doors on escape routes servicing more the 60 people should:

- Be provided with panic fastenings in accordance with BS EN 1125 if locks are required.
- Should be hung to swing in the direction of escape, if escape is available in both directions these doors should be double swing door sets.

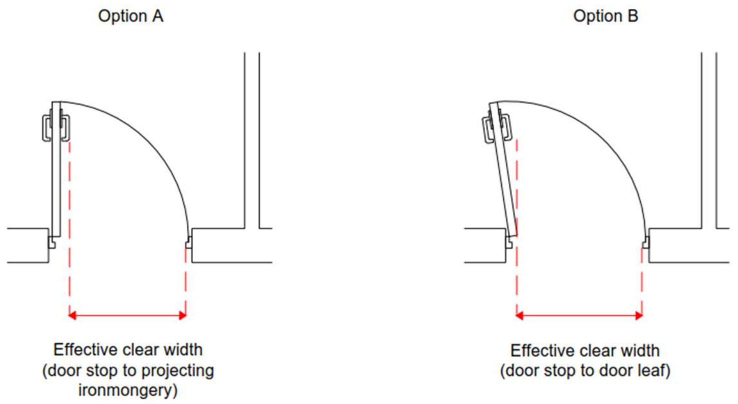

Figure 11. Door Widths

2.11 Evacuation of Non-Ambulant Persons

Residential

2.11.1 While not required for Building Regulations but part of the fire safety management plan, it is critical that adequate provisions are provided for the evacuation of any disabled users. The fire safety for the building needs to take account of the disabled occupants who may have access to the premises.

2.11.2 In the event of a fire, the building is afforded with enhanced levels of compartmentation which allows occupants to remain in the non-fire affected apartment.

2.11.3 On occupation, residents may be present with any combination of disabilities throughout the premises. Visitors to the flats will be the responsibility of the tenants. It is recommended the client informs the future responsible person for the premises (under the Regulatory Reform (Fire Safety) Order 2005) [RRO] to undertake an assessment towards a tenant's ability to react to a fire within the premises on taking up residence.

2.11.4 The responsible person under the RRO should provide information and regularly remind tenants on the fire procedures by providing leaflets and where necessary encouraging new tenants to have a home fire safety check by the local fire service. Specific measures regarding tenants with any disabilities identified can be discussed and implemented following the home fire safety check in conjunction with relevant local community services. It is advisable that details of any residents who would require assistance in an evacuation by the Fire and Rescue Service should be kept in a premises information box in the entrance foyer which can be obtained on their arrival to allow immediate prioritisation of the affected person(s). The corridors and stair landings would be suitable as a temporary refuge for persons with severe mobility impairment to wait for assistance due to the layout and fire resisting construction (very few occupants should be using the stairs for evacuation at any one time, such that the implications of restrictions in the escape routes would be minimal).

Commercial

2.11.5 The ground floor is access directly to the external. Therefore, it may be reasonable to assume that occupants with mobility impairment can easily escape to the external on the accessible levels of the commercial unit.

2.12 Emergency Lighting

2.12.1 Emergency lighting should be provided in accordance with BS EN 1838 and BS 5266 to meet the recommendations of BS 9991.

2.12.2 The escape lighting should be sited to provide an appropriate luminance near each exit door and where it is necessary to emphasise potential danger or safety equipment. The following bullet points indicate some of the critical areas:

- At each exit door intended to be used in an emergency
- Full length of stair to ensure good visibility
- Near stairs so that each flight of stairs receives direct light
- Near any other change in level
- Mandatory emergency exits and safety signs
- At each change of direction
- At each intersection of corridors
- Outside or near to each final exit
- Near each first aid post
- Near each piece of firefighting equipment, call point and fire alarm panel.

2.13 Emergency Escape Signage

2.13.1 Fire escape signs are to be provided to guide occupants from any point in a building via a place of relative safety (the escape route) to the place of ultimate safety (outside the building). Exit and directional signage should be provided in accordance with the requirements of:

- BS ISO 3864-1, BS 5499-4 and BS EN ISO 7010:2012+A7:2017.

2.13.2 Signage is provided to identify the primary escape route from each location within the building. To achieve this, the following principles have been adopted.

- At least one escape route or doorway leading to an escape route should be visible from any place within every room or enclosure (with the exception of the internal apartments).
- Where direct sight of the escape route is obstructed, additional signage to be considered.
- Escape route signage is to take precedence over all other signs.
- All changes of direction in corridor, stairways and open spaces forming part of an escape route will be marked with intermediate signs. Each intermediate door or junction will also be similarly signed.

- Signs are not to be fixed to doors or sited where they are obscured by open doors.

2.13.3 Escape route signs are to be sited conspicuously within the normal field of vision. The following principles, which will assist the evacuating occupants to predict the location of successive signs, should be applied:

- Signs above doors or open spaces should be mounted between 2m and 2.5m from floor level, measured to the base of the sign and be sited as close to the centre line of the escape route as practicable.
- Signs sited on walls should be mounted between 1.7m and 2m from floor level to the base of the sign.

2.13.4 Signs should be sited at the same height throughout the escape route, so far as is reasonably practicable.

3. Internal Fire Spread

3.1.1 The choice of materials for walls and ceilings can significantly affect the spread of a fire and its rate of growth, even though they are not likely to be the materials first ignited. It is particularly important in circulation spaces where the rapid spread of fire is most likely to prevent occupants from escaping. The surface linings are restricted by limiting the surface spread of flame and minimising heat release rates.

3.1.2 All surface finishes are to achieve the classification in Table 3.1 when tested under then National Classifications in accordance with BS 476 or the European Classifications in accordance with BS EN 13501-1.

Table 3.1 Classification of Internal Linings

Location	National Class	European Class
Rooms not more than $30m^2$ in non-residential areas	3	D-s3, d2
Other rooms	1	C-s3, d2
Escape routes and stairs	0	B-s3, d2

3.1.3 Parts of walls in rooms may be of poorer performance than specified in 0 (but not less than Class 3/Class D-s3, d2) provided that the total area of those parts in any one room does not exceed half of the floor area of the room and is subject to $60m^2$ in non-residential accommodation.

3.2 Structural Requirements

3.2.1 Premature failure of the structure can be prevented by the provisions of load bearing elements of structure to have a minimum standard of fire resistance, in terms of resistance to collapse or failure of load bearing capacity.

3.2.2 The purpose of providing the structure with fire resistance is:

- To minimise the risk to occupants
- To reduce the risk to firefighters who may be engaged on search and rescue operations
- To reduce the danger to people in the vicinity of the building

3.2.3 As the height of the development is greater than 50m all elements of structure are to achieve 120 minutes structural fire resistance when tested in accordance with the appropriate parts of BS 476 for load bearing elements of structure.

3.2.4 All elements supporting the firefighting shafts are to achieve 120 minutes structural fire resistance when tested in accordance with the appropriate parts of BS 476 for load bearing elements of structure

3.2.5 All penetrations through fire resisting construction are to be enclosed in fire resisting construction or fire stopped.

3.2.6 The periods of fire resistance refer to the performance achieve by the structural elements when tested in accordance with the appropriate parts of BS 476 for load bearing elements of structure. Elements of structure require fire protection to all exposed faces.

3.3 Elements of Structure

3.3.1 Elements of structure are defined as follows:

- A member forming part of the structural frame of a building or any beam or column
- A load bearing wall or load bearing element of a wall
- A floor
- A gallery
- An external wall structure supporting fire rated elements for the prevention of external fire spread
- A compartment wall

3.3.2 The following are excluded from the definition of elements of structure

- A structure that supports a roof unless
  - The roof performs the function of a floor such as parking vehicles or as a means of escape
  - The structure is essential for the stability of an external wall that need to be fire resisting (e.g. to achieve the compartmentation or for the proposes of preventing fire spread between buildings
- The lowest floor of the building
- A platform floor
- A loading gallery, fly gallery, stage grid, lighting bridge or any gallery provided for similar purposed or for maintenance and repair
- External walls, such as curtain walls or other forms of cladding, which transmit only self-weight and wind loads and do not transmit floor load

3.3.3 Where an element of structure forms part of more than one building or compartment, that element should be constructed to the standard of the greater of the relevant provisions

3.3.4 Where one element of structure support, carries or give stability to another, the fire resistance of the supporting element should be no less than the minimum period of fire resistance for the other element (whether that element is load bearing or not).

3.4 Sprinkler System

Residential & Non-Residential

3.4.1 All apartments and non-residential areas at ground and basement levels (excluding common corridors) should be provided with sprinkler protection. Due to the development being greater than 45m from the lowest adjacent ground floor level to the topmost occupied storey it is recommended the following criteria are met;

- A BS 9251 Category 3 sprinkler system should be provided;
- The water supply duration should be extended to 60 minutes;
- A back up pump is to be provided,
- A secondary power supply is to be available to each pump.

3.4.2 Sprinkler protection should be provided in all areas with the exception of the following:

- Bathrooms with a floor area less than $5m^2$;
- Cupboards and pantries with a floor area less than $2m^2$ or where the least dimension does not exceed 1m and the walls and ceilings are covered with non-combustible materials or materials of limited combustibility;
- Crawl spaces, ceiling voids, uninhabited loft/roof voids;
- Common Corridors.

3.4.3 Additionally, due to the high degree of electrical items it is deemed acceptable to omit sprinkler protection to the following areas;

- Comms Room;
- Life Safety Distribution Board Room;
- Main Low Voltage Switch Room;
- Ground Floor Substation.

3.4.4 The minimum operating pressure at any sprinkler should not be less than 0.5 bar.

3.4.5 As LD1 detection is provided to all apartments, only one sprinkler alarm value is required per floor, providing the following conditions are met;

- The alarm zone should cover no more than a single floor.
- The LD1 alarm system should have a minimum of a grade D power supply, designed, installed and maintained in accordance with BS 5839-6:2013.
- The sprinkler alarm device should be connected to suitable control and indicating equipment so that management are alerted and the emergency action plan can be initiated.
- In multi-staircase buildings, the control equipment should clearly indicate the floor level and appropriate staircase.

3.4.6 There are a number of winter gardens located from the 15th storey upwards. These winter gardens should be provided with sprinkler protection due to the semi enclosed nature of the area. This aspect has been discussed and agreed with Building Control.

3.4.7 The sprinkler system can be combined with the domestic water tank providing both the sprinkler flow demand and the domestic peak flow demand are met simultaneously. However, a priority demand valve can be used to close the domestic supply in the event of sprinkler activation, allowing the full capacity of the tank to be used for firefighting purposes.

Commercial

3.4.8 In line with BS 16925 areas of the building that are not residential occupancies but not greater than Ordinary Hazard as defined in EN 12845 may be protected with quick response type sprinklers in accordance with EN 12259-1 providing the following conditions are met;

- The total area is more than 50m^2 but less than 100 m^2;
- The design density is increased to 5mm/min;
- The area of operation shall be taken as the smaller of the area defined in EN 12845 for Ordinary Hazard or that area of the building if less.

4. Provisions of Compartmentation

4.1.1 The spread of a fire within a building can be restricted by subdividing the building into compartments separated from one another by walls and/or floors of fire resisting construction. This is to restrict rapid fire spread which could trap occupants of the building and to reduce the risk of a fire becoming large.

4.2 Compartmentation Requirements

4.2.1 Each apartment is to be a separate compartment and all partition walls (and walls to common areas) are to be compartment walls. As the building provides residential accommodation all floors are to be constructed as compartment floors.

4.2.2 Where a fire separating element is required, this element of construction should provide the minimum level of fire resistance as stated when tested in accordance with the appropriate European Standard and classified to the relevant part of BS EN 13501 or tested to the relevant part of BS 476.

4.2.3 Fire-resisting doors should be specified as complete fire door sets and should achieve the minimum level of fire resistance when tested in accordance with either BS 476-22 or the appropriate European Standard and classified in accordance with BS EN 13501-2.

4.2.4 A fire door that is needed to resist the passage of smoke at ambient temperate conditions i.e. fire doors having suffix S/Sa should either:

- Have a leakage rate not exceeding 3 m^3/h per metre, when tested in accordance with BS 476-31.1 with the threshold taped and subjected to a pressure of 25 Pa; or
- Meet with the classification requirement of Sa when tested in accordance with BS EN 1634-3.

4.2.5 Threshold gaps for timber doors should be in accordance with BS 8214. Threshold gaps for all other door types should be based on the principles of BS 8214.

4.2.6 Table 4.2 and Table 4.2 provides a summary of the specific fire compartmentation requirements

Table 4.1 Compartmentation Summary

Floor/Wall Location	Fire Rating (minutes)	European Standard (minutes)
Compartment Floors	120	REI 120
Firefighting stairs	120	REI 120
Firefighting Lifts	120	REI 120
Common corridor	60	REI 60
Walls separating apartments	60	REI 60
Bin stores	60	REI 60
Service Risers (if <u>not</u> fire stopped at floor level)	120	REI 120
Service Riser (if fire stopped at floor level)	30	REI 30
Storage and Plant	30	REI 30

Table 4.2 Fire Door Requirements

Locality of the door	Fire Rating (minutes)	European Standard (minutes)	Self-closing device required?
Apartment entrance doors	FD30s	E30Sa	Yes
Doors into firefighting stairs	FD60s	E60Sa	Yes
Firefighting Lift doors	FD60	E60	N/A
Riser Doors (if <u>not</u> fire stopped at floor level)	FD60s	E60Sa	No (to be kept locked shut)
Riser Doors (if fire stopped at floor level)	FD30s	E30Sa	No (to be kept locked shut)
Smoke Shaft Doors	FD60s	E60Sa	No (only to be opened on activation of localized detection)

4.3 Automatic Hold Open Devices

4.3.1 Where automatic hold open devices are to be installed in the development it is essential that these hold open devices release automatically on activation of the fire alarm system and failsafe to release the door in the event of a power failure. The hold open devices should comply with BS 5839-3.

4.4 Protection of Openings and Fire Stopping

4.4.1 To ensure all fire separating elements are effective, every joint or imperfection of fire, or opening to allow services to pass through the element suitable fire protection is to be provided by sealing or fire stopping so that the fire resistance of the element is not impaired. If there are any bathroom pod risers these should be fire stopped at floor level and the pod walls themselves should not be used to provide any fire-resistance for either compartmentation or structural fire protection.

4.4.2 Fire stopping/sealing should be undertaken with suitable products to maintain the standard of fire resistance of the surrounding structure in accordance with BS 476 Pt 22 or BS EN 1364 Pt 1 to 6.

4.5 Fire Stopping

4.5.1 All openings for pipes, ducts, conduits or cables that pass through and/or any joints between fire separating elements should be appropriately fire stopped with consideration for a potential thermal movement of pipes and ducts. Where non-rigid materials are adopted or unsupported spans exceeding 100mm are adopted, the fire stopping material should be reinforced with materials of limited combustibility.

4.6 Openings of Pipes

4.6.1 Where services pass through a fire separating element, the following three fire stopping measures will need to be considered to evaluate the most appropriate fire protection measure.

Method 1 – Proprietary Seals

4.6.2 Provide a proprietary sealing system e.g. intumescent collar which has been tested to maintain the fire resistance of the walls, floor or cavity barrier for a pipe of any diameter.

Method 2 – Pipes with a restricted diameter

4.6.3 On the provision that the type and internal diameter dimension satisfies the requirements in Table 4.3, fire stopping such as cement mortar or intumescent mastic may be used around the pipe.

Method 3 – Sleeving

4.6.4 A pipe of lead, aluminium alloy, fibre cement or uPVC with a maximum nominal internal diameter of 160mm may be used with a sleeving of non-combustible pipes. The specification for non-combustible and uPVC are given in Table 4.3.

Table 4.3 Maximum nominal internal diameter of pipes passing through a compartment wall/floor

Situation	Pipe material and maximum nominal internal diameter (mm)		
	High melting point metal(1)	Lead, aluminium, aluminium alloy, uPVC,(2) fibre cement	Any other material
Structure (but not a wall separating buildings) enclosing a protected shaft that is not a stair or a lift shaft	160	110	40
Compartment wall or compartment floor between apartments	160	160 (stack pipe)3 110 (branch pipe)3	40
Any other situation	160	40	40

Note 1: Any metal (such as iron, copper or steel) which if exposed to a temperature of 800 degrees will not soften or fracture to the extent that flame or hot gas will pass through the wall of the pipe.

Note 2: uPVC pipes complying with BS 4514 and uPVC pipes complying with BS 5255

Note 3: These diameters are only in relation to pipes forming part of an above ground floor drainage system and enclosed in Method 3. In other cases, the maximum diameters against situation 3 apply.

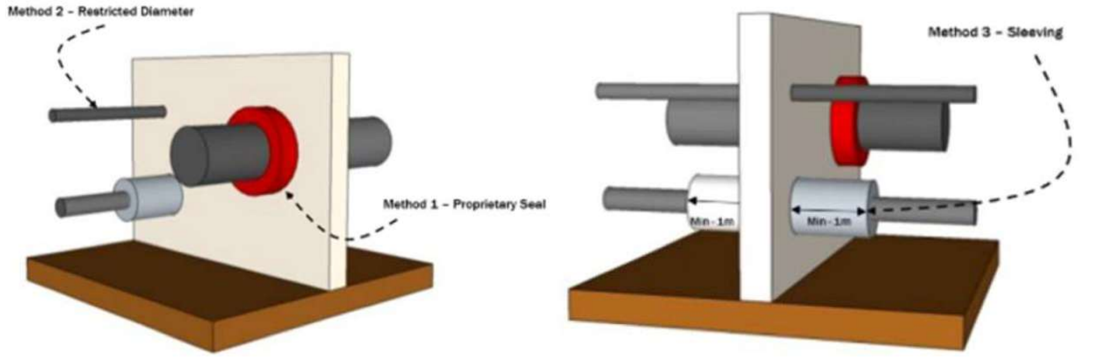

Figure 12. Service Breaches to Compartment Walls

4.7 Fire/Fire and Smoke Dampers

4.7.1 Where necessary, fire/ fire and smoke dampers should be provided in accordance with BS 9991, BS 9999 and ASFP Grey Book: Fire and smoke resisting dampers. The fire/ fire and smoke dampers should be appropriate for the duct and location as recommended in the above guidance documents. Fire dampers should have an E classification (integrity) and leakage-rated fire dampers should be provided with an ES classification (integrity and smoke).

4.7.2 Fire dampers are to be operated by smoke detection and thermal fusible link if ducts access or leave a compartment (corridor/stair/riser/etc.)

4.7.3 All fire dampers are to be tested to BS EN 1366-2 and be classified to BS EN 13501-3. The dampers are to have the same fire resistance as the wall or compartment floor they penetrate (subject to a minimum fire resistance of 60 minutes). All such dampers should be accessible for maintenance.

4.7.4 In ancillary accommodation or other non-residential accommodation, fire/ fire and smoke dampers should be provided on compartment boundaries. Where ductwork crosses an escape route, fire dampers should be actuated by automatic smoke detection.

4.7.5 Where dampers cannot be provided in general ductwork for any reason, the duct should be fire-rated or enclosed in fire-resisting construction (integrity and insulation) to the highest period of fire-rated construction through which it passes. The ductwork would need to be fire rated from the point it penetrates the compartment wall of the compartment it serves (or furthest compartment it serves if multiple compartments are served) to the point it terminates.

4.8 Services

4.8.1 The routing of building services through the common residential corridor introduces a fire risk in the space and BS 9991 recommends against this where possible. However, where the routing of services though the corridor is unavoidable, the services should be run in separating construction or in a secured fire-resisting method. There are two options available in this regard:

1. Construct a fire resisting ceiling that achieves 30 minutes fire resistance as required by the location of the riser with all services being above the ceiling line & risers in the corridor; or
2. Control the fire load in the ceiling and riser space through the specification and selection of low-risk materials. This approach will require a fire risk assessment and agreement from Building Control; and should include but not limited to the following aspects as a minimum:
   a. Minimising the number of electrical connections within the residential corridor
   b. Correctly sized cables and follow up with comprehensive on-site testing and inspection
   c. The surfaces of materials exposed to the corridor (i.e. ceiling void) will be of Class 0 (National Class) or Class B-s3, d2 or better (European Class)
   d. The materials within the corridor (inclusive of any insulation) will be of limited combustibility (National Class) or Class A2-s3, d2 or better (European Class)
   e. The services to be located within the corridor ceiling void will be of low fire risk
   f. Any electrical cabling will be laid in metal trays or metal conduit
   g. Access panels into ceiling voids to be secured (this can be by releasing devices or screw fixings to close)
   h. Any material or equipment located within the common corridor which have not been fire tested will have been fire risk assessed to demonstrate its low risk items in terms of ignition, combustibility and flammability by the system designer and system manufacturer
   i. Methods of cable support should be non-combustible (such as cable clips, cable ties or trunking)

4.9 Fixing of Cables – Fire-resisting Cable Supports

4.9.1 It is noted the latest edition of the IET Wiring Regulations (BS 7671:2018) has been release and came into force in January 2019. The previous version includes a requirement that wiring systems in escape routes shall have fire-resisting supports and in the latest edition this extends the requirement to all areas, i.e. any wiring in the building that could fall prior to fire service arrival should be restrained to prevent entanglement. All wires need to be supported such that they wouldn't present an entanglement risk to firefighters, it's not just a requirement for wires serving life safety equipment. Cables run along walls should be fixed with metallic ties/clips rather than plastic.

4.10 Cavity Barriers

4.10.1 Concealed spaces or cavities in the construction of a building provide a route for smoke and flame spread. This is particularly in the voids above and below the construction of the building e.g. walls, floors, ceilings, roofs, around the windows and compartment walls. The provision of cavity barriers within the voids is intended to restrict the spread of smoke and flames.

4.10.2 Fire resistant cavity barriers are to be installed in cavity spaces exceeding 20m in any direction. The cavity barriers will offer a minimum of 30 minutes fire resistance and 15 minutes fire resistance insulation (European standard E30 and EI15)

4.10.3 See Table 4.4 for a summary of cavity barrier locations and the differentiation between cavity barriers and fire stopping.

4.10.4 Table 4.4 indicates the maximum dimensions of undivided concealed spaces for the different classifications of cavity barriers.

Table 4.4 Maximum Dimensions of Cavities

Location of Cavity	Class of surface / product exposed in cavity	Maximum dimensions in any direction (m)
	European	
Between roof and ceiling	Any	20
Any other cavity	Class C-s3, d2 or better	20
	Not any of the above classes	10

4.10.5 Any exclusion from Table 4.4 should be in full accordance with the recommendations and specifications with BS 9991.

4.10.6 Cavity barriers are required at all floors, compartment walls and openings (e.g. windows and doors). Additional cavity barriers are required where a compartment walls meets an external wall of the building.

4.10.7 Where a concealed space is undivided area which exceeds 40m in either or both directions on plan there is no limit to the size of the cavity if:

- The room and the cavity together are compartmented from the rest of the building
- An automatic detection system compiling to BS 5839-1 is installed. Detectors are only required in the cavity to satisfy BS 5839-1.
- The cavity is used as a plenum and the recirculation air distribution systems in BS 5588-9 are followed.
- The surface of the material/product used on the construction of the cavity is Class 0 (National class) or Class B-s3, d2 or better (European class) and the supports and fixings on the cavity are non-combustible.
- The flame spread rating of any pipe insulation system is Class 1 (National class) or Class C-s3, d2 or better (European class)
- Any electrical wiring in the voids is laid in metal trays, or in a metal conduit
- Any other materials in the cavity are of limited combustibility or Class A2 or better (European class)

4.11 Construction and Fitting of Cavity Barriers

4.11.1 The cavity barriers should be tightly fitted to a ridged construction and mechanically fixed in position. Where this is not possible (e.g. junctions with slates, tiles, corrugated etc.) the junction should be fire stopped in accordance with Section 4.12 of this report. Cavity barriers should also be fitted so that their performance is unlikely to be made ineffective by movement of the building due to subsidence, temperature change etc. failure of their fixings, material or construction they abut or collapse of any services penetrating them.

4.11.2 Cavity barriers in a stud wall or partition or provided around openings may be constructed from:

- Steel at least 0.5mm thick
- Polythene sleeved mineral wool slab, in either case under compression when installed in the cavity; or
- Calcium silicate, cement-based or gypsum-based boards at least 12mm thick

4.11.3 It should be noted that cavity barriers provided around openings may be formed by the window or door frame if the frame is constructed of steel or timber of the minimum thickness above. Any openings in a cavity barrier should be limited to those for:

- 30-minute fire rated doors
- The passage of pipes which meet the provisions set out in section 4.4 of this report.
- The passage of cables or conduits
- Openings or ducts (unless fire rated) fitted with a suitable automatic fire damper where they pass through the cavity barrier.

4.11.4 Cavity barriers should not be provided above party walls between flats. The party walls should be taken up to the underside of the slab and fire stopped.

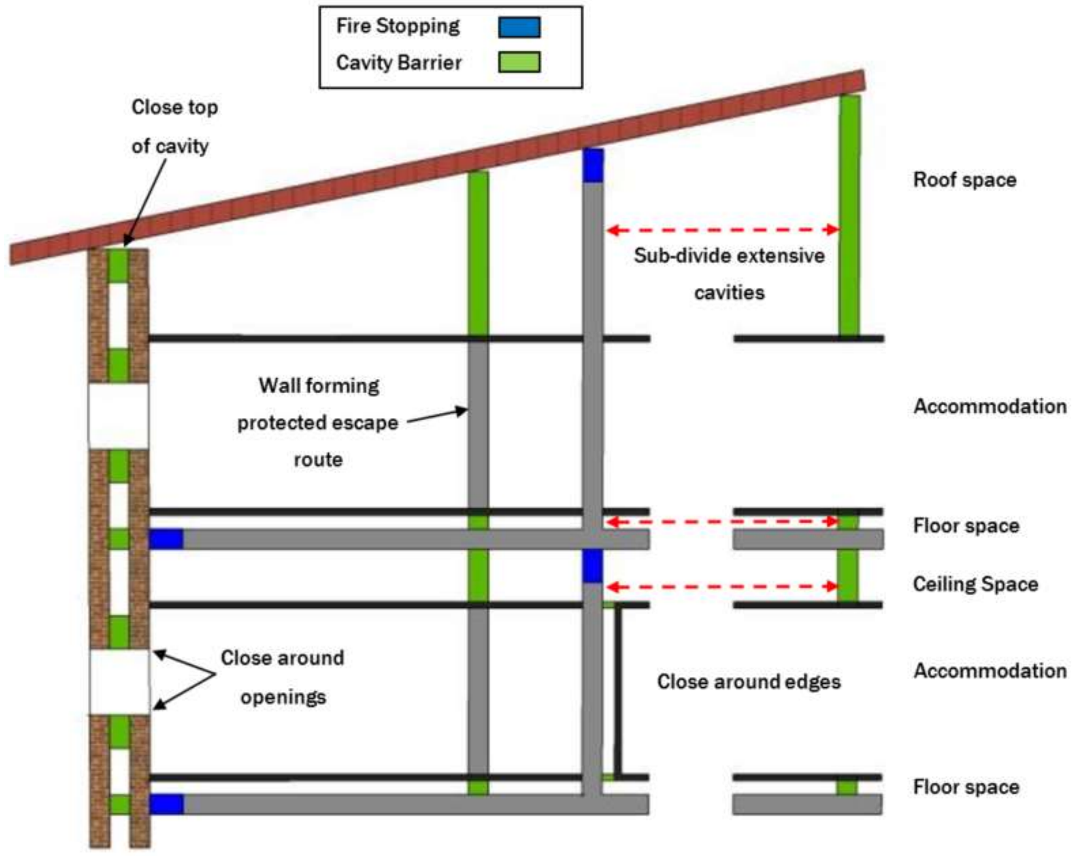

Figure 13. Typical Provision of Cavity Barriers

4.12 Junction of Compartment Wall with the Roof

4.12.1 A compartment wall should achieve both of the following:

- Meet the underside of the roof covering or deck, with fire-stopping to maintain the continuity of fire resistance.
- Be continued across any eaves.

4.12.2 Partition walls to flats should continue through the roof void to the underside of roof covering, common voids within roof spaces are not permitted.

4.12.3 To reduce the risk of fire spreading over the roof from one compartment to another, a 1500mm wide zone of the roof, either side of the wall, should have a covering classified as AA (BROOF(t4)), on a substrate or deck of a material rated class A2-s3, d2 or better, as set out in Figure 14a.

4.12.4 As an alternative to the provisions of paragraphs above, the compartment wall may extend through the roof for a minimum of either of the following (see Figure 14c).

- Where the height difference between the two roofs is less than 375mm, 375mm above the top surface of the adjoining roof covering.
- 200mm above the top surface of the adjoining roof covering where either of the following applies.
  - The height difference between the two roofs is 375mm or more.
  - The roof coverings either side of the wall are of a material classified as B_{ROOF}(t4).

4.12.5 The requirements for junction of compartment walls with the roof has been highlighted below in Figure 14.

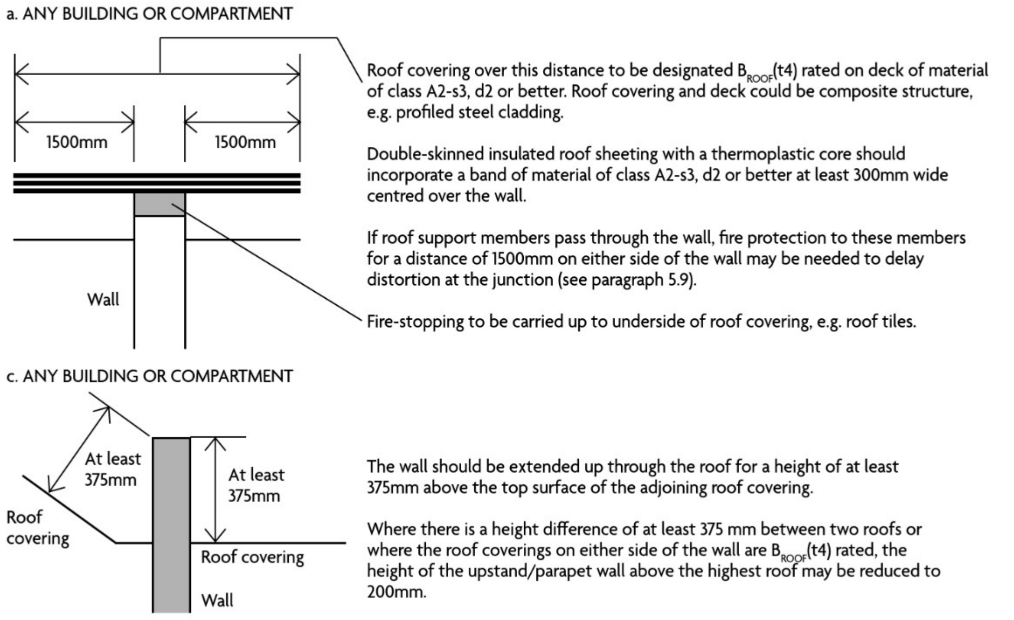

Figure 14. Junction of Compartment Wall with the Roof

5. External Fire Spread

5.1.1 The relevant site boundary for the scheme has been highlighted in red on Figure 15. Where the site opposes an area unlikely to be developed upon, the relevant boundary has been taken as halfway across that boundary. Areas unlikely to be developed upon include roads, railways and rivers.

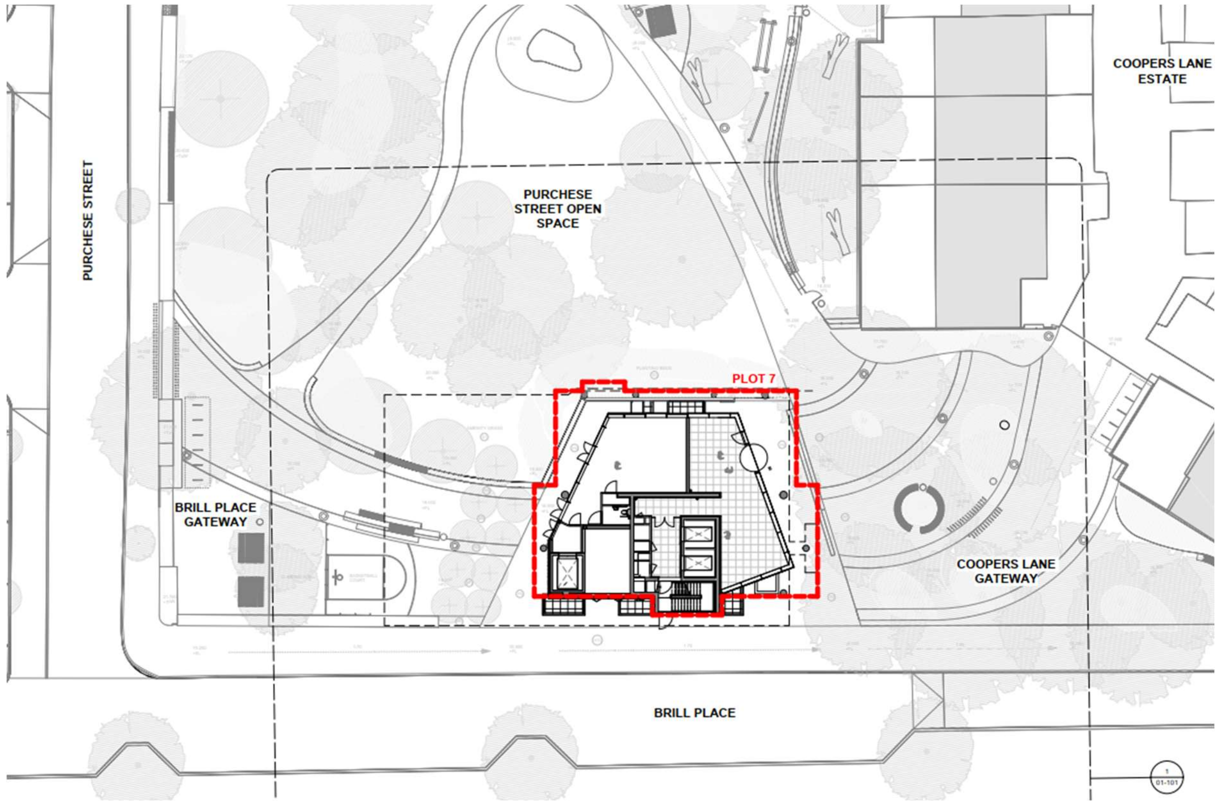

Figure 15. Brill Place Relevant Boundary

5.2 Space Separation

5.2.1 The space separation of the building from its relevant boundaries has been assessed in relation to preventing external fire spread. This is achieved by limiting the area of non-fire rated elements of the façade where the separation is less than the minimum requirement within BR 187 – External Fire Spread, Building Separation and Boundary Distances.

5.2.2 External fire spread, calculations are based on the alternative approach included in Appendix A of BR 187, 1st edition (now 2.2.4 & 2.2.5 in the 2nd edition) which uses specific calculation rather than indicative tables to provide a precise measurement of unprotected area. An example of the calculation performed for each compartment can be seen below.

$$u = \frac{(d/f)^2}{(wh)}$$

Where:

- d = distance to boundary
- h = height of compartment
- w = width of compartment
- f = factor from Table 3 (in BR 187)

5.2.3 The Unprotected Area (UPA) for each type of compartment within the building was calculated considering the distance from the relevant boundary, the compartment height and width along with the occupancy profile, with the results tabulated in Table 5.1.

5.2.4 Sterile areas such protect stairs and corridors have not been included in the analysis as these areas have little fire load and therefore would not contribute to a fire.

Table 5.1 **External Fire Spread Analysis**

Elevation	Use	Width of Panel (m)	Height of Panel (m)	Distance to Boundary (m)	Unprotected Area (%)	Protected Area (%)
L1.01 South Facade	Residential	5.96	3.13	8.7	100%	0%

5.2.5 The southern façade apartment L1.01 represents the largest compartment on the southern façade, therefore, L1.01 was analysed in terms of external fire spread. Based on the large separation distances and high degree of compartmentation, the assessment has found that there is no requirement for protected areas in relation to external fire spread in this apartment. It can also be assumed that all other compartments on the southern façade can be afforded 0% protected areas.

5.2.6 Areas that are less than 1.0m from the relevant boundary, will require 100% protected areas, which will need to be fire resistant from the outside and inside face (both sides) and achieve 120 minutes fire resistance for integrity, loadbearing capacity, and insulation (REI 120). This would apply to the north, east and west facades.

5.2.7 However an agreement has been reached with the council that will prohibit any building works on the surrounding park area and therefore the boundary distances can be increased. It has been confirmed that this agreement has been reached and the extents to which the non-development agreement applies – i.e the distance the relevant boundary can be taken. Refer to Appendix 4 for the correspondence regarding the agreement.

5.3 Unprotected Area

5.3.1 Small, unprotected areas in an otherwise protected area of wall construction are considered to pose negligible risk of fire spread and may be disregarded. Figure 16 highlights the permitted openings in relation to each other and to the lines of compartmentation inside the building.

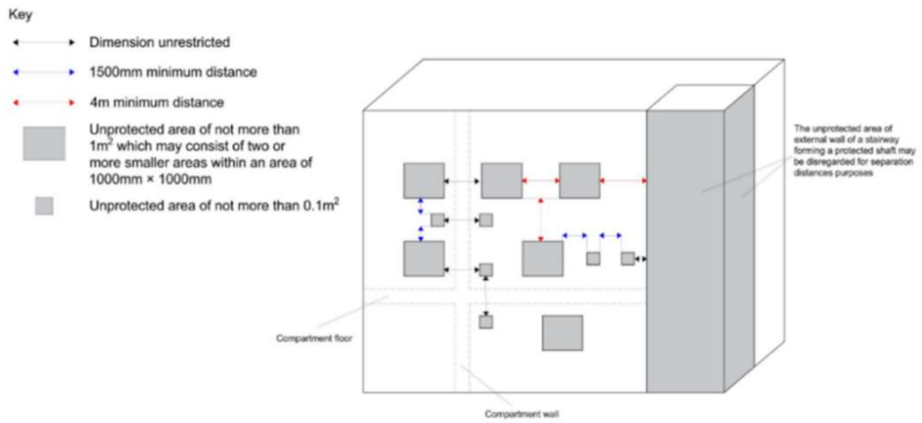

Figure 16. Unprotected Areas

5.4 Cladding, Insulation Material/Products

5.4.1 In a building with a storey 18m or more in height (when measured from the lowest adjacent side of the building to the upper floor surface of the topmost storey, excluding any floors consisting exclusively of plant), any insulation product, filler material (not including gaskets, sealants and similar) etc, used in the construction of an external wall and walls between heated and unheated spaces (such as refuse/plant rooms) should be of European Class A2-s1, d0 or better. Note, due to the use of some of the proposed buildings on site, Regulation 7(2) and 7(3) would be applicable and it prevails over the provisions stated within this paragraph.

- Note 1: Whilst the guidance above applies to any insulation product, filler material (not including gaskets, sealants and similar) etc. used in the construction of an external wall, consideration should be given to the choice of material used for any other parts of an external wall or attachments to the wall which could impact on the risk of fire spread over the wall.
- Note 2: Best practice guidance for green walls, if provided, (also called living walls) can be found in Fire Performance of Green Roofs and Walls, published by the MHCLG.

5.5 Regulation 7(2) of Building Regulations 2010

5.5.1 Regulation 7(2) applies to any building with a storey at least 18m above ground level (when measured from the lowest adjacent side of the building to the upper floor surface of the topmost storey, excluding any floors consisting exclusively of plant), and provides/is designed as residential accommodation.

5.5.2 Subject to exclusions stated in Regulation 7(3), building work shall be carried out so that materials which become part of an external wall, or specified attachment, of a relevant building are of European Classification A2-s1, d0 or Class A1, classified in accordance with BS EN 13501-1 entitled "Fire classification of construction products and building elements. Classification using test data from reaction to fire tests" (ISBN 978 0 580 59861 6) published by the British Standards Institution on 30th March 2007 and amended in November 2009. Therefore, materials achieving limited combustibility cannot be deemed to meet the requirement using an alternative classification method.

5.6 Regulation 7(3) of Building Regulations 2010 – Exclusions

5.6.1 Regulation 7(2) does not apply to the following (but not limited to):

j. Cavity trays when used between two leaves of masonry;

k. Any part of a roof (other than any part of a roof which falls within the definition of Building Regulations 2010) if that part is connected to an external wall;

l. Door frames and doors;

m. Electrical installations;

n. Insulation and water proofing materials used below ground level;

o. Intumescent and fire stopping materials where the inclusion of the materials is necessary to meet the requirements of Part B of Schedule 1;

p. Membranes;

q. Seals, gaskets, fixings, sealants and backer rods;

r. thermal break materials where the inclusion of the materials is necessary to meet the thermal bridging requirements of Part L of Schedule 1; or

s. Window frames and glass.

5.6.2 A summary of the information above has been tabulated in 0. Note, please refer to Section 5.6.3 for further considerations on additional provisions, depending on the building type.

Table 5.2 Exclusions from Regulation 7(2)

Products	Definition
Membranes	Membranes is a common term used in the industry and does not need any specific definition.
Roofing Materials	Components of a roof that extends to the junction of the external wall.
Internal Decorative Finish	Internal wall finish - inner most surfaces directly exposed to the interior of the building on the external wall.
Windows	Windows made out of glass and transparent and associated window frame including glazing, features, fixings and ironmongery.
Doors	Doors and door sets located on the external wall including associated frames and ironmongery.
Thermal Breaks	Thermal breaks where they are necessary to prevent thermal bridging and meet the requirements of Schedule 1 Paragraph L.
Cavity Trays	Cavity trays as part of a masonry wall systems including two leaves of masonry construction.
Seal, Fixings, Gaskets, Sealants and Backer Rod	Seal, fixings, gaskets, sealants and backer rod.
Electrical Installations	All electrical installations as defined in the Building Regulation already, i.e. fixed electrical cables or fixed electrical equipment located on the consumer's side of the electricity supply meter.
Fire Stopping and Intumescent Materials	Fire stopping and intumescent materials where they are necessary to meet the requirements of paragraph B of Schedule 1.
Insulation Used Under Ground Location	Insulation used where it is located underground.

5.6.3 In addition to the above, where a building type is in either category stated in Regulation 7(2) & requirement B4 – Exclusions, the following should also be considered:

a. Membranes used as part of the external wall construction should achieve a minimum classification of European Class B-s3, d0;

b. Internal linings should comply with the guidance provided in Section 6 of ADB;

c. Any part of a roof should achieve the minimum performance as detailed in Section 14 of ADB.

d. As per Regulation 7(3), window frames and glass (including laminated glass) are exempted from Regulation 7(2). Window spandrel panels and infill panels must comply with Regulation 7(2).

e. Thermal breaks are small elements used as part of the external wall construction to restrict thermal bridging. There is no minimum performance for these materials. However, they should not span two compartments and should be limited in size to the minimum required to restrict the thermal bridging (the principal insulation layer is not to be regarded as a thermal break).

f. Regulation 7(2) only applies to specified attachments. Shop front signs and similar attachments are not covered by the requirements of Regulation 7(2), although attention is drawn to paragraph below.

g. Whilst Regulation 7(2) applies to materials which become part of an external wall or specified attachment, consideration should be given to other attachments to the wall which could impact on the risk of fire spread over the wall.

5.6.4 Note, specified attachments referenced below are defined as follows:

- A balcony attached to an external wall;
- A device for reducing heat gain within a building by deflecting sunlight which is attached to an external wall; or
- A solar panel attached to an external wall.

5.6.5 Any balconies must be constructed of materials achieving at least a Class A2-s1, d0 rating.

5.6.6 External elements which are over 70 degrees to the horizontal are considered a wall rather than part of roof. i.e. lift overruns, upstands, parapets etc. These should also be constructed to meet A2-s1, d0 or Class A1.

5.7 Roof Coverings

5.7.1 Part of a roof is defined as having a slope less than 70°. As such, any part of a roof greater than 70° will be classified as forming part of the wall and should meet the provisions set out above.

5.7.2 The provisions limit the use, near a boundary of roof which will not give adequate protection against the spread of fire over them. The term roof covering is used to describe constructions which may consist of one or more layers of material but does not refer to the roof structure as a whole. The provisions in this section are principally concerned with the performance of roofs when exposed to a fire from outside.

5.7.3 Limitations of roof coverings are to be in accordance with the BS 9991. As the building comprises of apartments on the uppermost storey, the compartmentation walls/fire stopping are to be provided up to the underside of the roof. The roof construction within 1500mm of the compartment wall/fire stopping should achieve a rating of AA (B_{ROOF}(t4)) in accordance with Figure 14. Therefore, it is considered practical to provide the whole roof with a rating of AA (B_{ROOF}(t4)).

6. Access & Facilities – Fire Service

6.1 Vehicle Access

6.1.1 Access to the site should be designed in such way that the fire service can easily access the site upon a fire situation. Provisions should be made at the design stage to ensure any scheme is provided with adequate and sufficient means for the fire service to enter the site. The proposed fire service access arrangement within this report has not yet been consulted with the Fire Service. As such, further development of firefighting provisions may be required in order to satisfy the local Fire Authority.

6.1.2 Any works to the roads needs to be constructed in accordance with Table 6.1. It should be ensured that all access roads around the site will be adequate to accommodate the local fire service pump appliance.

Table 6.1 Typical Fire & Rescue Service Vehicle Access Route Specification

Appliance	Minimum Width of Road Between Kerbs (m)	Minimum Width of Gateways (m)	Minimum Turning Circle Between Kerbs (m)	Minimum Turning Circle Between Walls (m)	Minimum Clearance Height (m)	Minimum Carrying Capacity (tonnes)
Pump	3.7	3.1	16.8	19.2	3.7	14 (as per London Fire Brigade requirements)

Notes: This table is subject to agreement with the fire service as some fire services have appliances of greater weight or different sizes.

6.1.3 It will need to be ensured that the fire service do not reverse more than 20m. Where this distance is extended, a turning circle or hammerhead would need to be provided to facilitate the fire appliance to turn around. This should be designed within the requirements of Table 6.1.

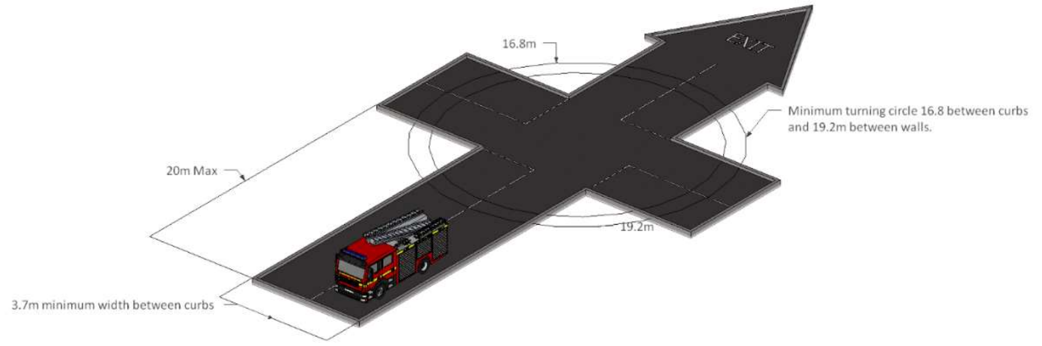

Figure 17. Turning Facility Diagram

6.1.4 Due to the height and size of the building it is not possible to meet the maximum 45m hose laying distance to the most remote point of the most remote dwelling. Therefore, it is required that the building is provided with a wet rising main.

6.1.5 The firefighting provision have been highlighted in Figure 18.

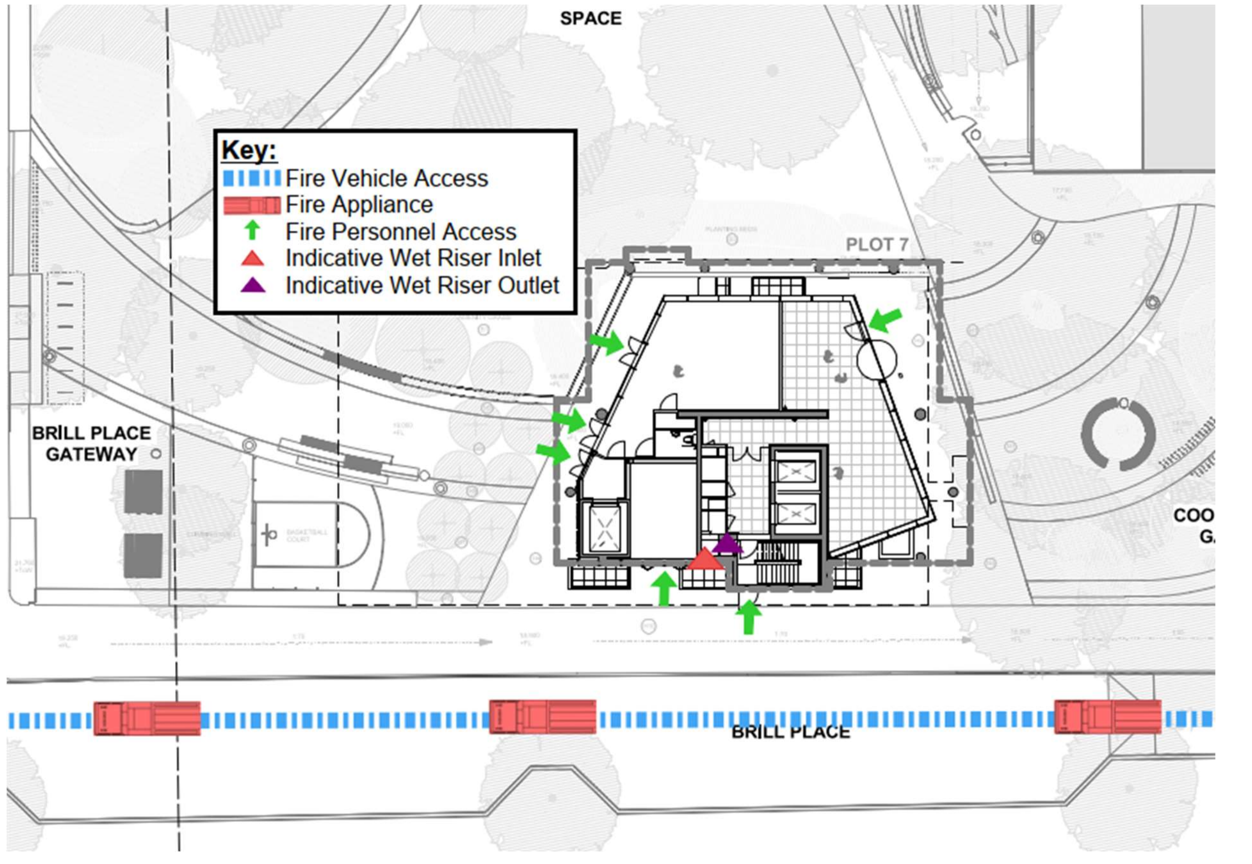

Figure 18. Fire Service Provisions

6.2 Firefighting Shaft

6.2.1 The development is to be provided with a firefighting shaft which serves all levels of the development and should contain the following:

- A 120-minute fire rated enclosed stair
- A 1100mm clear width in the stair
- A 1.0m² AOV at the head of the stair
- A Ventilated lobby/corridor
- A firefighting lift in accordance with BS EN 81-72
- A wet rising main with outlets within the stair at each level

6.2.2 The firefighting lift is to be installed in accordance with BS EN 81-72 and BS EN 81-2 as appropriate for the particular type of lift.

6.2.3 Where it is not feasible to utilise passive means to prevent water ingress into the lift well (such as a ramped access), a sump pump needs to be provided at the base of the lift well. The minimum flow rate of the sump pump should be agreed with the M&E consultant/Fire Officer.

6.2.4 Flooring and floor coverings within the firefighting shaft are to be provided in accordance with the recommendations of BS 9999. All floorings and floor coverings should be chosen so as to minimise loss of traction when wet, as resilient floor surfaces should be maintained in accordance with BS 6263-2, with only emulsion-based polishes used.

6.2.5 It is to be noted as the slip resistance of resilient floor surfaces is reduced by contamination by dust or materials such as oils or grease, it is essential that they are cleaned frequently. The flammability of any textile floor coverings needs to be low.

6.2.6 Textile floor coverings should:

- When tested together with any underlay, in accordance with BS 4790, suing the test procedure reflecting the method used for securing the floorcovering to the floor, either:
- Not ignite; or
- Have effects of ignition on both the use-and-under surfaces not exceeding beyond a circle of radius 35mm centred on the central point of application of the nut.
- Be firmly secured to the floor, with any adhesive being used non-water soluble; and
- Be interruptible at all doors to and within the firefighting shaft along the line of the threshold of the doorway with a metal or other non-combustible strip not less than 50mm in wide.

6.3 Wet Rising Mains

6.3.1 Wet rising mains are to be installed in buildings with an uppermost floor height in excess of 50m. This is due to pressure loss over the extended height.

6.3.2 Systems should be designed such that the maximum system pressures serving a fire main outlet do not exceed 20-bar.

6.3.3 Wet rising mains should not be located against or near external walls unless they are adequately insulated or otherwise satisfactorily protected against frost.

6.3.4 Wet risers should have an adequate water supply. A tank should be formed of two interconnected tanks with a combined minimum capacity of 45,000L ($45m^3$). The tanks should be sized to supply two firefighting jets for at least 45minutes at 1500L/min, i.e. 67,500L ($67.5m^3$) total capacity. The minimum tank size has been adopted therefore it should be ensured that the mains supply is sufficient to provide the additional water capacity, i.e. 500L/min.

6.3.5 Two automatic pumps should be installed to feed the wet fire main, one of which should act as duty pump and the other as standby. The standby pump should be configured to operate automatically on failure of the duty pump.

6.3.6 Landing valves in wet rising mains should comply with BS 5041-1 and be installed on all floors including the ground and basement.

6.3.7 The wet riser inlet connection point should be provided within 18m and will be required to be visible from the fire appliance parking position. The indicative wet riser inlet locations have been illustrated in Figure 18.

6.4 Basement Ventilation

6.4.1 Where a basement storey exceeds $200m^2$ in area or is greater than 3m below the adjacent ground level, a smoke and heat ventilation system should be provided. Basement smoke and heat ventilation systems may be either natural or mechanical.

6.4.2 It is proposed to provide a natural smoke outlet in the basement of the Brill place scheme. Where natural smoke outlets are proposed the following recommendations should be met;

- If a basement is compartmented, each compartment should have direct access to smoke outlet vents;
- The outlets should have a combined area of not less than 2.5% of the basement floor area;
- Sited at the highest level practicable, either in the ceiling or in the wall of the space they serve;
- Evenly distributed around the perimeter of the building, to discharge into the open air outside the building;
- Located such that they would not prevent the use of escape routes from the building.
- If an outlet terminates at a point that is not readily accessible, it should be unobstructed, and should be covered only with a non-combustible grille or louvre.
- If an outlet terminates in a readily accessible position, it may be covered by a panel, stallboard or pavement light that can be broken out or opened, the position of such covered outlets should be suitably marked;
- Separate outlets should be provided from places of special fire hazard.

6.4.3 The proposed basement outlet positions have been highlighted in Figure 19.

The corridor has not been provided with ventilation as all rooms accessed from the corridor have been provided with independent smoke outlets. The risk associated with the migration of smoke into the corridor is very low. Furthermore the occupancy in this area will be largely transient in nature and all areas will be covered by the fire detection system to give an early warning to any fire scenario.

Additionally, the refuse store should be provided with a lobby complete with $0.2m^2$ permanent ventilation ducted to the external, for the purpose of the prevention of the build-up of combustible gases. This area has been highlighted in Figure 19.

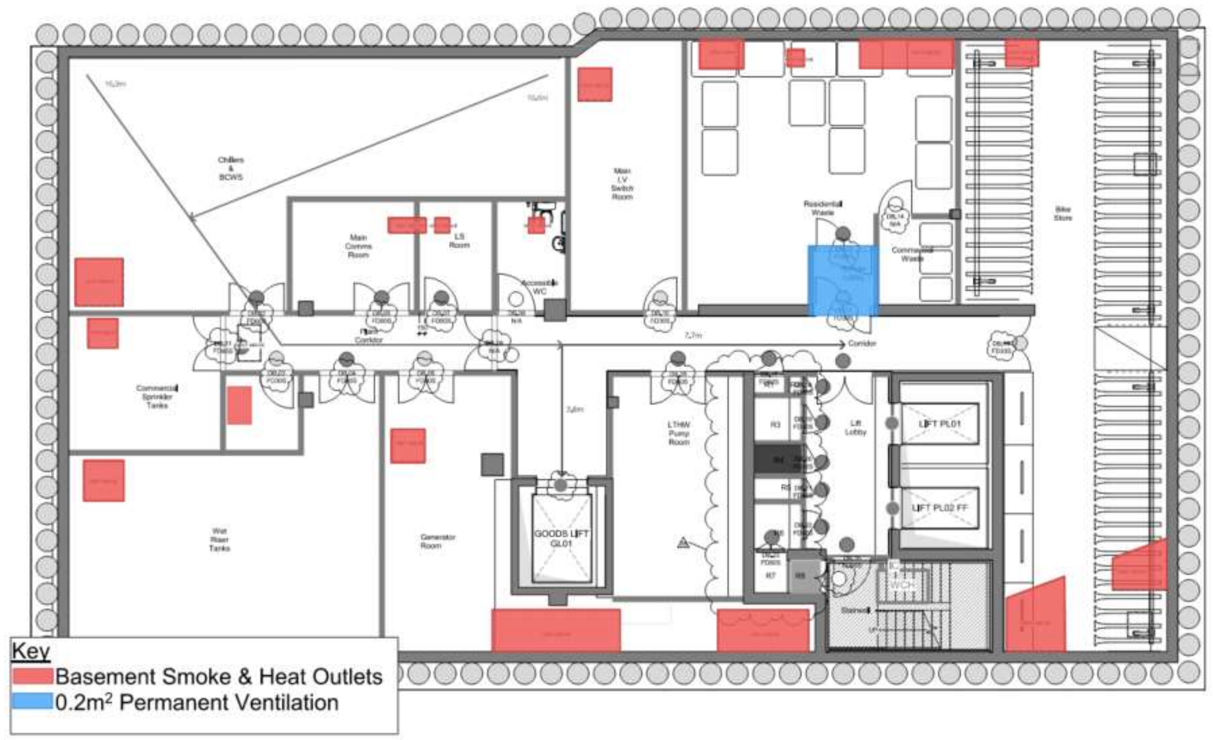

Figure 19. Basement Smoke Outlet Arrangement

6.5 Wayfinding Signage for the Fire Service

6.5.1 As part of the May 2020 amendments to ABD , guidance for wayfinding signage to assist firefighters is now provided; these amendments will come into force on 26/11/20. For blocks of flats with top floors more than 11m above the Ground floor, floor identification signs and flat indicator signs should be provided.

6.5.2 Floor identification signs denote which floor the reader is currently on, and flat indicator signs provide information regarding the flats accessed from that floor; the flat number for any multi-storey flats with two or more entrances should only be indicated on the normal access storey. Requirements for floor identification and flat indication signs are summarized in Table 14.

6.5.3 The floor closest to the mean Ground level should be designated as either Floor 0 or Ground Floor, and each floor above the Ground floor should be numbered sequentially, beginning with Floor 1. A lower Ground floor should be designated as either Floor -1 or Lower Ground Floor, and each floor below the Ground floor should be numbered sequentially beginning with Floor -1 or Basement 1.

Table 6.2 Wayfinding Signage Summary

	Floor identification sign	Flat indication sign*
Signage text	"Floor X", where X is a numeral.	"Flats Y-Z", where Y and Z are numerals. Lower number first; text supplemented by arrows if flats are in more than one direction.
Text height	≥50 mm, and ≥75mm for the floor numeral.	At least half that of the floor sign.
Text typeface	Sans serif.	Sans serif.
Mounting	Mounted 1.7m–2.0m above floor level; where practicable, all the signs should be mounted at the same height.	Directly below the floor signs, such that its top edge is no more than 50mm below the bottom edge of the floor sign
Visibility	Visible from the top step of a firefighting stair and, where possible, from inside a firefighting lift when the lift car doors open. Text (and any arrows) should be on a contrasting background, easily legible and readable in low level lighting conditions or when illuminated with a torch.	

6.6 Fire Fighting Hydrants

6.6.1 Hydrants should be located in positions that are near to the building entry points. In buildings provided with dry rising mains a fire hydrant should be located within 100m of the dry riser inlet. If an existing hydrant is not within 100m of the building of the building a new hydrant would be required within 90m of the building.

6.7 Premises Information Box – For Fire Brigade Use

6.7.1 It is advisable the end-user ensures a Fire Service Information Box is provided adjacent to entrance to the building. It is preferable that only fire service information is stored in the box. The following are essential items:

- Operational Continency Plans
- Evacuation plans
- Simple single line plans and/or schematic representations of the building and any relevant information relating to equipment/fixed installations design and operation provided for means of escape or firefighting operations (fire resistance, access, firefighting facilities, equipment, services, hazards etc.).
- Information about the nature of any lifts intended for use by the Fire and Rescue Service
- Basic operating instructions for fire protection and fixed firefighting equipment.

6.7.2 The systems on any of these plans should be labelled. Where plan symbols are to be used they should follow the system outlined by the local Area Fire Safety Team and include a key with a suitable description alongside.

6.7.3 When one or more of the same type of system is installed they should be individually identified.

6.7.4 The responsible person on occupation should liaise further with the local Area Fire Safety Team and Fire Station(s) with regards to the preferred format and content of the information to be provided within this.

6.7.5 The contents of the box should be kept up to date and kept under regular review

7. Emergency Power

7.1.1 Fire protection systems designed to operate in a fire require enhanced provisions to ensure a secure supply is available. Specific recommendations are detailed within BS 9999 Section 38.2.3, but the main aspects are detailed below.

7.2 Secondary Power Supply

7.2.1 To reduce the risk of the loss of the electrical supply to critical fire safety systems a secondary power system is required to maintain a continuous power supply during a fire condition in accordance with BS 9991.

7.2.2 The secondary power supplies will be provided to the following:

- AOV's
- Sprinkler System
- Mechanical Smoke Shaft
- Emergency lighting
- Fire detection and alarm systems
- Firefighting lift
- Firefighting shafts (associated equipment and lighting)

7.2.3 Where secondary power supplies are recommended, these should have a primary supply taken from a public supply and a secondary supply from either

- An alternative utility supply from another substation
- A generator
- An uninterruptible power supply (UPS)
- Batteries

7.2.4 Alternative utility supplies and a second substation is not always possible due to the onerous requirements of the utility providers; as dual supplies can cause other safety risks relating to isolation. Generators, UPS and batteries may also not be considered feasible by the Electrical Engineer due to the low reliability of the systems. Due to the infrequent use, only during an emergency, it is often found that these systems are not functional when called upon. Regular testing and maintenance is required to keep the systems operational, however testing is not always effective as a system is rarely assessed for its full duration of operation.

7.2.5 This issue has been addressed in the updated version of BS 9991. The update provides an alternative arrangement for where the primary and secondary power supplies can originate from. The document states that the two power supplies can emanate from the same substation provided that a number of recommendations are met. This sentiment is echoed in the guidance of BS 9999 which states that two separate intakes from an external substation may be used in some residential buildings where regular maintenance of a generator would not be expected.

7.2.6 The recommendations in BS 9991 – Section 15: Power supplies, Cabling and Installation- are outlined as follows:

Where practicable, power supplies should be provided via two separate intakes into the building from the same external substation or via a single intake and a standby generator.

Where neither of these options is technically viable, e.g. a risk assessment has been undertaken by the M&E which concludes that a life safety generator would not be suitable, a single intake from the external substation may be provided as the only alternative option remaining, provided that the following recommendations are met.

a) The life safety system should be connected to an independent distribution board used exclusively for that system.

b) The life safety distribution board should be clearly marked at the point of isolation with a warning explaining that isolation would switch off the life safety system.

c) The life safety distribution board should be located in a separate fire-resisting enclosure (with a minimum of 60 min fire-resisting construction) to the primary main electrical distribution board and should not be accessible directly from the communal areas of the building or from a part of the building where dual supply is required

d) The enclosure surrounding the primary main electrical distribution board should be provided with a minimum of 60 min fire-resisting construction.

e) The substation or transformer room should be either located outside the building or separated by 120 min fire-resisting construction and directly accessible from the outside.

7.2.7 The diverse (primary and secondary) power cables should only come together in the fire compartment housing the control panel by means of an automatic change-over switch, unless the cable route is via a fire compartment which does not open onto areas requiring protection via the relevant life safety system.

7.3 Compliance with BS 9991-Section 15 Recommendations

7.3.1 It is stated that a single intake from a substation can be provided as long as the recommended criteria listed [a-e] are adhered to. The basis of the design for the development is outlined by the following key elements:

- The primary and secondary power supplies will be diversely routed. They will be routed in separate fire compartments that will correspond to the required item of life safety equipment.
- The two supplies will be terminated at an automatic change over switch device. This ensures that in the event of the primary power supply failing, the secondary power supply will be able to automatically take over. The automatic take over device must be designed in accordance with the relevant Standard (BS EN 60947-6) and must be located in an enclosure that is fire rated and houses the life safety equipment that its serving.
- Protective devices such as circuit breakers and fuses will be required to be discriminated. This ensures that if there is a fault on the primary power supply cable it won't affect the secondary power supply cable.
- Failure of the life safety systems could only occur from a fire in the intake room which is fire separated from the rest of the building. A fire in the intake room would be fought externally and would not rely on any systems within the building.

7.3.2 Note: A Fire Risk Assessment is to be undertaken by the M&E Subcontractor.

7.4 Wiring

7.4.1 The wiring systems (for both primary and secondary power supply) for the smoke control systems, fire-fighting shaft systems, motorised fire shutters and/or data communication systems that link fire safety systems are required to conform with the following specifications:

- The wiring should consist of either

1. Mineral-insulated, copper-sheathed cables conforming to BS EN 60702-1 and meeting the relevant life safety and/or fire safety performance objectives given in BS7346-6; or
2. Cables meeting the relevant life safety and/or fire safety performance objectives given in BS 8491; or
3. Be protected against exposure to the fire by separation from any significant fire risk by a wall, partition or floor with a fire resistance of not less than that required of the building.

- The wiring systems should be separate from any circuit provided for any other purpose;
- Jointing and termination methods for cables conforming to BS EN 60702-1 should in addition conform to BS EN 60702-2;
- The wiring systems should be protected from mechanical damage.
- Any wiring in the building that could fall prior to fire service arrival should be restrained with metal fittings to prevent entanglement.

8. Fire Strategy Management

8.1 Regulatory Reform (Fire Safety) Order 2005

8.1.1 The Regulatory Reform (Fire Safety) Order 2005 places a general duty of fire safety care on employees, occupiers and/or owners of businesses to provide and maintain adequate fire precautions.

8.1.2 The legislation is supported by requiring a fire risk assessment and a fire safety plan.

8.1.3 The Order places a responsibility on the responsible person to carry out a fire risk assessment on the premises. This process looks to:

- Identify potential fire hazards.
- Evaluate the risk from the hazards
- Identify who would be at risk
- Identify an adequate level of fire precautions to compensate for the risk

8.1.4 The significant findings of the fire risk assessment should be recorded if the responsible person employs five or more employees.

8.1.5 The fire safety management plan details the arrangements to implement, control, monitor and review fire safety standards and to ensure those standards are maintained. The plan describes the arrangements for effectively managing fire safety so as to prevent fire occurring and, in the event of fire, to protect people and property.

8.1.6 A fire safety management plan should be completed on occupation of the building and a fire risk assessment should be undertaken following the occupation of the premises to comply with Article 9 of The Regulatory Reform (Fire Safety) Order 2005.

8.1.7 The responsible person on occupation should provide adequate fire safety information to all eventual residents of the flats. This could be in the form of a home user guide to include basic prevention measures and the fire evacuation strategy and procedures. Further information on advice to occupiers of dwellings in residential buildings including an example fire evacuation plan is provided in Annex F of BS 9991:2015.

8.1.8 The fire emergency plan ought to be communicated to each resident on occupation. Residents ought to have a clear understanding of what actions to take should a fire situation change, and they need to evacuate the building.

8.2 Regulation 38

8.2.1 Regulation 38 requires that, where work involves the erection or extension of a relevant building, or relevant changes of use of a building, fire safety information shall be given to the responsible person at the completion of the project or when the building or extension is first occupied. The information will facilitate the production of the risk assessment, a requirement under the Regulatory Reform (Fire Safety) Order 2005.the adjacent table provides a precis of the active and passive systems provided within the building.

8.2.2 It will need to be ensured that the building fabric and fire protection measures are maintained throughout the life cycle of the premises. All fire safety systems, installations and equipment should be maintained in accordance with the manufactures recommendations.

Table 8.1 Passive & Active Systems

Passive System	Provision	Reference in Strategy
Compartmentation	In accordance with the recommendations of BS 9991	Section 4
Fire Doors	In accordance with the recommendations of BS 9991	Section 4.2
Internal Linings	In accordance with BS 9991 Section 31	Section 3
Structural Elements	120 minutes fire resistance	Section 3.2
Cavity Barriers	In accordance with BS 9991. Cavity barriers are to be provided at all junctions or apartment walls and floors with the external wall and are to be provided around all windows and doors in the external façade.	Section 4.10 & 4.11
Roof Coverings	Designation rating of AA (BRoof(t4)).	Section 5.7
Signage	In accordance with BS 5499-4, BS 5499-5 and BS ISO 3864-1	Section 2.13
Façade & attachments	To achieve a minimum of Class A2 or better.	Section 5.4
Active System	**Provision**	**Reference in Strategy**
Alarm & Detection	Grade D1 Category LD1 to all apartments in accordance with BS 5839-6, Category L5 to BS 5839-1 in the stair/stair lobby Category L2 to BS 5839-1 to the ancillary accommodation Category M to the commercial unit	Section 2.3
Emergency Lighting	In accordance with BS 5266 and BS EN 1838.	Section 2.12
Ventilation	0.8m^2 mechanical smoke extract shaft controlled via L5 detection and a pressure sensor in the common corridors. 1m^2 AOV at the head of the stair	Section 2.8
Fire and Smoke Dampers	All fire dampers are to be tested to BS EN 1366-2 and be classified to BS 13501-3. The dampers are to have the same fire resistance (integrity) as the wall or floor they penetrate (subject to a minimum of 60 minutes)	Section 4.7
Sprinklers	BS 9251 Category 3 sprinkler system with a minimum supply duration of 60 minutes to be provided to all areas except common corridors. 5mm/min in the commercial unit to 16925.	Section 3.4
Secondary power	In accordance with BS 9999 and Supplementary 9991 guidance that is specific to residential buildings.	Section 7
Firefighting system	**Provision**	**Reference in Strategy**
Wet Risers	wet rising mains to be provided within the firefighting stair.	Section 6.3
Fire Hydrants	It should be ensured than an existing hydrant is within 100m of the building or an additional hydrant will be required within 90m of the development.	Section 6.6
Fire Fighting Lift	In accordance with BS 9991 and BS EN 81	Section 6.2
Basement Ventilation	combined area of not less than 2.5% of the basement floor area	Section 6.4

9. Conclusion

9.1.1 The design of the building, in general, meets with prescriptive requirements at the time this report was produced. The key prescriptive requirements have been stated within this report as a performance specification and shall be adhered to by the design team in the design of the project. Unless explicitly stated otherwise all aspects are to be in full accordance with the relevant British Standards and codes of practice. Where codes of practise are restrictive to the design, an alternative (fire engineering solution) has been considered.

9.1.2 The drawings used in Table 1.1 have been used in the production of this report and no other drawings have been reviewed. If you feel additional information should be considered or may have an impact on this report, we are to be informed as it may have a bearing on the conclusion of this report.

9.1.3 The fire engineering design is based on first principles and utilises accepted design practice and tools for assessment. The fundamental criteria set were to ensure that occupants would be exposed to conditions commensurate or improved to that of the prescriptive requirements.

9.1.4 It is considered that between a culmination of the prescriptive requirements and fire engineering approach, a solution will be provided which is adequate to address the risk, therefore providing a detailed strategy how compliance with the functional requirements of the Building Regulations can be met if the strategy is adopted in full by all design team members.

9.1.5 The engineered solutions presented within this report are a deviation from the accepted guidance and represent an approvals risk, as such these should not be relied upon for design until approved by the relevant approvals body, be this the Fire Service and Building Control.

9.1.6 This report will be discussed with the appointed Building Control representative and should be issued for agreement in principle with the Fire and Rescue Service.

Appendix 1. Cooking Facilities Fire Separation Calculations

A1.1.1 It is assumed that the cooking hobs will not exceed 2.5 kW per ring. This is conservative as this will be assuming that the hob is on full power and that the heat transfer process from the hob into the pan is 100% efficient and all the heat is transferred straight to the fuel, without accounting for any energy lost. Calculations will be made based on a worst-case scenario pool fire based on the hob. A pool fire is chosen as this will allow for accurate estimations of pan fires. The scenario calculated will be of a 0.25m diameter pan containing cooking oil (data gathered is based on properties of olive oil as this has the highest heat of combustion).

A1.1.2 In the absence of a specification for the cooking hob, the 2.5kW is considered a reasonable maximum heat output based on:

- a review of commercially available hobs;
- the conservative assumptions discussed above; and
- the apartment is fitted with a residential sprinkler system designed and installed in accordance with BS 9251. It is noted the benefit of sprinkler suppression has not been accounted for in the calculations thus further increasing the conservatism of the calculations.

A1.1.3 It should be noted that while these calculations are theoretical rather than experimental, this will result in estimations higher than expected in real world cases. This is due to the fact that no consideration is given to heat loss from the pan etc. so it is assumed that the fire is 100% efficient and all heat that is not radiated outwards is radiated back into the base of the fire. It also assumes that all energy provided by the hob is transferred directly to the oil with no energy lost to the pan or surroundings. It is also to be assumed that the flame from the pan is conical.

A1.1.4 To calculate the heat release rate of a self-sustaining oil fire i.e. the pan is on fire, but the hob is switched off the following properties of olive oil need to be considered:

- Heat of Combustion, ΔHc – 39.6 MJ/kg
- Regression Rate, m'' – 0.02 kg/m^{2}s

A1.1.5 For a 0.25m diameter, an area, Af of 0.049m^2 can be calculated. The fire should be circular as it the fuel is held in shape by the pan. A radiative heat fraction of 0.35 has been selected for this case. 0.35 has been selected as a conservative value, as materials that produce more soot when they burn have higher radiative fractions, and the value of 0.35 was taking from a plastic and wooden crib (which produce more soot than olive oil).

A1.1.6 Putting the data into the equation for heat release rate:

$$Q^{\cdot} = \dot{m}'' \, \Delta H_C A_f$$

$$Q^{\cdot} = 0.02 * 39.6 * 0.049$$

$$Q = 0.0396MW$$

$$0.0388MW = 38.8kW$$

A1.1.7 This calculated result of 38.8kW is similar to the experimental results recorded by a recent study on oil fires in woks by Chow (Experimental Evaluation on Performance of Open Kitchen Fire Suppression Systems. Chow, W.K. & Ni, X. 2014), where a solution of multiple cooking oils was used. Olive oil was selected for this case as it has the highest heat of combustion as listed in the SFPE handbook. Using a wok of the same diameter of the theoretical frying pan used in these calculations, the control test from Chow and Xi's experiment resulted in a measured average HRR of between 24-27kW with peak HRR's nearer to the calculated value. However, the peak heat release rate from this experimental data may have only being recorded for a fraction of a second whereas the higher HRR acquired from the calculations is assumed to be constant which has resulted in a much higher HRR overall.

A1.1.8 It is assumed that 50% of the thermal radiation travels towards the seat of the fire. This results in a worst-case scenario as all radiation that is not heading directly out of the fire is used to supply further energy to the liquid fuel. Thermal radiation to the fire bed, $\dot{Q}_{Rf}$ can be calculated with the following equation:

$$\dot{Q}_{Rf} = \frac{F\dot{Q}_R}{2}$$

A1.1.9 To calculate $\dot{Q}_{Rf}$, the configuration factor, F needs to be found, which has the equation:

$$F = \frac{1}{(1 + H^2)^{0.5}}$$

A1.1.10 To calculate F, H needs to be found, which has the equation:

$$H = \frac{2L}{D}$$

A1.1.11 To calculate H, Flame Length, L must be found, which has the equation:

$$L = 0.23\dot{Q}_C^{\frac{2}{5}} - 1.02D$$

A1.1.12 Where $\dot{Q}_C$ is the convective fraction of heat transfer from a pool fire. Heat generated in the flame will be partly convected away by smoke flow in the plume and partly radiated to the surrounding. The fraction of heat radiated out of the flame, as stated earlier, is 0.35 which is adequate for small pool diameter. This gives a convective fraction of 0.65.

$$L = 0.23 * (0.65 * 38.8)^{\frac{2}{5}} - 1.02 * 0.25$$

$$L = 0.5821\ m$$

Now a value of H can be found:

$$H = \frac{(2 * 0.5821)}{0.25}$$

$$H = 4.657$$

NOTE: H has no units.

A1.1.13 Now the configuration factor, F can be found:

$$F = \frac{1}{(1 + 4.657^2)^{0.5}}$$

$$F = 0.2010$$

NOTE: The configuration factor has no units.

A1.1.14 The thermal radiation that transfers back into the fire bed can then be calculated using the configuration factor and the radiative fraction of heat transfer (0.35 multiplied by the overall heat release rate):

$$\dot{Q}_{Rf} = \frac{0.2010 * (0.35 * 38.8)}{2}$$

$$\dot{Q}_{Rf} = 1.428\ kW$$

A1.1.15 This means that when there is a heat release rate of 38.8kW in the oil fire there is 1.428kW being radiated back into the bed of the fire. As the reaction is self-sustaining it can be said that 1.428kW is enough heat to evolve the liquid fuel into gas for combustion and result in the 38.8kW HRR.

A1.1.16 In the worst-case scenario, the hob will still be active and so the 2.5kW from the hob to the pool needs to be accounted for. It is assumed that the heat from the hob is transferred entirely into the pool fire with no loss. The 2.5kW will be defined as $\dot{Q}_S$

A1.1.17 Now that there are two heat sources available to evolve the liquid fuel into gas the original 1.428kW value changes to ($\dot{Q}_{Rf}$ + $\dot{Q}_S$). Only $\dot{Q}_S$ is only known now because as the HRR rate increases, the fire size increases, and so more heat is available to be radiated back into the bed of the fire. To calculate the new $\dot{Q}_{Rf}$ it can be assumed to be 1.428kW initially, this will result in a much lower value for HRR, but the answer will be improved to within 1% accuracy through further calculations. The accuracy increases inverse-exponentially each time the method is repeated with the new numbers.

A1.1.18 The mass burning rate of this fire can be calculated with the follow equation:

$$\dot{m} = \frac{\dot{Q}_{Rf} + \dot{Q}_s}{L_t}$$

A1.1.19 L_t is the specific latent heat of evaporation. The mass burn rate is linearly proportional to the heat input into the liquid. Using the values from the self-sustaining fire calculated earlier, as well as taking into account the additional 2.5kW heat source

$$\frac{1.428}{38.8} = \frac{\dot{Q}_{Rf} + \dot{Q}_s}{\dot{Q}}$$

A1.1.20 Transpose equation to find $\dot{Q}$

$$\dot{Q} = \frac{38.8}{1.428}(\dot{Q}_{Rf} + \dot{Q}_s)$$

A1.1.21 Using the initial 1.428 kW value for $\dot{Q}_{Rf}$ the equation becomes:

$$\dot{Q} = \frac{38.8}{1.428}(1.428 + 2.5)$$

$$\dot{Q} = 106.9\ kW$$

A1.1.22 Now that there is an initial estimate for HRR for the pan fire, which is being supplied with heat from the hob, it can be improved upon through repeating previous steps. Finding new values for the flame length to the heat release rate and calculating all values repeatedly until the change in magnitude is minimal.

Second Iteration:

New Flame Length:

$$L = 0.23 * (0.65 * 106.9)^{\frac{2}{5}} - 1.02 * 0.25$$

$$L = 0.9996\ m$$

New H:

$$H = \frac{2 * 0.9996}{0.25}$$

$$H = 7.997$$

New F:

$$F = \frac{1}{(1 + 7.997^2)^{0.5}}$$

$$F = 0.1241$$

New $\dot{Q}_{Rf}$:

$$\dot{Q}_{Rf} = \frac{0.1241 * (0.35 * 106.9)}{2}$$

$$\dot{Q}_{Rf} = 2.321\ kW$$

A1.1.23 With the new $\dot{Q}_{Rf}$ found, a new estimate of heat release rate can be calculated:

$$\dot{Q} = \frac{38.8}{1.428}(2.321 + 2.5)$$

$$\dot{Q} = 131.2\ kW$$

A1.1.24 Then the method is repeated again to increase accuracy:

Third Iteration

New Flame Length:

$$L = 0.23 * (0.65 * 131.2)^{\frac{2}{5}} - 1.02 * 0.25$$

$$L = 1.107m$$

New H:

$$H = \frac{2 * 1.107}{0.25}$$

$$H = 8.854$$

New F:

$$F = \frac{1}{(1 + 8.854^2)^{0.5}}$$

$$F = 0.1122$$

New $\dot{Q}_{Rf}$:

$$\dot{Q}_{Rf} = \frac{0.1122 * (0.35 * 131.2)}{2}$$

$$\dot{Q}_{Rf} = 2.578\ kW$$

New Heat Release Rate:

$$\dot{Q} = \frac{38.8}{1.428}(2.578 + 2.5)$$

$$\dot{Q} = 138.2\ kW$$

Fourth Iteration

New Flame Length:

$$L = 0.23 * (0.65 * 138.2)^{\frac{2}{5}} - 1.02 * 0.25$$

$$L = 1.135\ m$$

New H:

$$H = \frac{2 * 1.135}{0.25}$$

$$H = 9.081$$

New F:

$$F = \frac{1}{(1 + 9.081^2)^{0.5}}$$

$$F = 0.1095$$

New $\dot{Q}_{Rf}$:

$$\dot{Q}_{Rf} = \frac{0.1095 * (0.35 * 138.2)}{2}$$

$$\dot{Q}_{Rf} = 2.647\ kW$$

New Heat Release Rate:

$$\dot{Q} = \frac{38.8}{1.428}(2.647 + 2.5)$$

$$\dot{Q} = 140.1\ kW$$

Fifth Iteration

New Flame Length:

$$L = 0.23 * (0.65 * 140.1)^{\frac{2}{5}} - 1.02 * 0.25$$

$$L = 1.143$$

New H:

$$H = \frac{2 * 1.143}{0.25}$$

$$H = 9.142$$

New F:

$$F = \frac{1}{(1 + 9.142^2)^{0.5}}$$

$$F = 0.1087$$

New $\dot{Q}_{Rf}$:

$$\dot{Q}_{Rf} = \frac{0.1087 * (0.35 * 140.1)}{2}$$

$$\dot{Q}_{Rf} = 2.665\ kW$$

New Heat Release Rate:

$$\dot{Q} = \frac{38.8}{1.428}(2.665 + 2.5)$$

$$\boldsymbol{\dot{Q} = 140.6\ kW}$$

A1.1.25 After repeating enough times, the change in heat release rate starts to become negligible. In order to check if the newest one is accurate enough it is necessary to calculate how similar it is to the previous calculated heat release rate. In this particular case 140.6 kW and 140.1 kW. This can be done by calculating the percentage difference.

$$Percentage\ Difference = \frac{140.6 - 140.1}{140.6} * 100$$

A1.1.26 The result is 0.36%. This means that the most recent calculation of HRR is less than 1% larger than the previous one, the increase from here on will be negligible.

Radiation Calculations

A1.1.27 As calculated above for a 0.25 diameter pan fire on a 2.5 kW heat source, an **HRR of 140.6 kW** is estimated as a peak fire size.

A1.1.28 The analysis will seek to determine that an appropriate separation distance can be maintained between the cooking area and the egress route such that the escaping occupants are not exposed to excessive radiation. In accordance with PD7974-6 (British Standards Institution, 2004) Table G.3 the tenability limits for received radiation are as follows;

- <2.5kW/m^2 for 5 over minutes
- 2.5kw/m^2 for 30 seconds
- 10kW/m^2 for 4 seconds

A1.1.29 Generally, a tenability criterion of 2.5m kW/m^2 will be adopted as a received radiant heat flux on the basis that any received thermal radiation less intense than that value is tolerable for over 5 minutes. To work out the radiative intensity for this case we can use the HRR of the fire and the distance to a specific point away from the pool fire. As well as the radiative fraction of heat transfer for the fire (which is still 0.35).

$$\dot{q}'' = \frac{X_r \dot{Q}}{4\pi R_0^2}$$

A1.1.30 Where X_r is the radiative fraction, Q is the heat release rate of the fire and R_0 is the distance to the point where radiation is to be measured. This is taken as the distance to the nearest obstruction, less 500mm to allow an occupant room to escape. The method of measuring R_0 has been illustrated in Figure 1.

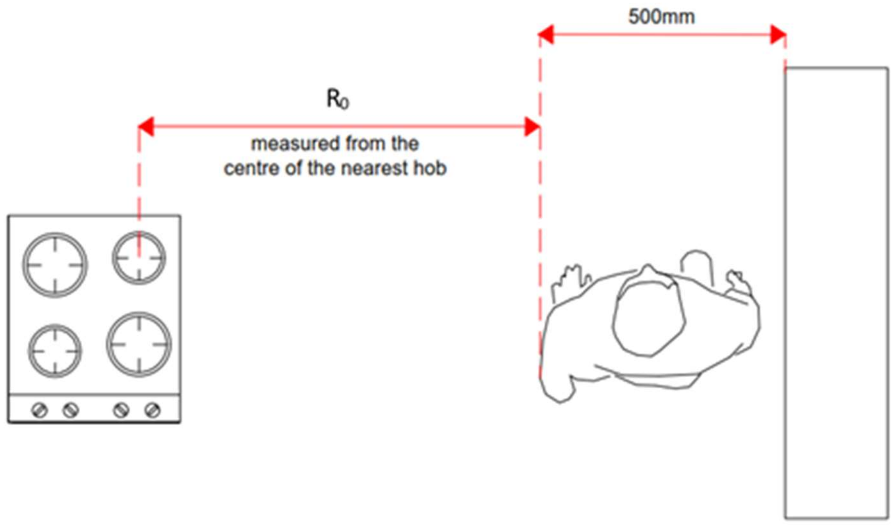

Figure 1: Separation distance from Hobs to Escape Route

A1.1.31 The equation can be rearranged to determine a minimum safe distance to achieve a received radiant heat flux of 2.5 kW/m² or less. This would result in the below equation:

$$R_0 = \sqrt{\frac{X_r \dot{Q}}{\dot{q}'' 4\pi}} = \sqrt{\frac{0.35 * 140.6}{2.5 * 4\pi}} = 1.252m$$

A1.1.32 Based on the above, any apartments with a separation distance exceeding 1.25m (i.e. 1.75m from the centre line of the hob to the nearest obstruction or the apartment entrance door) are deemed acceptable with no further assessment.

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Appendix 2. CFD Analysis - Open Plan Apartments

Brill Place - Open Plan Study

CFD Analysis

08 April 2021

Henry Construction Projects Ltd

11963BB

Revision History

Version	Date	Author	Comments
01	08/04/2021	Chris Kaye	First Issue

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Contents

Executive Summary

An engineered study has been undertaken for the proposed open-plan layout apartments in the residential Brill Place development in Camden. The building will have residential apartments over twenty-two floors, with amenity spaces between the basement and mezzanine levels, and a commercial area on the ground floor. All of these floors are served by a single stair core.

It has been requested that modelling and justification for the proposed open-plan apartments be provided due to their dimensions being larger than those permitted in standard guidance, and these open-plan areas also containing open kitchens, which are not recommended in the standard guidance.

The engineering method used was a comparative engineering study. The method involved comparing the required safe egress time (RSET) for each scenario and using CFD modelling to demonstrate when the tenability limits have been exceeded.

For the smallest and largest open plan layouts within the building (K01 and K05 respectively), the following scenarios were modelled:

- Proposed open plan apartment assuming a fire being controlled on activation of sprinklers.
- Equivalent code compliant model with a fire in the enclosed kitchen.
- Equivalent code compliant model with a fire outside the enclosed kitchen.

The CFD results showed that the proposed open plan apartment is no worse than an equivalent code compliant scenario as both are compromised by smoke and temperature briefly (no other tenability limit is exceeded). The temperatures at high level exceed the tenability limit in both the proposed layout and the code compliant models, although it can be seen that it takes longer for these high temperatures to descend in the open plan model. This demonstrates that the occupants in the code-compliant layout may find it more difficult to escape than those in the proposed layout.

Therefore, it is considered that the study does demonstrate that the open plan apartments with open kitchens in the proposed development, with the benefit of sprinkler and enhanced detection, are at least comparable or better than a code-compliant layout. Therefore, on this basis, the scenario is considered to fulfil the functional requirements of the Building Regulations.

1. Introduction

The Brill Place development in Camden will be a new residential building with a Basement level containing amenities, a Ground level containing amenity and commercial spaces, and a Mezzanine level consisting of amenity spaces. The First to Twenty-Second floors consist of residential apartments, and each storey is served by a single stair. The top level is approximately 71m above ground level, but this is a three-storey apartment accessed at the Twentieth floor; all other apartments are single-storey and exit onto a lobby to the stair.

The fire strategy developed by BB7 Fire recommends that all apartments be provided with a residential sprinkler system in line with BS 9251:2014. The strategy also requires all open plan apartments be provided with LD1 fire detection and alarm system in line with BS 5839-6:2019.

As part of the statutory approval process for the proposed development, has been requested that modelling be undertaken as justification for the proposed open-plan apartment layouts, due to the fact some of the open plan apartments exceed the recommended areas detailed in BS 9991. Currently, the maximum size and type of an open plan apartment is limited by the scope of research undertaken by BRE for the NHBC Foundation. Therefore, due to the lack of detail in guidance provisions, BB7 propose that an engineering study will be used to demonstrate that the conditions within the proposed apartment layouts are acceptable and the conditions are no worse than a code compliant scenario.

This CFD modelling report details the design of the scenarios, the assumptions made for the input parameters of the CFD model and the results from the assessment to demonstrate the proposals comply with the Building Regulations.

2. Engineering Study

2.1 Purpose of the Study

The objective of this study is to demonstrate that the conditions afforded to occupants within the proposed open plan apartments are the same as, or no worse than, an equivalent code compliant design.

The study was designed to determine if the conditions are acceptable based on engineering methods. A deterministic engineering study is used to demonstrate that persons are likely to be able to evacuate before conditions prevent them from doing so in the first instance. However, it should be noted that the main comparison is against the guidance. Depending on the time taken for occupants to move, conditions might be untenable but would be no worse than the code compliant designs. The results are also compared with those expected under similar fire conditions in a code-compliant layout.

To determine the results, CFD (Computational Fluid Dynamics) modelling will be undertaken. The CFD package used will be FDS version 6.7.5 (Fire Dynamics Simulator) developed by the USA's National Institute of Standards and Technology (NIST), and has been subjected to extensive validation against real fires. It has been used and been under continuous development for several years. FDS is accepted as a fire engineering tool worldwide, having been widely employed and developed over the past 25 years.

2.2 Proposed Building Measures

2.2.1 General Considerations

To compensate for the lack of protected entrance hallways in a number of the open plan apartment layouts, the following fire safety measures are proposed in each open plan apartment:

- Early warning system (LD1 fire alarm and detection system)
- Sprinkler system

2.2.2 Early Warning

The dwellings will be fitted with a category LD1 Grade hard-wired smoke detection and alarm system as described in BS 5839-6:2019. Each detector head will have a sounder incorporated into it.

If a fire should occur when occupants are awake, they should hear the alarm and react. People who are awake will almost certainly hear something as their auditory threshold is only 20 dB (A). If occupants are sleeping, they will be harder to rouse; and they will require a noise exceeding 75dB (A). Even persons who have hearing impairments are likely to hear 75 dB (A).

2.2.3 Sprinkler Systems

A sprinkler system will be installed throughout all open plan apartments. Sprinkler systems do not prevent the risk of a fire starting or developing nor do they ensure a safe evacuation for all the occupants. However, they do increase the likelihood of the fire being extinguished and of the occupants making a safe evacuation.

For the purposes of the open plan arrangement, the sprinkler system should be designed and installed in accordance with the requirement set out in BS 9251:2014, as required in BS 9991:2015. The advantages of a sprinkler system are as follows:

- Sprinkler systems are often able to extinguish a fire; this can significantly reduce the risk to occupants.
- Sprinkler systems reduce the maximum likely fire size and cool the combustion products aiding the tenability for occupants.
- Sprinkler systems are likely to contain the fire to the room of fire origin and prevent spread past this area. This means that occupants who do not move immediately are likely to be safe away from the room of origin.
- In some cases, sprinkler systems may provide protection to persons in the room of fire origin.
- Sprinkler systems reduce the buoyancy of a hot combustion layer, and reducing the likelihood of smoke rising and spreading, especially in the early stages of fire.
- Sprinkler systems also significantly increase the protection for fire fighters, radically reducing the risk of fatality to personnel. The sprinkler system also allows better opportunity to rescue persons if necessary.

A key advantage of a sprinkler system discussed above is their ability to potentially extinguish the fire in some instances and their ability to protect persons not in the room of fire origin.

The strategy for escape contained in this document is designed to allow occupants the opportunity to safely egress the apartment of fire origin before they are prevented from doing so by the products of fire. The harsh reality of fire fatalities is that a large proportion of persons often get trapped by a fire within the dwelling, and it is considered important that this is considered when reviewing the fire safety measures provided.

For example, the majority of fatalities in dwelling fires involve persons of limited mobility/elderly, persons asleep, and persons incapacitated by intoxicating substances. Elderly or intoxicated persons asleep in the upper levels have a far greater chance of survival with a sprinkler system if their door is shut than in a code compliant example. It is, therefore, a significant advantage if the fire is contained within the room of origin and persons trapped can remain in a place of relative safety.

2.3 Comparison with Guidance

Open plan living is becoming increasingly popular for residential apartments. Although not traditionally acceptable under the guidance documents in the UK, it has become increasingly more acceptable since the publication of the BRE paper (commissioned by the NHBC Foundation); "Open Plan Flat layouts, assessing life safety in the event of a fire."

The guidance contained within Approved Document B Volume 1 (ADB) does not specifically suggest that open flats are not acceptable, however it does not provide this layout as one of its possible solutions which are deemed to satisfy the Building Regulations. However, it limits the size of the open plan to a maximum travel distance not more than 9m from any point in the flat which has no bedroom accessed through the living room.

BS 9991:2015 provides guidance to open plan arrangement with travel distance greater than 9m with an inner room being bedroom. The guidance for open plan apartments reflects the design measures used in the BRE study "Open plan flat layouts". The guidance in BS 9991 does cover certain areas of open plan apartments but the guidance and accompanying justification is very limited due to the NHBC Open Plan study, which only involved specific single apartment sizes.

However, the recommendations in BS 9991:2015 do not deem to satisfy the legislative requirements of the Building Regulations in the same way that those in ADB would. Although a British Standard does go a long way to achieving this and most approval authorities would look favourably on it, there is no precedent to use this guidance and the guidance ADB offers.

The maximum size and type of an open plan apartment included in BS 9991:2015 is limited by the scope of research undertaken by BRE for the NHBC Foundation. The limitation includes that:

- The size of the open plan flat should not exceed 16 m×12 m.
- Open-plan flats should be situated on a single level only.
- The ceilings within the open plan flat should have a minimum height of 2.25 m.
- The kitchen should be enclosed in open-plan flats having an area exceeding 8m×4m. Cooking appliances in open-plan flats having an area smaller than 8m×4m should not be adjacent to the entrance of the flat.

In the current proposed design of the open plan apartments have open kitchen arrangement with all cooking facilities at distance at least 1.8m from the escape route. However, the sizes of these apartments (as shown in Table 2.1) exceed the limit imposed in the design guidance for kitchen being integrated within living area despite the area exceeding the 8m×4m.

Table 2.1 Open Plan Apartments

	Apt 16.03 (type K01)	Apt 18.01 (type K05)
Total internal area (m^2)	55.5	135
Open plan area (m^2)	35.1	47.8
Total distance (m)	11.0	14.0
Change due to kitchen enclosure (m^2)	10.0	13.5
Apartment smaller than 16m×8m	Yes	No
Apartment larger than 8m×4m	Yes	Yes
Selection of modelled apartments	The size of the open plan areas are representative of the smallest and largest open plan apartment areas.	
Scenarios considered	K01-P / K05-P: Proposed layout, with a fire in the kitchen area. K01-EK / K05-EK: Code-compliant layout, with a fire inside the enclosed kitchen area. K01-EO / K05-EO: Code-compliant layout, with a fire outside the enclosed kitchen area.	
Fire size (see Table 3.2)	Fire sizes are based on the first sprinkler activation in the apartment and range from 190kW – 250kW.	

Therefore, it is proposed that an engineering study based on comparative CFD modelling is conducted to demonstrate that the conditions within the proposed open pan apartment layout is acceptable. The report intends to demonstrate that with the benefit of sprinklers and other associated measures, the proposed open plan apartment layouts provide a better solution than a layout that complies with the guidance in BS 9991:2015. This will provide a specific bespoke solution to the proposed building and its occupants.

Shown in Figures 1 and 2 are the proposed layouts of Apt 16.03 and 18.01, with open-plan areas K01 and K05, respectively. In these figures, the areas highlighted in yellow are the open plan areas and highlighted in green are the corridors areas within the apartment. These highlighted areas were modelled as they may form part of the escape route.

The performance of each model will be analysed, and a comparison will be made between the data obtained from the CFD results. The locations of the fire in the three layouts are chosen such that they are at similar distance away from the sprinkler head and similar distance from the escape route. Altogether six scenarios are modelled as shown in Table 3.2, in the following section.

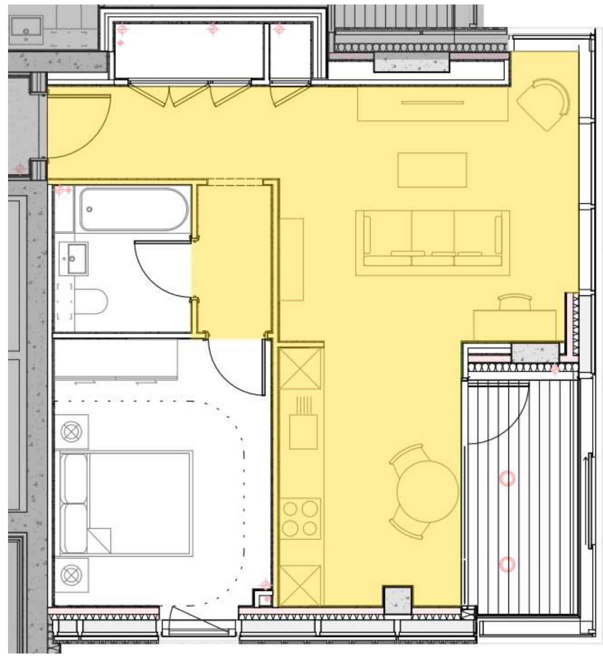

Figure 1. K01 Proposed Layout

Figure 2. K05 Proposed Layout

3. Modelling Assumptions

3.1 Grid Size

CFD models are composed of meshes that consist of a three-dimensional grid of cells. Data from each cell is shared with its neighbouring cells at each time step to determine how the model evolves with time. For a mesh composed of smaller cells, more calculations will be required at each time step due to the higher number of cells; it should be noted, however, that smaller grid cells also increase the resolution and accuracy of the results. To balance the resolution and runtime requirements for the models, a grid cell size of 0.1m×0.1m×0.1m was used. These cell dimensions are widely used as the finest cell size employed for this type of modelling within the industry, and experience shows that a further reduction in cell size does not lead to material changes within the model.

3.2 Model Geometry

The domains of the models were constructed using the architectural plans. The modelled open plan apartments are shown in Figures 3–6. The models are as accurate as possible, within the limits imposed by the model resolution. While the model is not an exact representation of the actual building, it is considered that the model is adequately representative of the building geometry, and that the results produced therefore have a reasonable degree of accuracy. A representation of each model can be seen in the below diagrams, with the proposed scenario and two code-compliant variants per layout.

3.3 Material Assumptions

The default material is Gypsum Plaster (with Quintiere, Fire Behaviour- NIST NRC Validation properties):

- Conductivity= 0.48W/m/K,
- Specific heat capacity= 0.84kJ/kg/K,
- Density = 1440kg/m^3.

Accurately modelling the material properties is difficult, but the real make up will be a combination of plaster board, masonry construction and glazing. The materials will affect the heat loss from the domain. It is however considered that the above is a reasonable representation of what is modelled.

3.4 Sprinkler/Detection Specifications

Both apartments are modelled with a fire and detection system and designed in accordance with BS 5839-6:2013 - Fire detection and fire alarm systems for buildings. Both the code compliant scenarios and proposed open plan apartment are provided with a LD1 system, which involves a detector to be installed throughout the apartments. The position of the detectors has been designed from using BS 5839-6:2013.

Both proposed and code compliant scenarios are provided with a sprinkler system, in accordance with the BS 9251:2014. Table 3.1 outlines details of the sprinkler system incorporated within the model, which has been based on the information in BS 9251 and the FDS 6 user manual.

Table 3.1 Sprinkler System Properties

Activation Temperature	68.33 °C
Response Time Index	50 (m s)$^{1/2}$
Sprinkler Positioning	0.1m below the ceiling
Sprinkler Spacing	<5.5m apart, and <2.4m from compartment wall
C Factor	0 (m/s)$^{1/2}$
Flow Rate to Sprinkler Heads	49.05 L/min

3.5 Modelling Assumptions

The open plan apartments are provided with a suppressed fire as open plan apartments will have a sprinkler system installed. As detailed in Sections 2.2.3 and 3.4, the sprinkler system has additional benefits where it works effectively on a residential fire.

Therefore, it is considered reasonable to model the open plan apartments with a reduced fire size from the typical 2.5MW used for residential occupancy, reflecting the effect of the fire suppression system.

The fire sizes in both the open plan apartment and the code compliant models were determined from various sensitivity runs to find the time at which the sprinkler system would activate. Theoretically the sprinkler would control the fire size at activation, which is an acceptable approach detailed in BS 7974:1. Initial sensitivity study, based on a radially expanding fire of 600kW heat output, shows that the maximum time to sprinkler activation in the six scenarios is as shown in Table 3.2. As the fire may not be immediately controlled in reality by the activation of sprinkler, a margin of safety is therefore adopted, and 10 seconds are added in the sprinkler activation time for conservatism. This accounts for any changes in the model itself due to fire size (vent area) changes which may affect the activation. Adding a slight increase in the fire size would ensure that there is no problem with the activation of sprinklers in the final model.

Table 3.2 Sprinklered Fire Properties

Scenario	Sprinkler activation time (s)	Fire size (kW)	Fire area	HRRPUA (kW/m^2)
K01-P – as proposed	127 (137 modelled)	220	1.0m×1.0m	220.0
K01-EK – enclosed kitchen; fire in kitchen	117 (127 modelled)	190	0.9m×0.9m	234.6
K01-EO – enclosed kitchen; fire outside kitchen	133 (143 modelled)	240	1.0m×1.0m	240.0
K05-P – as proposed	135 (145 modelled)	250	1.0m×1.0m	250.0
K05-EK – enclosed kitchen; fire in kitchen	120 (130 modelled	200	1.0m×1.0m	200.0
K05-EO – enclosed kitchen; fire outside kitchen	136 (146 modelled)	250	1.0m×1.0m	250.0

3.6 Ventilation

To support the combustion in the apartment to achieve the design fire size, ventilation is required. Low level vents are provided in all scenarios considered, low level vents of 0.2m in height were provided. A leakage area of 0.1m2 was also provided near to doors that lead outside of the apartment.

It should be noted that the assumed low-level ventilation does not necessarily coincide with any window in the proposed arrangements. In reality, this ventilation would likely come from the breakage of a window, which is likely to occur at a higher level. If these ventilations do not exist in the early stage of the fire, the fire may not be able to grow to the designated level. Hence the modelled fire sizes are considered to be conservative.

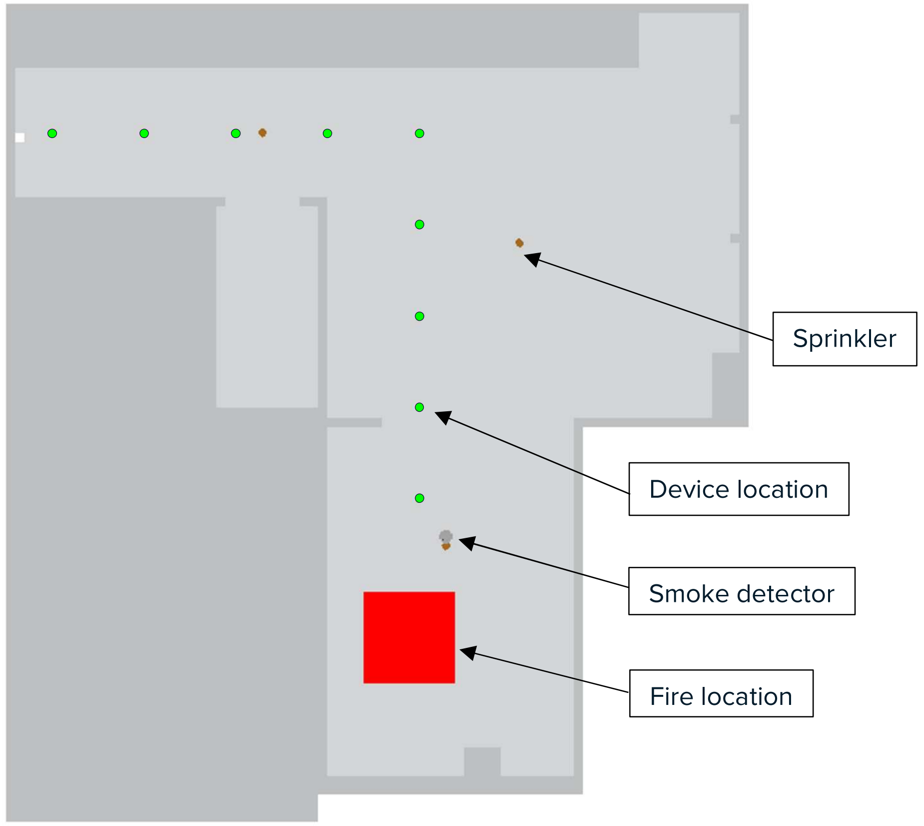

Figure 3. Proposed K01 layout

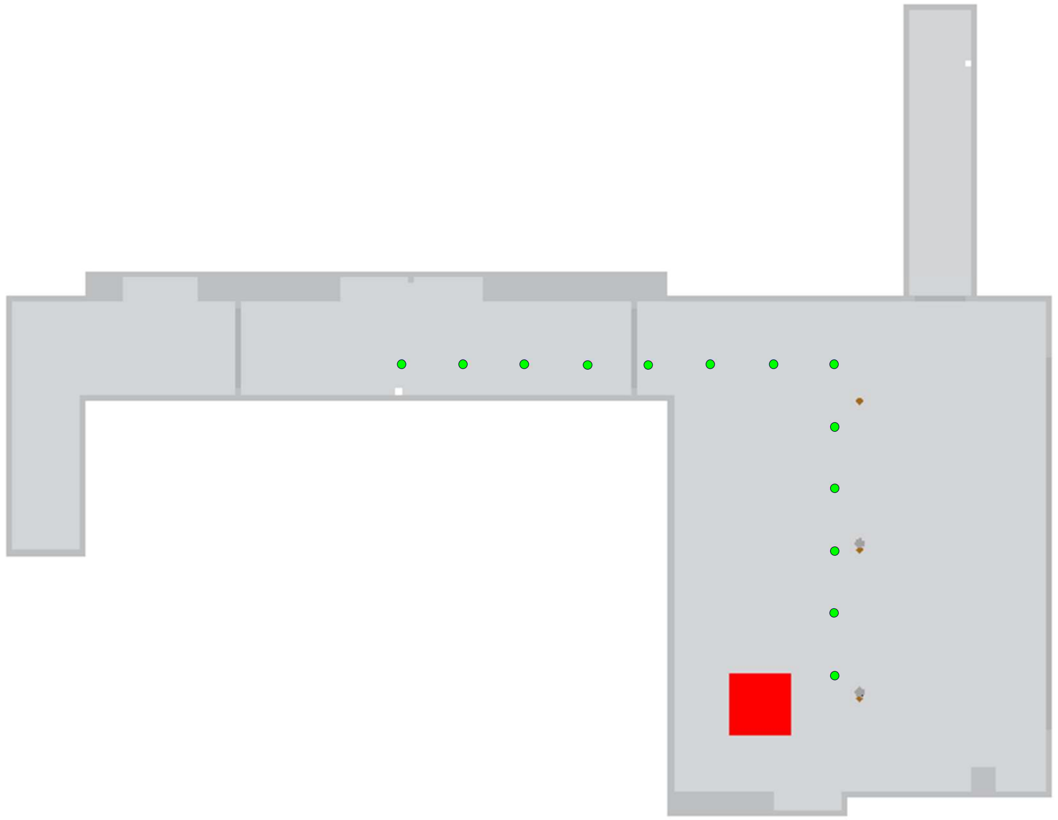

Figure 5. Proposed K05 layout

Figure 4. Code-compliant K01 layout

Figure 6. Code-compliant K05 layout

3.7 Tenability Limits

To demonstrate that conditions in the open plan apartment is no different than the equivalent code compliant scenario under BS 9991, the time when untenable conditions occur will be assessed for all three scenarios in both apartment layouts.

Untenable conditions are considered to occur at the end of the Available Safe Escape Time (ASET), in which occupants exposed to a fire are likely to be unable to evacuate due to the effects of exposure to smoke, radiant heat and toxic gases. From reviewing the CFD models, ASET can be extracted for various parameters. The results then can be presented and compared between the scenarios. It is proposed to assess four criteria for means of escape to ensure that the occupants of the building are able to evacuate effectively without risk: temperature, visibility, radiation and fractional effective dose. The tenability limits for each condition are shown in the sections below.

3.7.1 Visibility

Following CIBSE Guide E and PD 7974-6 a minimum visibility of 10m is required in large enclosures; this is generally assessed at 2.0m above the floor level – approximately at head height. However, the apartments are fairly small, and the occupants would be familiar with the apartment layout and therefore, it is considered acceptable to use 5m visibility to determine when the tenability limit is met in terms of visibility.

3.7.2 Temperature

Following PD 7974-6 persons are able to withstand temperatures of up to 60°C for periods up to 30 minutes. Based on this, within the apartment the temperature limit will be assessed on 60°C.

3.7.3 Thermal Radiation

Under the guidance of CIBSE Guide E and PD 7974-6, radiant heat fluxes of less than 2.5 kW/m^2 can be tolerated for up to over 5 minutes, after which point severe skin pain can occur. Therefore, 2.5kW/m^2 has been adopted as the tenability criteria from the hot smoke layer.

3.7.4 Fractional Effective Dose

The Fractional Effective Dose index (FED), developed by Purser, is a commonly used measure of human incapacitation due to the combustion gases. The FED value is calculated as

$$FED_{tot} = (FED_{CO} + FED_{CN} + FED_{NOx} + FLD_{irr}) \times HV_{CO2} + FED_{O2}$$

All terms in the expression are evaluated based on integration over time from the beginning of the fire to the time of concern. FED can only be available as a point measurement and cannot be integrated over the escape path.

An occupant would be considered incapacitated when the FED value exceeds unity. A tenability criterion of 0.3 will be used in this assessment based on the guidance of PD 7974.

3.7.5 Summary

The variables considered in this study and their respective tenability limits are summarised below:

Table 3.3 Tenability Limits

Parameter	Tenability limit	Guidance/Reference
Visibility	5m	CIBSE Guide E and PD 7974-6
Temperature	60°C	PD 7974-6
Radiation	2.5kWm^{-2}	CIBSE Guide E and PD 7974-6
FED	0.3	PD 7974-6

3.8 Sensors and Devices

Apart from the smoke detectors and sprinkler heads, additional sensors are provided along the escape route to monitor the conditions. Nine and thirteen sets of sensors (for K01-type and K05-type models respectively) are provided along the escape route at heights of 1.0m, 1.5m, and 2.0m above floor level.

The sensors monitor the temperature, smoke visibility, thermal radiation and the FED. The locations of the sensors are shown in Figures 3-6, on the previous page of this report.

4. Means of Escape

4.1 General

The expected timeline for the means of escape from the apartments has been determined. It should be noted that the values calculated are only estimates, due to the many factors that cannot be accounted for. In the following sections, we outline how these timelines were determined.

4.2 Means of Escape Assessment

The means of escape assessment can be reviewed with respect to the required safe egress time (RSET), which consists of the individual time elements that contribute to the total escape time. Each individual element depends on a range of factors, including detection, warnings and range of parameters affecting occupant evacuation behaviour movement. An example of an escape timeline is shown below, which has been extracted from BS 7974-6:

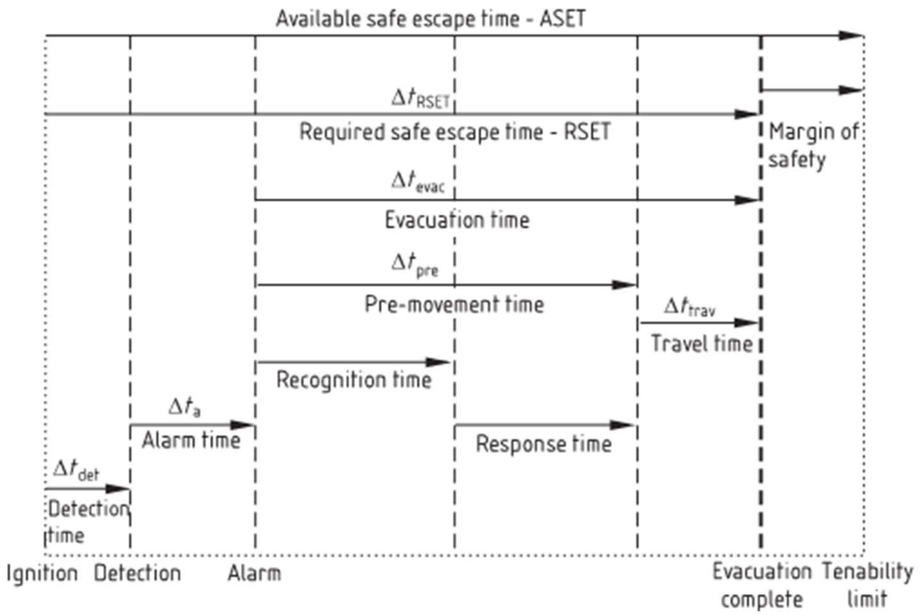

Figure 7. RSET Outline

4.3 Fire Detection and Alarm System

The time taken for the detection system to activate is determined via CFD modelling. This detection times for each scenario ranges from 24s–27s, with an average activation time of 26.2s. The activation time for each model is recorded in Table 4.1.

4.4 Evacuation Time

Pre-movement Time

The evacuation time includes both the pre-movement and travel time, both of which are affected by multiple factors, some of which vary with the occupant, making them difficult to calculate. BS 7974 suggests that pre-movement times could be as high as 15–30 minutes, but this is clearly a very pessimistic and onerous timeline. Due to the enhanced protection present in the proposed apartments, it is unlikely this would occur. As this is a comparative study, the same pre-movement time will be used for all three scenarios. Therefore, it is considered reasonable to use the values from Table E.1 in PD 7974-6:2019. It has been assumed that the pre-movement time for all scenarios will be 5 minutes.

Travel Time

The travel time is the time taken for persons to move from the furthest location in the apartment to the apartment exit. The travel time would be same in all modelled scenarios as the furthest distance does not change. In both the proposed layout and the code-compliant layouts, the longest travel distance will be the furthest point in the living room area to the apartment entrance door. In all cases, the escape route will have to pass through the living room area and by the kitchen and occupants in the worst case will be escaping away from the fire as shown in Figure 7 in Section 4.2 of the report.

As the escape route passes through the living room and the kitchen where the fire will most likely be located, it is considered reasonable to assume that smoke will have started filling up the means of escape route. As smoke spreads, it is more likely to reduce the speed of the occupants escaping, and in addition if the occupants are elderly, they are more than likely to have a slower walking speed. In general, 30% of occupants would likely turn back when smoke visibility is below 2m (PD 7974-6). In this case, as the living room is the only means of escape, they will have to try to escape through the dense smoke. Most may need to bend down to avoid irritant smoke. The walking speed will be of the order of 0.3m/s as travelling in the dark (PD 7974-6).

4.5 RSET Summary

A summary of the required safe egress time is detailed below providing an overall required safe escape time. This information was taken from the above sections:

Table 4.1 Matrix of Runs

Scenario	Detection time (s)	Pre-Movement time (s)	Travel distance (m)	Travel time (s)	RSET time (s)
K01-P – as proposed	25	300	11	37	362
K01-EK – enclosed kitchen area; fire in kitchen	27	300	11	37	364
K01-EO – enclosed kitchen area; fire outside kitchen	27	300s	11	37	364
K05-P – as proposed	27	300	14	47	374
K05-EK – enclosed kitchen area; fire in kitchen	24	300	14	47	371
K05-EO – enclosed kitchen area; fire outside kitchen	27	300	14	47	374

The detection times for all other fires are fairly consistent, with a range of 3s, which is less than a 15% variation in detection time, regardless of the scenario. In terms of the RSET, this small variation is not considered significant.

5. Results and Discussion

5.1 Visibility

The visibility data from the worst affected device in each model is shown in Figures 8 and 9. Note that the plotted data are taken from the worst-affected location in each model and are not necessarily at the same location. As can clearly be seen, the visibility rapidly drops for each of the models; the times at which the visibilities of each model decrease below 5m are summarised below:

Table 5.1 Visibility Summary

Scenario	Tenability failure time (seconds)
K01-P	45
K01-EK	35
K01-EO	42
K05-P	65
K05-EK	48
K05-EO	46

The tenability limit is reached at similar times for the two different apartment layouts, with the proposed open plan model performing slightly better in both cases. It's important to note, however, that the smoke density criteria do not necessary result in a fatality; as soot density increases, a person is more likely to be more reluctant to move through it, however. This is not to say that fatalities due to smoke are impossible, especially in individuals who may have respiratory health issues. The smoke is more likely to affect the occupants escaping; therefore, the radiative heat, FED, and temperature are considered the more important factors to determine the difference between proposed and equivalent code compliant models. It is considered reasonable to assume the occupants would still escape due to size of the apartment and the familiarity of their surroundings.

In the Figures 10-17, the smoke density through the open plan areas is shown for each of the models at 100s and 200s, which shows how the smoke density increases at the roof and descends down as the fire continues to grow. The smoke data in these slices is trimmed between 0m and 5m visibility.

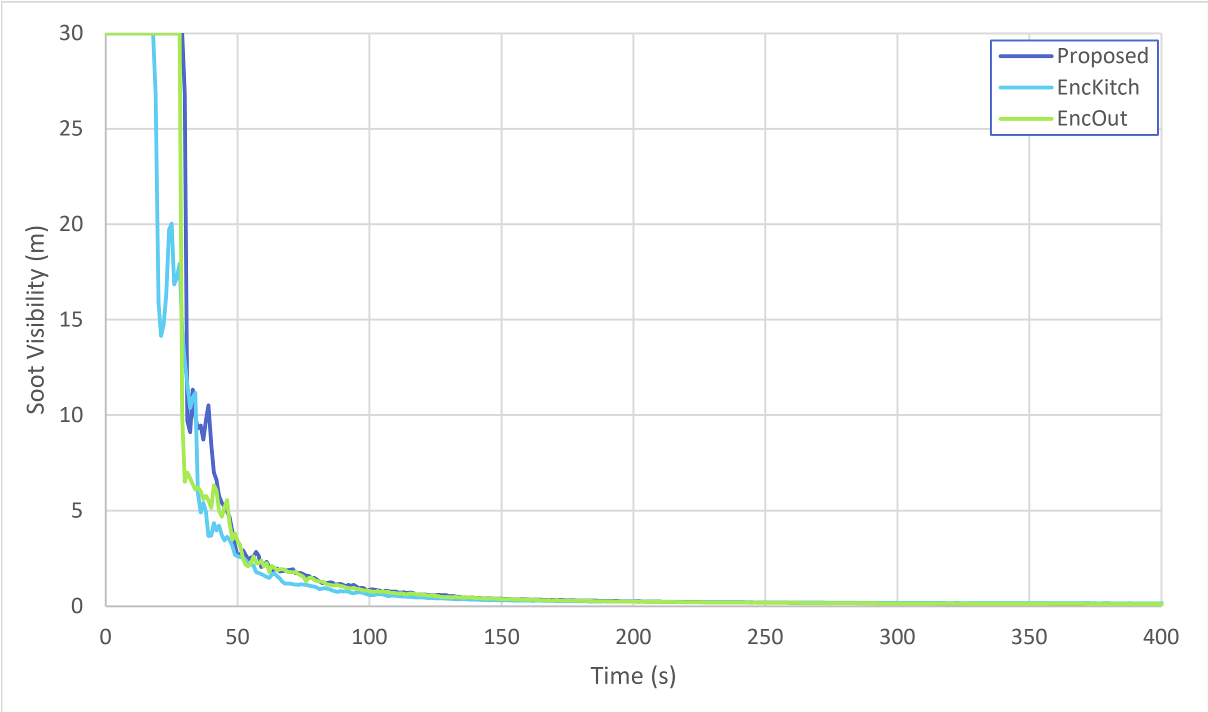

Figure 8. K01 models – Visibility

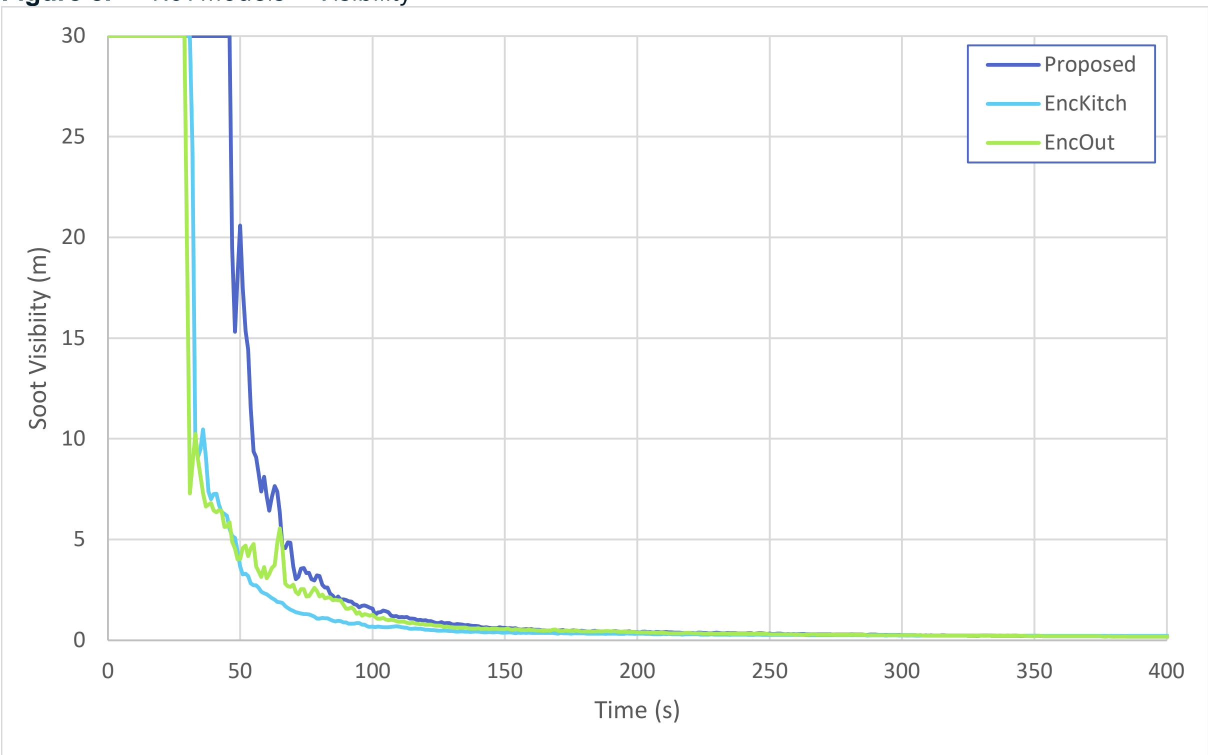

Figure 9. K05 models – Visibility

K01-type Models – Visibility Data Slice

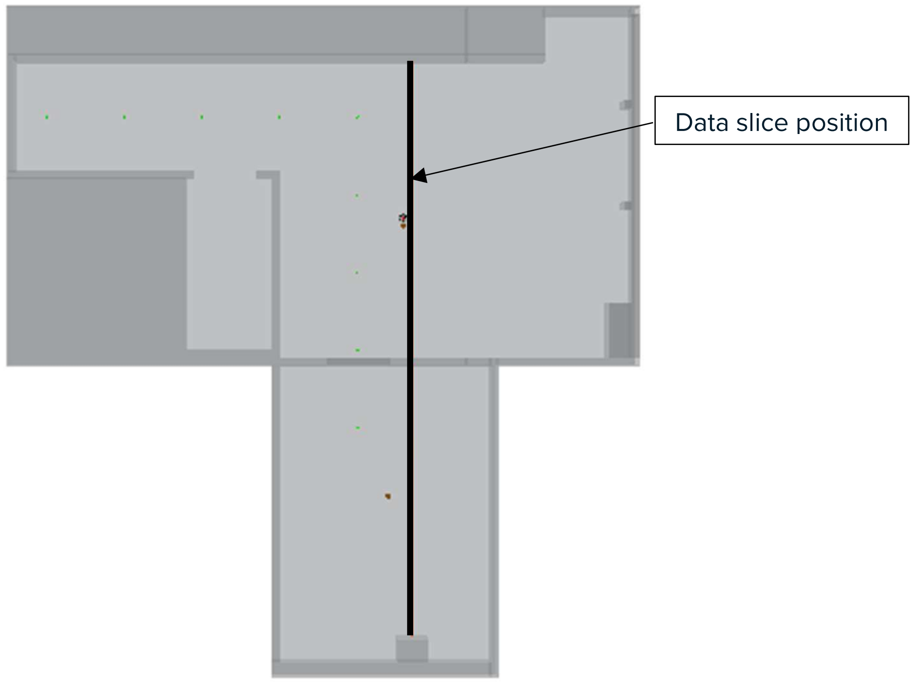

Figure 10. Slice Position for the K01-type models

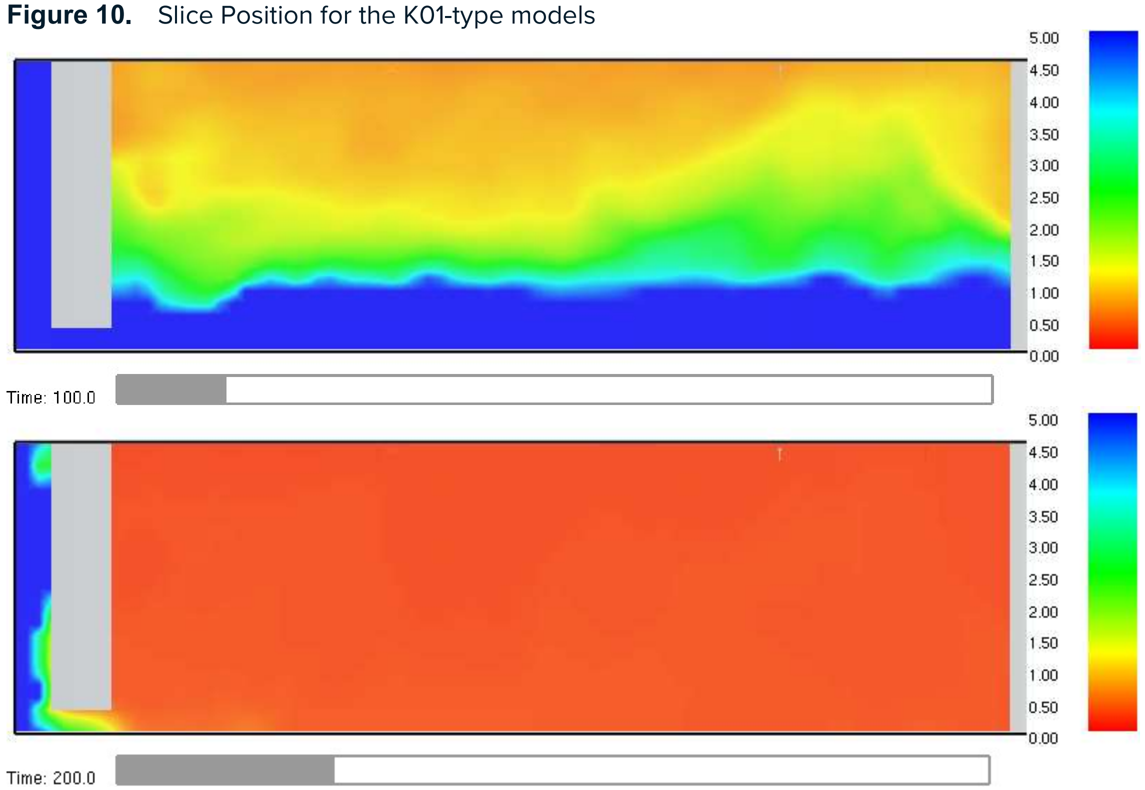

Figure 11. K01-P model visibility slice at 100s (top) and 200s (bottom)

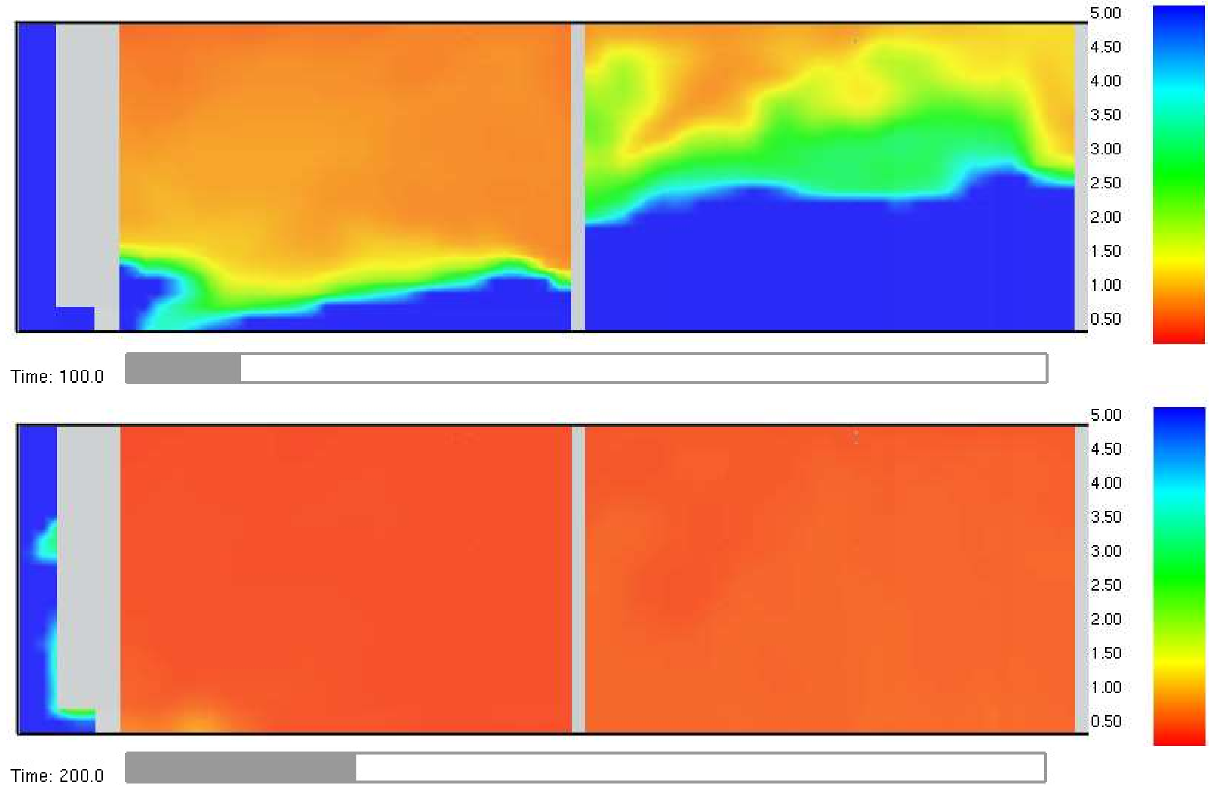

Figure 12. K01-EK model visibility slice at 100s (top) and 200s (bottom)

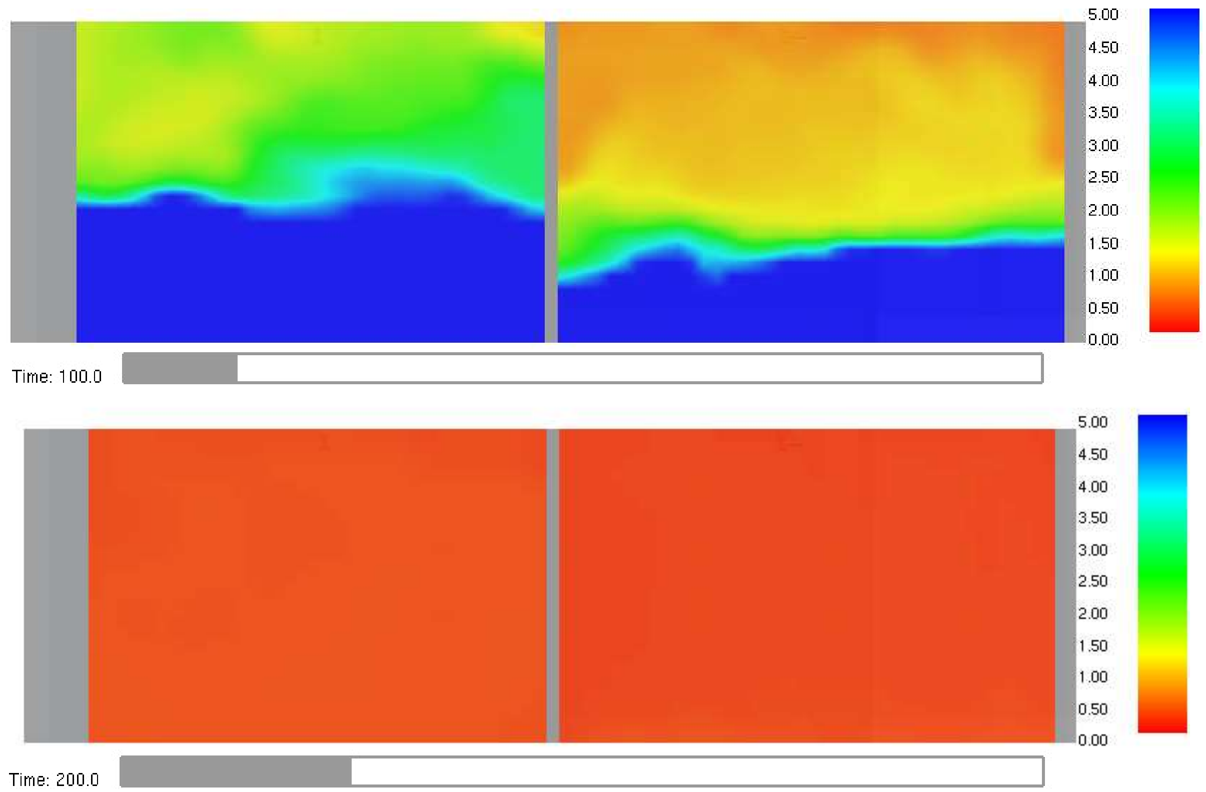

Figure 13. K01-EO model visibility slice at 100s (top) and 200s (bottom)

K05-type Models – Visibility Data Slices

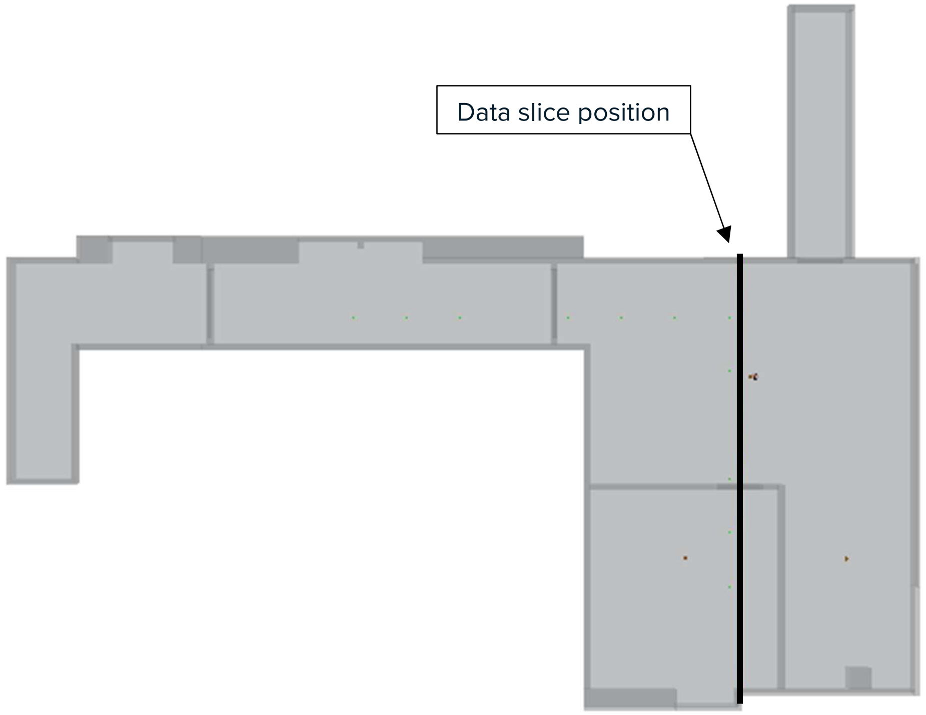

Figure 14. Slice Position for the K05-type models

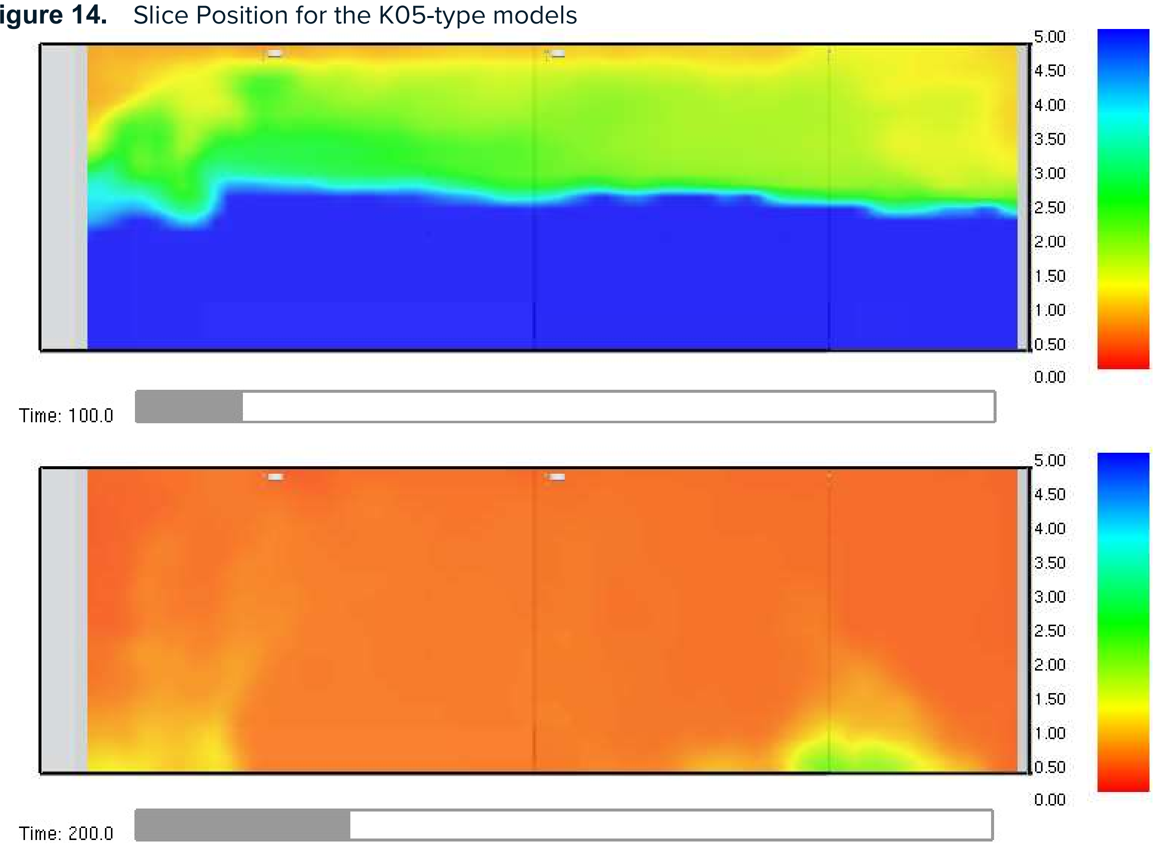

Figure 15. K05-P model visibility slice at 100s (top) and 200s (bottom)

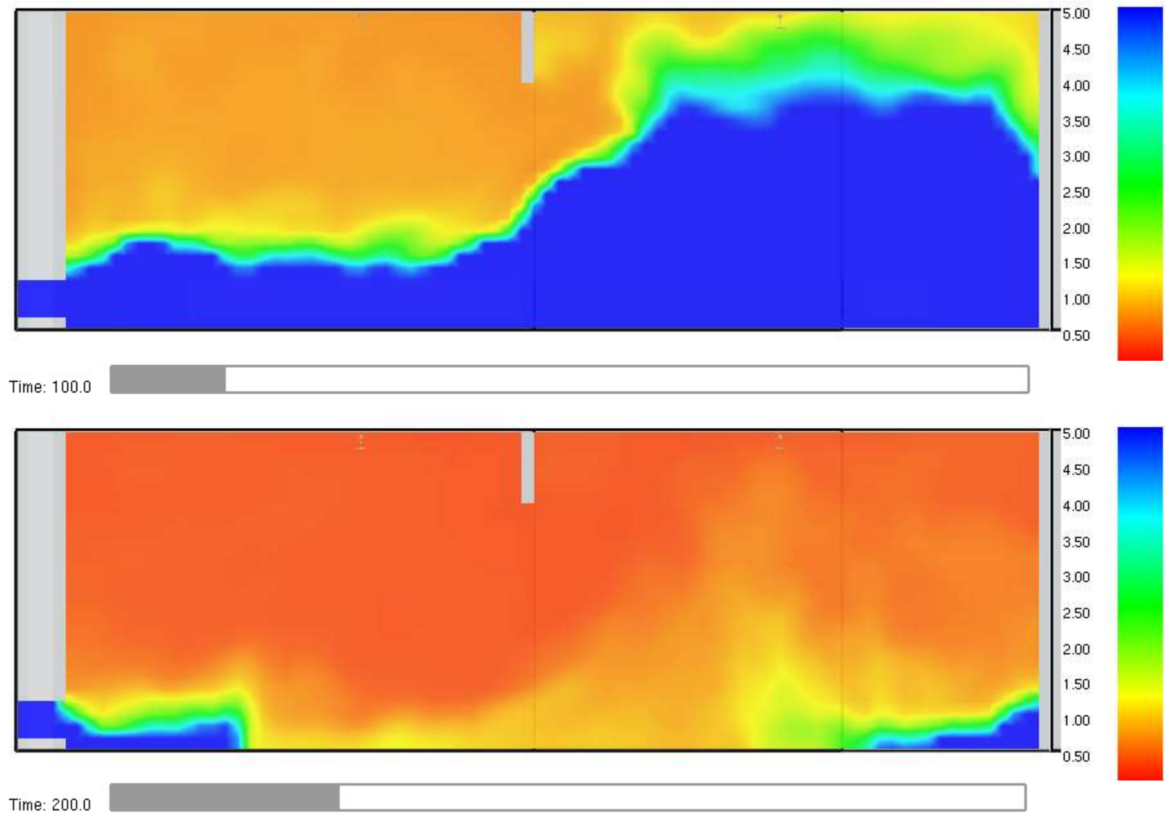

Figure 16. K05-EK model visibility slice at 100s (top) and 200s (bottom)

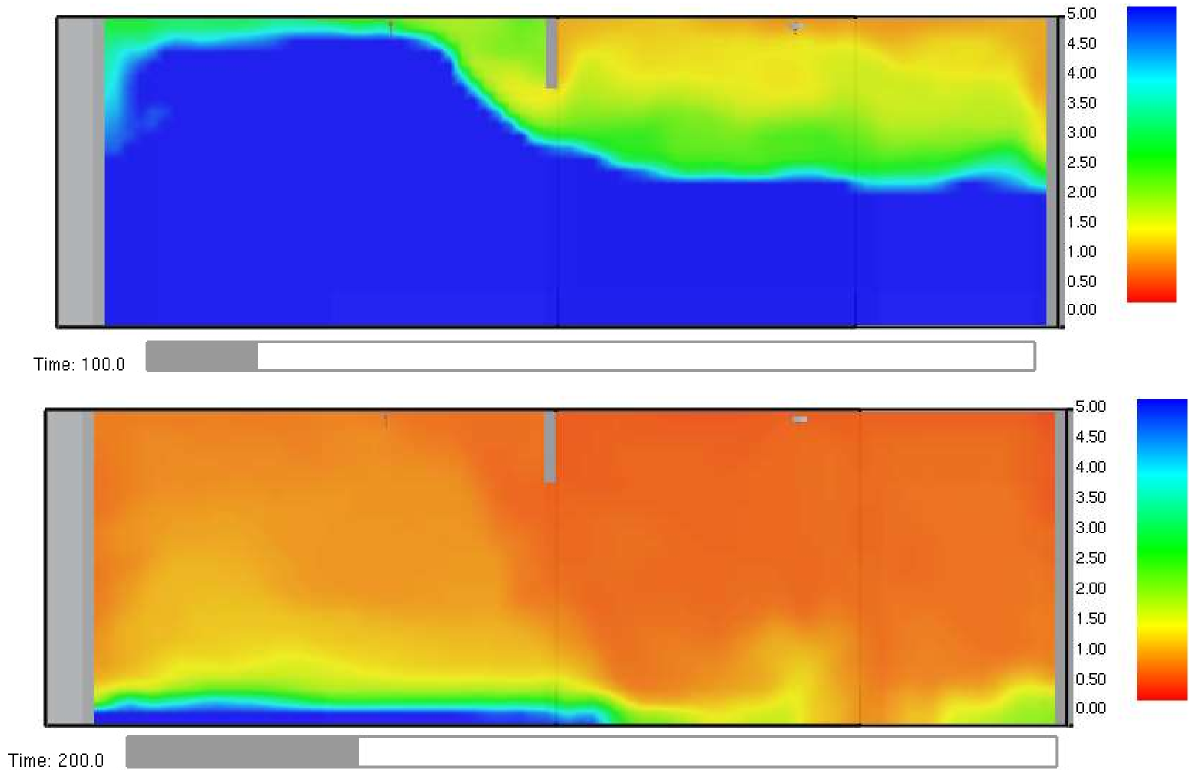

Figure 17. K05-EO model visibility slice at 100s (top) and 200s (bottom)

5.2 Temperature

The graphs below illustrate the comparison of the temperature results for the modelled scenarios. The results for the modelled scenarios displayed on the graphs below have been presented based on the worst-case scenario of each model (i.e., they are not at the same location in each model). Figures 20-27 show the temperature data as a slice through the model geometries and should be used in the case of a like-for-like comparison.

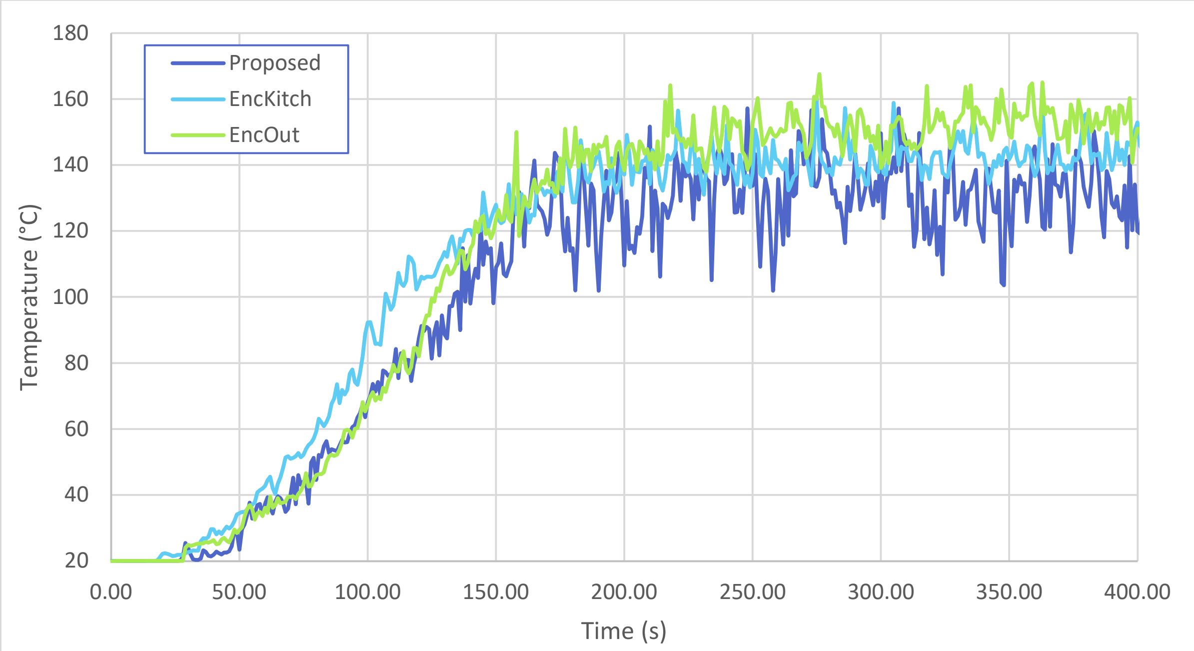

Figure 18. K01 models – Temperature

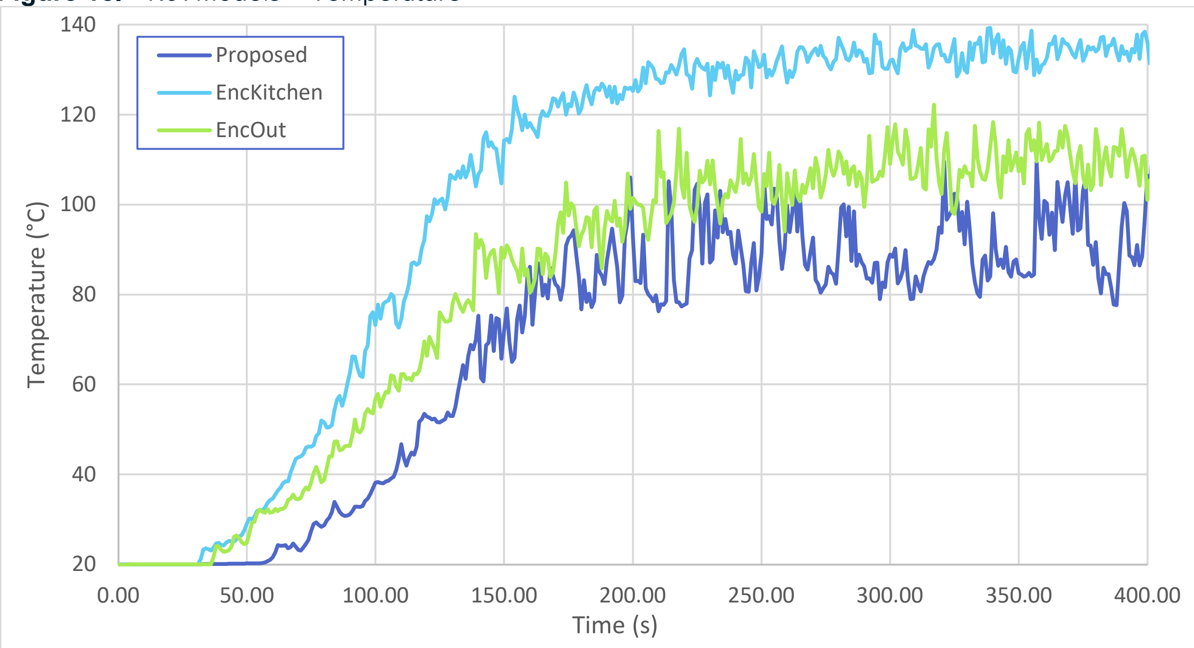

Figure 19. K05 models – Temperature

The table below tabulates the times at which temperatures along the escape route reach the tenability limit of 60°C, and the highest temperatures occurring during the means of escape.

Table 5.2 Temperature Summary

Scenario	Time 60°C is exceeded (s)	Highest Temperature (°C)	Time Recorded (s)
K01-P	93	157	307
K01-EK	80	160	275
K01-EO	94	168	276
K05-P	132	110	321
K05-EK	88	139	339
K05-EO	109	317	122

The temperature at the upper layer exceeds 60°C in 93s for the K01-P model, and within 132s for the K05-P model. It should be noted, however that the code-compliant models all also breach this tenability level even sooner than the respective proposed model (except for K01-EO, which reaches the temperature tenability 1 second slower than the proposed K01-P). These increased temperatures may temporarily cause difficulty to occupants escaping.

The temperature in the code-compliant layouts appear to have slightly higher peak temperature than the scenarios in the proposed layouts; for the K01-type models this average difference is approximately 20°C, while for the K05-type models this average difference is up to approximately 40°C. This is depicted on the table above. It is noted that the temperature results for the proposed layout do exceed the 60°C tenability limit set. However, same is the case the code compliant layouts. The temperatures at lower levels also eventually exceed this tenability limit, but it takes slightly longer; this is illustrated in Figures 20-27.

These images show that the higher temperatures take longer to descend from the ceiling in the proposed model; this is likely due to the hot smoke layer being able to spread thinner across the larger ceiling area in the proposed open-plan layouts. The temperature data slices are trimmed between 20°C and 100°C.

K01-type Models – Temperature Data Slices

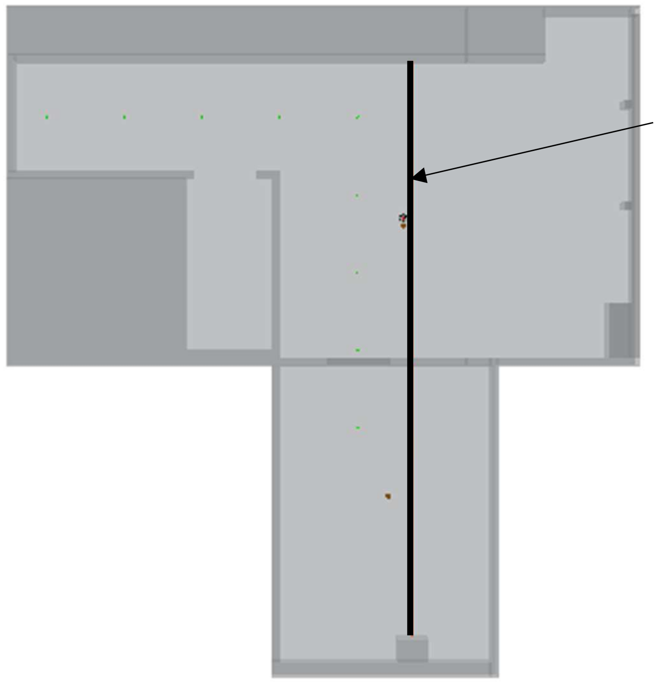

Figure 20. Slice Position for the K01-type models

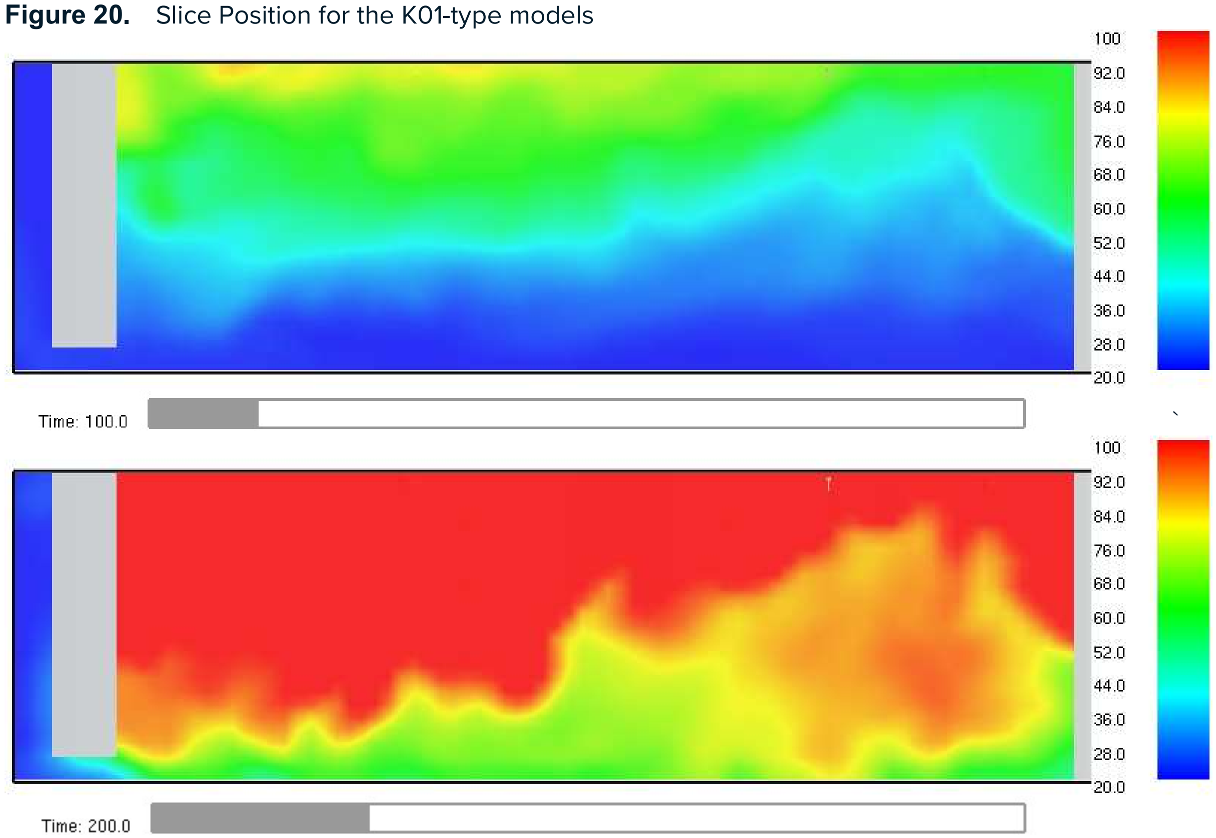

Figure 21. K01-P model temperature slice at 100s (top) and 200s (bottom)

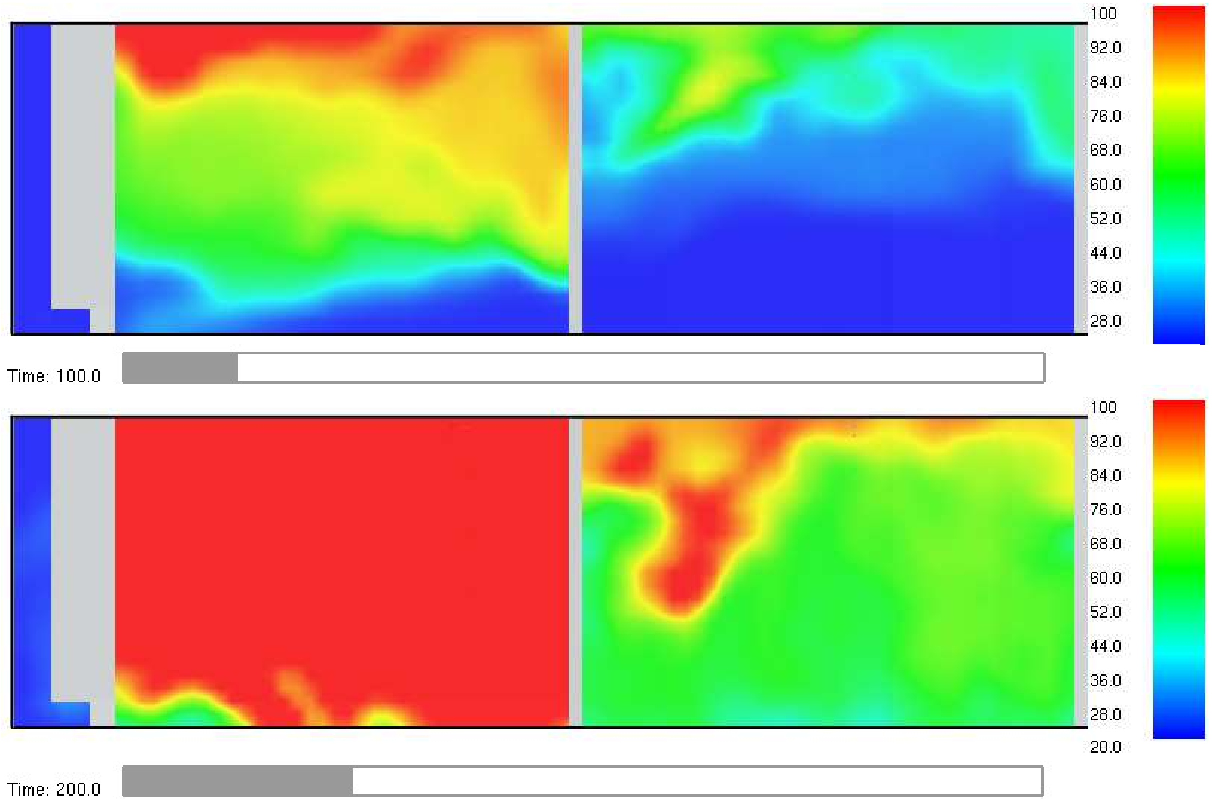

Figure 22. K01-EK model temperature slice at 100s (top) and 200s (bottom)

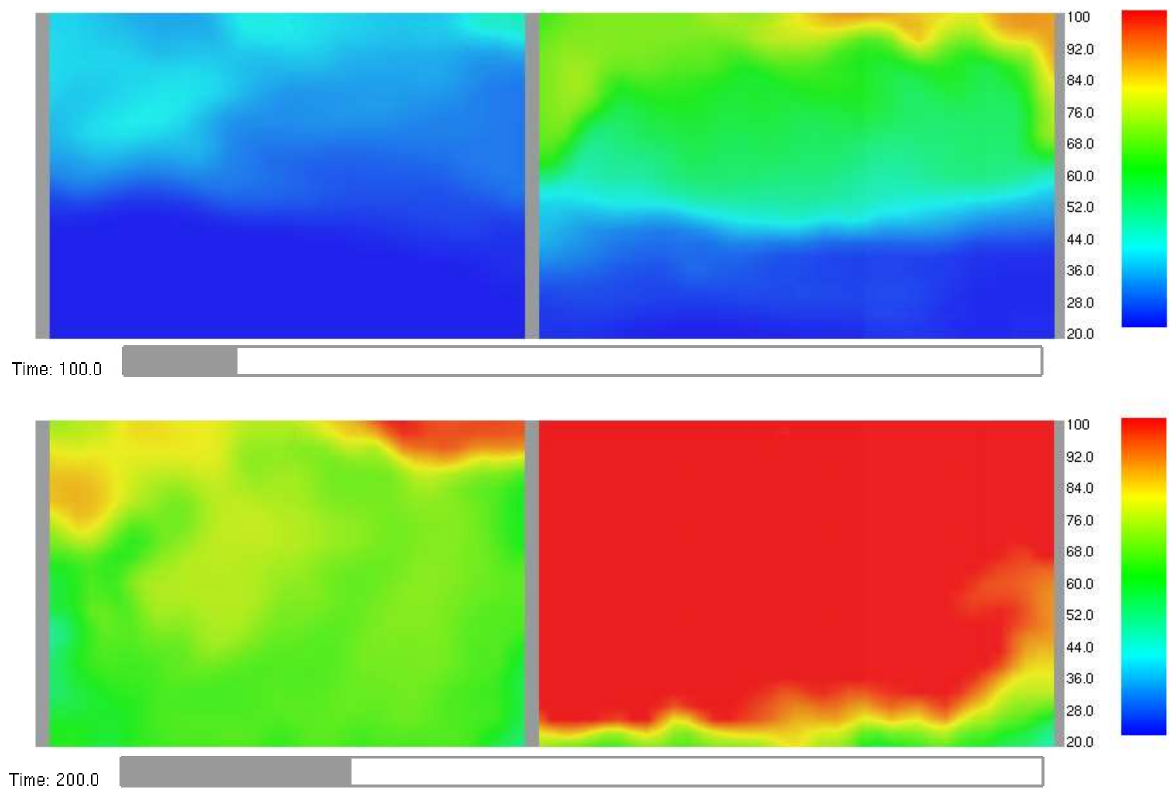

Figure 23. K01-EO model temperature slice at 100s (top) and 200s (bottom)

K05-type Models – Temperature Data Slices

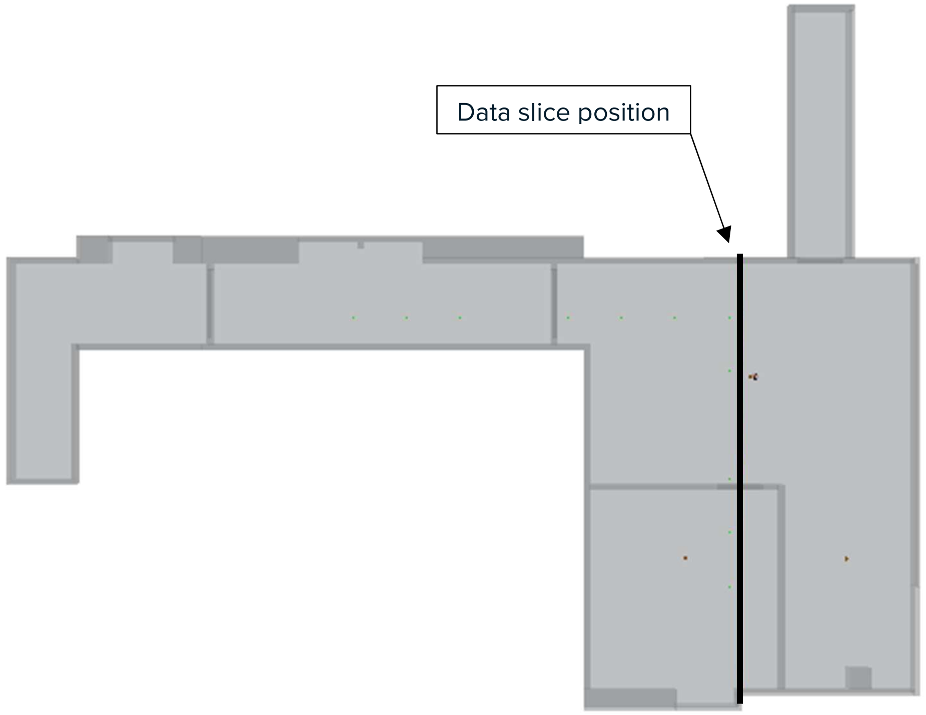

Figure 24. Slice Position for the K05-type models

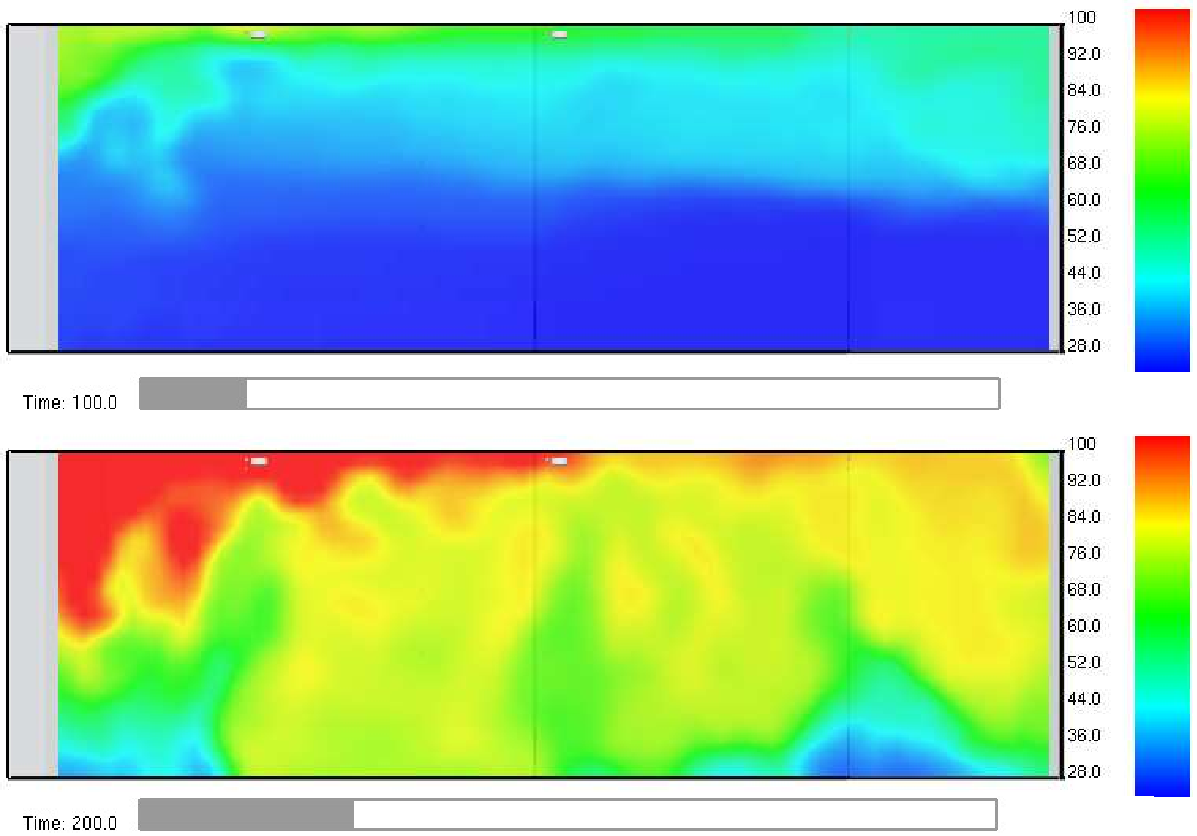

Figure 25. K05-P model temperature slice at 100s (top) and 200s (bottom)

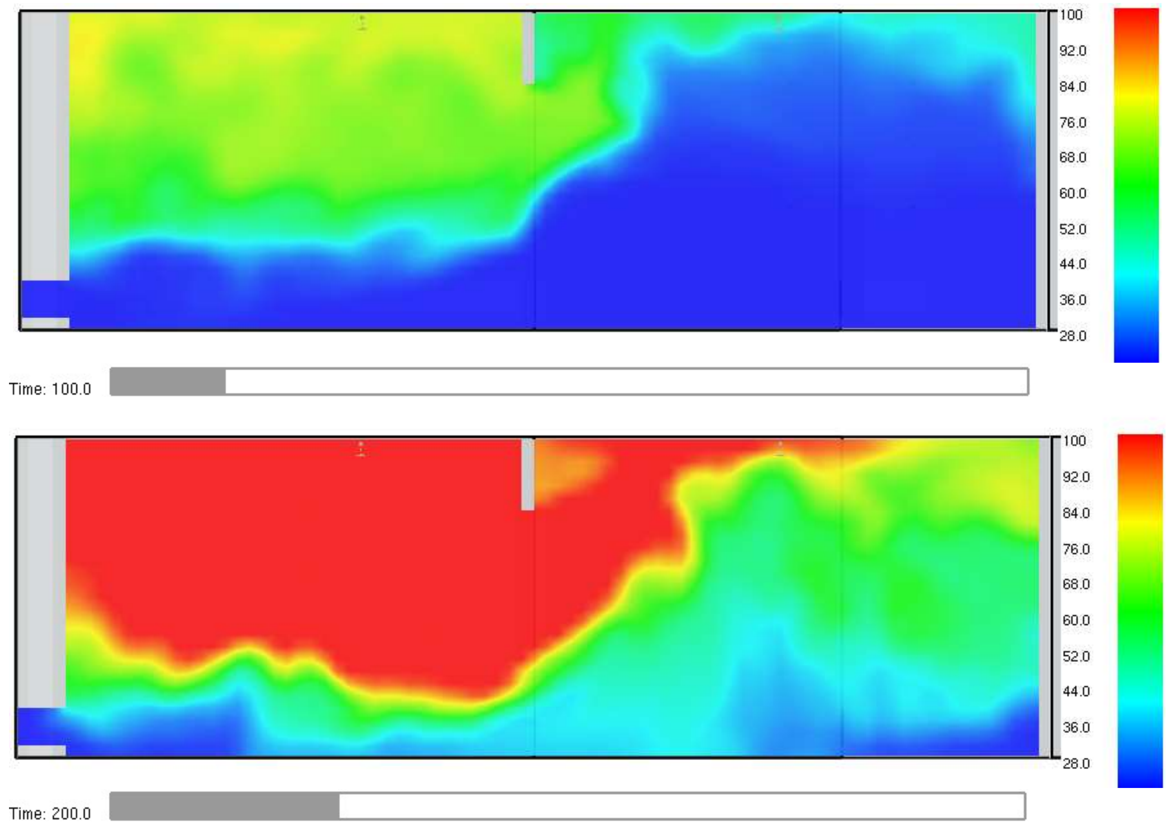

Figure 26. K05-EK model temperature slice at 100s (top) and 200s (bottom)

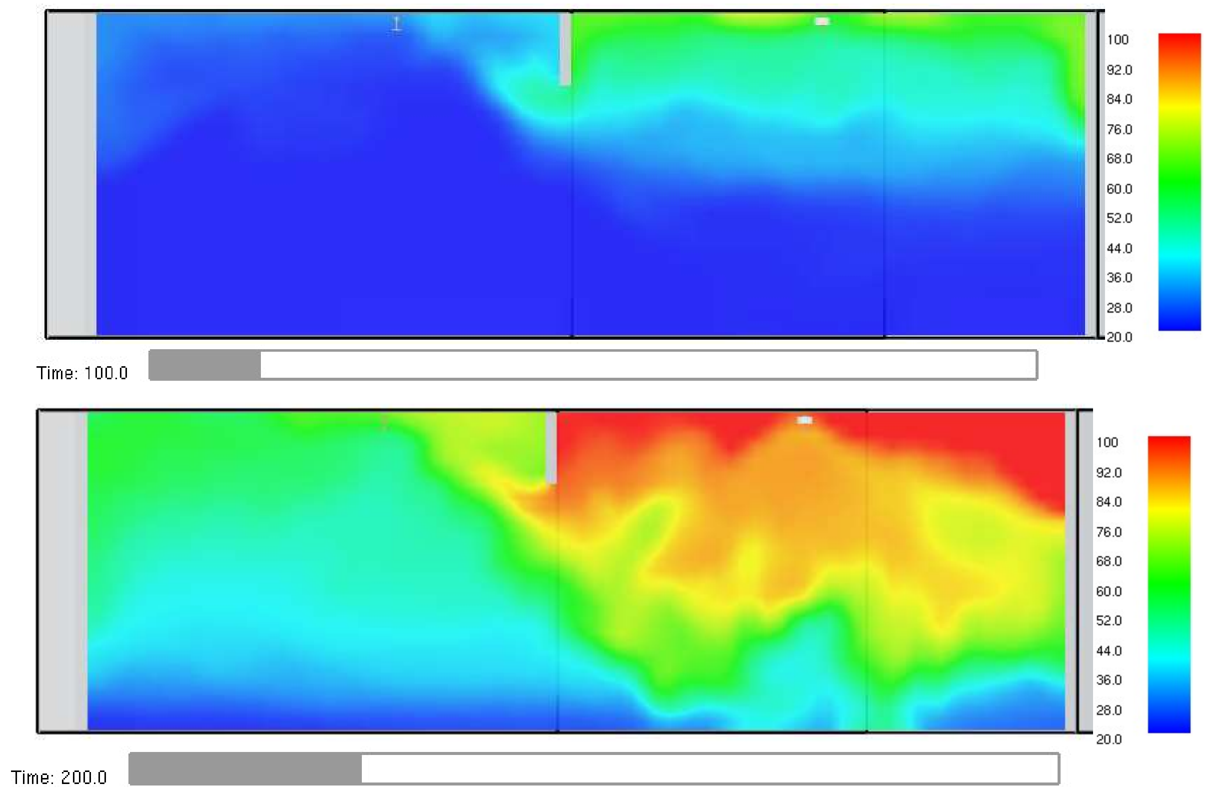

Figure 27. K05-EO model temperature slice at 100s (top) and 200s (bottom)

5.3 Thermal Radiation Flux

The graphs below illustrate the comparison of the results for the modelled scenarios. The results for the modelled scenarios displayed on the graphs below has been presented based on the worst-case scenario of each model (i.e., they are not at the same location in each model).

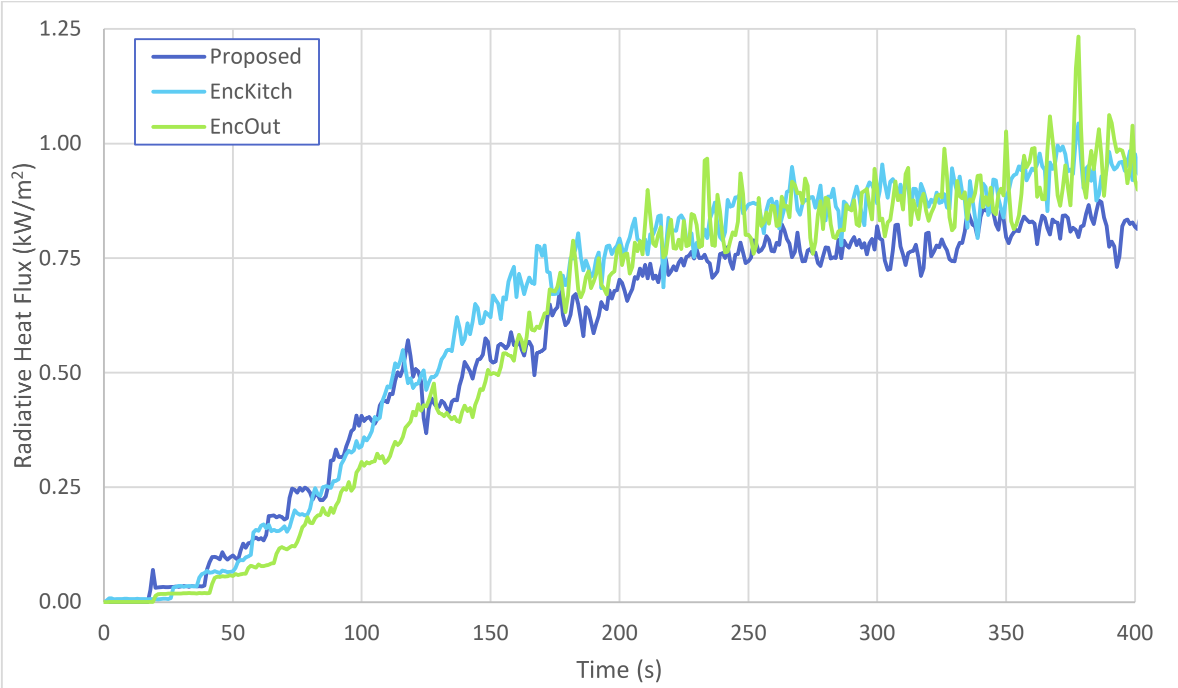

Figure 28. K01 models – Radiative Flux

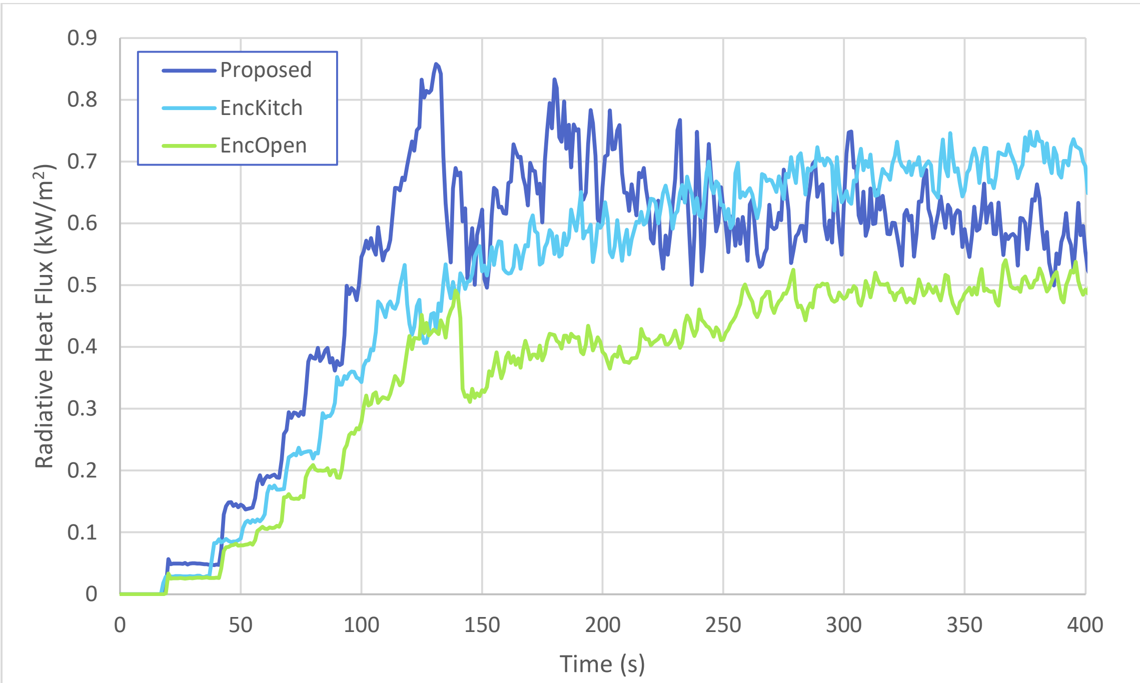

Figure 29. K05 models – Radiative Flux

As can clearly be seen in Figures 28 and 29, the critical level of 2.5kW/m². The figures above show the comparison of the results for thermal radiation levels recorded by the sensors along the escape route for the worst-case scenario. The critical level is 2.5kW/m², which is not exceeded by any of the scenarios simulated. The table below tabulates the times at which the maximum radiation flux is detected.

Table 5.3 Radiative Flux Summary

Scenario	Peak Radiative Flux (kW/m²)	Time of Peak Flux (s)	Tolerable duration (s)
K01-P	0.875	386	179
K01-EK	1.044	378	142
K01-EO	1.233	378	114
K05-P	0.842	133	189
K05-EK	0.748	380	221
K05-EO	0.540	367	340

The radiation flux is lower than the tenability limit of 2.5kW/m² throughout, even for the worst affected detectors. Additionally, any obstruction between the fire and a person (including furniture) will temporarily reduce the amount of radiation incident on an individual.

Additionally, while the radiation flux in the proposed layouts tend to increase slightly quicker during the growth phase of the fire, the average peak flux detected tends to be lower than for the code-complaint versions of the same apartments. It should be noted that the distance between the seat of the fire and the worst affected detector is similar in each case.

The difference between the peak radiation fluxes detected in the K05 models can be seen to occur in the proposed model, which peaks and then gradually decreases. This is the result of the sprinkler positioning. In the two-code compliant K05 models there is a sprinkler between the detector location and the base of the fire, while in the proposed model the detector is between the sprinkler and the fire, and is thus worse effected before the sprinkler activates, Regardless, the relative positions of the sprinklers, size of the apartment, fire, and the escape route are not considered to result in significant differences.

Further assessment has been undertaken as detailed in the figure below to assess the suitability of the radiation recorded at its effect on the occupants. The following equation gives the time that a given level of radiation may be tolerated for:

$$t_{\text{tolrad}} = \frac{r}{q^{1.33}}$$

where:

r is the radiant heat exposure dose [(kW·m⁻²)$^{4/3}$min] required for any given endpoint

q is the radiant heat flux kW.m^-2

If the radiant heat flux is taken to be the peak radiative flux shown in Table 5.3, and the radiant heat exposure dose r=2.5kW/m², then the tolerance times are as shown in the final column of Table 5.3. It is noted that none of the models are able to be tolerated for their expected RSET time, although this additional calculation is extremely conservative in its assumptions, both neglecting the “ramp-up” time of the radiative flux, and assuming that the occupant will be directly adjacent to the fire for this entire duration, which is incredibly unlikely. The peak radiation for the proposed apartment whilst occupants make escape from the apartment past the highest radiative region is tolerable for a period of 179 seconds in the smallest apartment and 189 seconds in the largest apartment. The travel time required in comparison to the exposure that can be maintained at the peak region is significantly less, therefore it is considered that occupants would be able to evacuate safely from the respective apartments.

5.4 Fractional Effective Dose

The graphs below illustrate the comparison of the results for the modelled scenarios. The results for the modelled scenarios displayed in the graphs below have been presented based on the worst-case scenario of each model (i.e., they do not represent the same location in each model). None of the scenarios modelled are close to the tenability level for FED of 0.3, they are all significantly below this critical level. Furthermore, while the FED levels for each apartment type are similar between scenarios, it is noteworthy that the proposed open plan apartments tend to perform better than the code-complaint solutions on average, especially at earlier times.

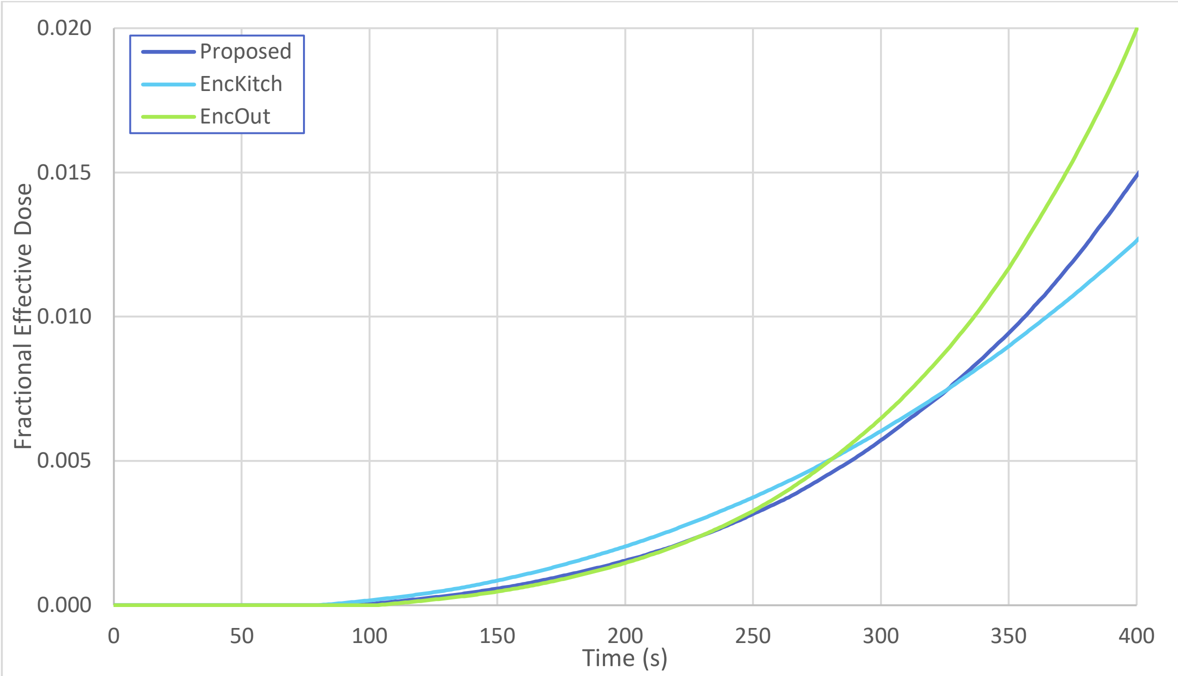

Figure 30. K01 models – FED

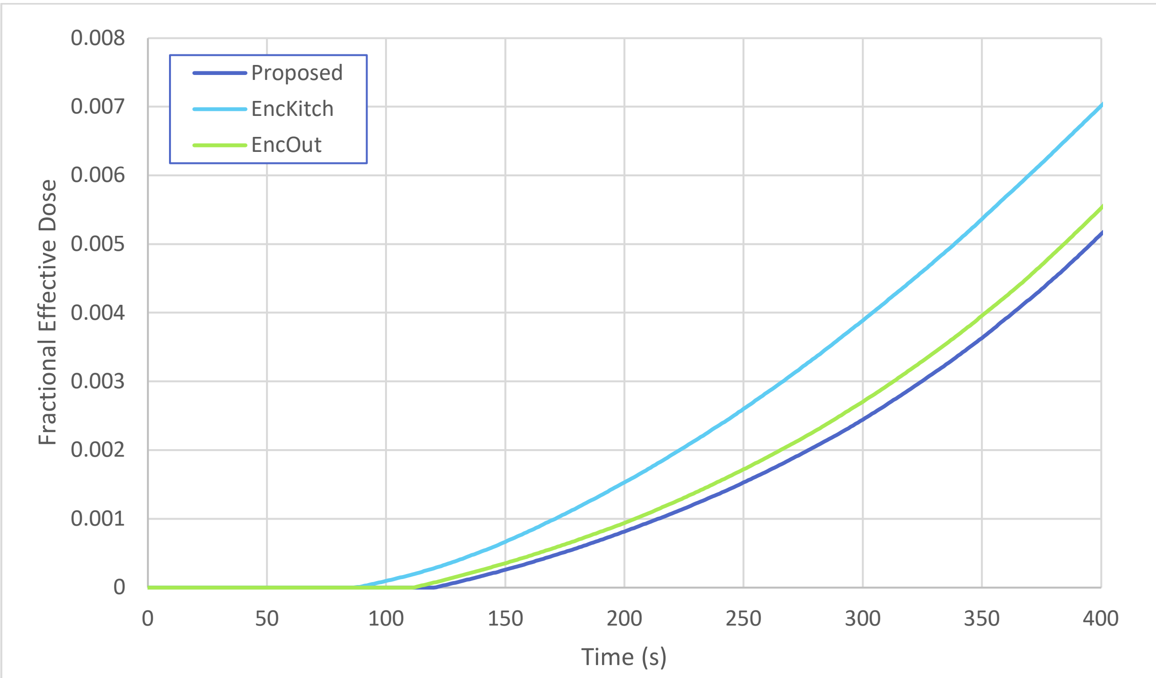

Figure 31. K05 models – FED

5.5 ASET/RSET Summary

The results of the models show the following:

- The visibility levels deteriorate very quickly for each model, with no significant difference in the performance between the open plan and code-complaint models.
- The temperatures exceed the tenability limit at 2.0m above the floor in each model, but the results are better for the proposed layouts than the code-compliant models, with it taking longer for temperatures to descend in the proposed open-plan layouts.
- The FED and radiative flux tenability levels are not exceeded for any model, even at the worst-affected detector for each parameter in each model.
- The positioning of the cooking hobs is ideal; they are most likely to be the source of an apartment fire and are positioned remotely from the escape routes from the apartment.

6. Conclusions

An engineered study has been undertaken on the open plan apartment layouts of the Brill Place residential development, in Camden. The smallest and largest open plan areas (K01 and K05 respectively) were compared against two code-complaint versions of the same apartments, which have enclosed kitchen areas.

It is proposed to provide automatic detection in each room (LD1 and automatic sprinkler system throughout the open plan apartments. The sprinkler system, which should be designed and installed in accordance with BS 9251:2014, would provide protection to the occupants escaping, and in addition the apartment will be afforded with early detection, so occupants will be more likely to escape before combustion products would prevent them doing so. Sprinkler systems are also widely observed to reduce fire spread and decrease fire size, which is a factor reducing fatalities due to fires.

The CFD results show that the proposed open plan apartments are no worse than an equivalent code compliant open plan scenario as both are compromised by smoke and temperature briefly, although no other tenability limit is exceeded. The temperatures at high level exceed the tenability limit in both proposed layout and code compliant models. At lower level, the temperature tenability limit is notably less impacted for the proposed layouts. This demonstrates that the occupants in the code-compliant layout may find it more difficult to escape that those in the proposed layout.

To conclude the report, it is considered that the study does demonstrate that even though the proposed apartment layouts are large open plan apartments with open kitchen, with the benefit of sprinkler and enhanced detection, the proposed apartment layout provided are at least comparable or better than a code compliant layout within BS 9991. Therefore, on this basis, the scenario is considered to fulfil the functional requirements of the Building Regulations.

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Appendix 3. Brill Place Qualitative Design Review

Brill Place, London

Qualitative Design Review

12th April 2021

BB7

BB-QDR-10634 – 01B

Revision History

Version	Date	Author	Comments
01	09/02/2021	Ellis White	Initial Issue
A	26/02/2021	Ellis White	Updated following Building Control Comments.
B	12/04/2021	Conor McBride	Updated following design team review

Document reference
BB-QDR-10634 – 01B

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Contents

1. Introduction

1.1 Project information

1.1.1 BB7 Fire has been commissioned by Henry Construction to produce a Qualitative Design Review in tandem with the Detailed Fire Strategy for the proposed Brill Place development, London. Brill Place is a proposed new build tower, primarily consisting of residential accommodation and a ground floor commercial unit.

1.1 Building Description

1.1.2 The Brill Place development comprises of primarily residential accommodation over 25 stories with a height of c.71m when measured from the lowest adjacent ground to the topmost occupied storey. The development consists of a basement level, ground & mezzanine, and first to 23rd storeys.

1.1.3 The basement level consists of a bike store, bin store and plant areas. The ground floor consists of a residential entrance, substation and small commercial unit.

1.2 Legislation

1.2.1 The Brill Place development will adopt "BS 9991 – Fire safety in the design, management and use of residential buildings" as the basis of the fire safety design of the residential accommodation.

1.2.2 BS 9991 recognises that buildings with a height in excess of 50m pose an increased demand on the design in terms of fire safety functionality for the scheme. As such, where a proposed development exceeds 50m in height, a qualitative design review (QDR) in accordance with BS 7974 should be undertaken to determine whether the recommendations in BS 9991 are appropriate, or whether a full fire engineered solution is required, as per section 0.7 of BS 9991.

1.2.3 The QDR will focus solely on the issues associated with the height of the building and will seek to agree the strategic fire engineering principles to justify the building height and the application of BS 9991.

1.2.4 The Qualitative design review should be read in conjunction with the fire safety provisions listed within the detailed fire strategy for the scheme, these fire safety provisions are informed from the analysis conducted within this Qualitative design review.

1.2.5 The main stages in the QDR are to:

a. Review architectural design and selection of materials including their suitability and fire properties, occupant characteristics and client requirements;

b. Establish functional objectives for fire;

c. Identify fire hazards and possible consequences;

d. Establish trial Fire Safety Engineering (FSE) designs;

e. Set acceptance criteria;

f. Identify method of analysis;

g. Establish fire scenarios for analysis; and

h. Document outputs of QDR.

2. Architectural Review

2.1 Building Characterisation

2.1.1 A full architectural review has been conducted within the detailed fire strategy - BB-DFS-10634-OF-01B. Therefore, this document aims to summarise the key points within the detailed fire strategy.

2.2 Upper Floors

2.2.1 The typical upper floor layout has been highlighted in Figure 1, the smoke ventilation provisions have also been highlighted.

2.2.2 The typical upper floor layout consists of 4 apartments, a ventilated lobby (common corridor), 2 lift cores and a protected stairwell. The 2 southernmost apartments on the typical upper floor are of an open plan layout.

2.2.3 Computational fluid dynamics (CFD) analysis will be undertaken and the results will be issued in a separate report, the purpose of the CFD analysis is to ensure the conditions experienced within a fire scenario within an open plan apartment are equal to or more tenable than if a protected lobby was to be provided.

2.2.4 A BS 9251 system is to be provided to the development (BS EN 16925 in the commercial unit) in all areas except common corridors. In addition to sprinklers, the apartments are to be provided with a Grade D1 LD1 automatic detection and alarm system.

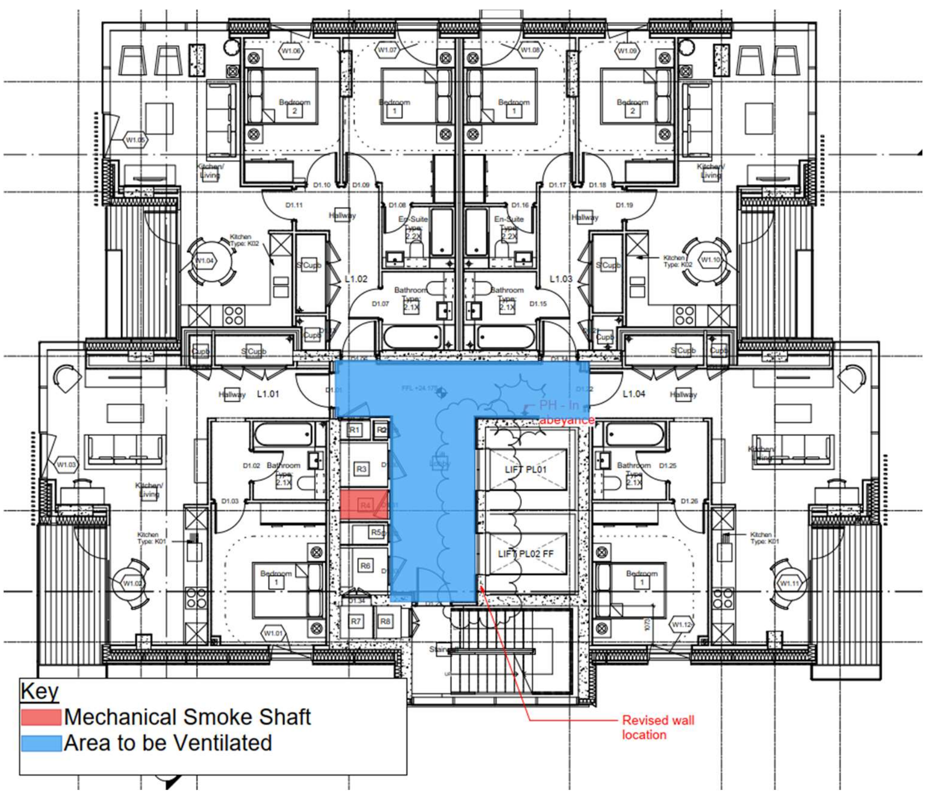

Figure 1. Typical Upper Floor Arrangement

3. Functional Objectives for Fire Safety

3.1.1 BB7 have been appointed to assess the fire safety provision on a life safety basis only, no further property protection or client requirements have been identified.

3.2 Life Safety Functional Objective

3.2.1 The guidance of BS 9991 and related documents can be applied to buildings of any height as many elements of building design remain consistent beyond certain thresholds. However, the potential consequence of fire can increase as building heights increase, which requires further consideration.

3.2.2 The purpose of this report is to address the life safety issues associated with increased building height and to agree strategic principles upon which the detailed fire strategy will be developed to justify them. The aim will be to agree with all relevant stakeholders that the principles discussed within the document are deemed to be appropriate to justify the fire safety design of the building once detailed analysis has been conducted during the development of the detailed fire strategy.

3.2.3 When the life safety criteria is further refined, it can be split into the following objectives;

- The occupants are alerted and able to make their egress from the building in reasonable safety, to a place of relative safety, without being subject to an increased risk;
- Collapse of the building does not endanger surrounding people or fire fighters:
- Fire fighters are able to carry out firefighting operations without undue risk;
- The increased height does not present an increased risk to rapid fire spread;
- Adequate management provisions are in place.

3.3 Fire Hazards & Possible Consequences

3.3.1 The development is generally compliant to BS 9991 with no fire engineered solutions other than the slightly extended basement travel distances and open plan apartment CFD analysis, which is detailed in a separate report. Therefore, the main consideration within this report is the potential increased risk from the building height in excess of 50m.

3.4 Trial Fire Safety Engineering Designs

3.4.1 A trial fire safety engineering design is simply a group of fire safety measures that, in the context of the building parameters, might meet the specified functional objectives.

3.4.2 Due to the open plan nature of some of the apartments at the development, CFD analysis will be undertaken to demonstrate that the conditions experienced within an open plan apartment are equal to or greater than a code compliant apartment. A separate report for the CFD analysis will be produced. The report will include the CFD specification and the justification of the chosen parameters.

3.4.3 The extended travel distances within the basement and the mitigating fire safety elements that demonstrate compliance with the functional requirements of BS 9991.

3.4.4 Due to the performance specification made in the detailed fire strategy, it is deemed that the development is in compliance with BS 9991 and no fire safety engineering solutions have been employed other than the two stated above in 3.4.2 & 3.4.3.

4. Method of Analysis and Acceptance Criteria

4.1 Acceptance Criteria

4.1.1 Acceptance that the functional objectives have been met requires a set of criteria against which as assessment can be measured.

4.1.2 The acceptance criteria should be set as appropriate to the specific scenario under consideration and it should be recognized that elimination of all risk from the effects of a fire is an unrealistic expectation.

4.1.3 The acceptance criteria proposed within this report is that; through comparative analysis, the fire safety provisions within the development, provide conditions equal to or greater than a BS 9991 compliant system.

4.2 Comparative Analysis

4.2.1 Specific criteria that indicate the functional objectives are likely to be met, might already be established in a published guidance document such as ADB or BS 9991. A comparison between the proposals under investigation and a similar code-compliant case may therefore be used to establish acceptability.

4.2.2 This report, in tandem with the DFS and CFD report demonstrate that through comparative analysis the Brill place development meets the established criteria specified within BS 9991.

5. Fire Scenario Analysis

5.1.1 The following items below identify and analyse possible scenarios where a fire could lead to an increased risk on the occupants due to the height and identifies mitigating factors that have been incorporated in the development.

5.2 Open Plan Flat Layout

5.2.1 Due to the kitchen areas not being enclosed within the open plan apartments and having an area exceeding 8m x 4m, Computational Fluid Dynamics (CFD) analysis will be undertaken to determine that the conditions within an open plan flat remain tenable in accordance with a code compliant layout. The CFD analysis will be produced within a separate report.

5.2.2 PD 7974-6 identifies tenability acceptance criteria, that should be met within an open plan apartment during CFD analysis. The required acceptance limits and criteria for assessment are detailed below;

- Visibility equal to or greater than 5m;
- The tenability limit for temperature will be defined as 60°C;
- In terms of toxicity, 0.3 Fed will be considered as the tenability limit;
- PD 7974-6 identifies the tenability limits for thermal radiation, stating that people can tolerate exposure to radiation levels of 2.5kw/m^2 for up to 30 seconds, and levels of 10kw/m^2 for just 4 seconds.

5.3 Fire load

5.3.1 The Brill Place development is primarily a residential development and as such there are no areas of increased fire loading. The development consists of several plant areas, however these will be provided with a high level of compartmentation and sprinkler protection.

5.4 Increased Egress Time Due to Height

5.4.1 As the development is over 50m in height, this can impose an increased time for occupants to reach the final exit to the external.

5.4.2 However, the floor plate at the development is small, containing 4 or less apartments per floor, providing BS 9991 compliant travel distances and shorter egress times.

5.4.3 The apartments are provided with a grade D1 LD1 automatic detection and alarm system, leading to faster detection times.

5.4.4 The development will be provided with a BS 9251 category 3 sprinkler system with an increased duration of 60 minutes, the sprinkler system will control the fire and reduce the impact of smoke spread, allowing more tenable conditions for the occupants.

5.4.5 Additionally, the travel distances within the common corridors are compliant to BS 9991 and are ventilated through a mechanical smoke extract shaft. The ventilation system is served by a secondary power supply. The ventilation system ensures the common corridor is tenable for occupants to make their egress by reducing the level of smoke present.

5.4.6 The increased height of the development results in an extended travel distance within the fire-fighting stair. However, the stair is a place of relative safety and will not be subject to smoke ingress due to the mechanical smoke extraction system, additionally, the stair is provided with 120min structural fire protection.

5.4.7 Due to the small floor plate and the familiarity of residents with the layout of the building it is not proposed to provide additional wayfinding signage above the recommended wayfinding signage as required under Approved Document B.

5.4.8 Management should provide information packs to residents highlighting the evacuation regimes, evacuation lift strategy and the fire safety systems in their apartments, as per the recommendations made for Regulation 38 compliance, stated in the detailed fire strategy.

5.5 Structural Engineering

5.5.1 The fire severity which is used to determine the fire resistance of total burn out of flats is deemed to be 60 mins, this has no reliance on sprinklers. This has served as a good measure over the years and there has been no revision to the requirement in the latest ADB (May 2020 amendment) which has been under significant scrutiny since Grenfell.

5.5.2 The fact that high rise buildings offer twice this rating to the structure and also provide enhanced sprinklers with a 60 minute duration, should limit the fire from reaching flashover temperatures at which the overall structure would be threatened. It is therefore considered that there is no need to increase the structural fire resistance beyond 120 mins.

5.5.3 Structural engineers would typically design for disproportionate collapse and as such it is highly unlikely that the building will collapse due to fire, this should be confirmed by the structural engineer.

5.5.4 Additionally, the structural engineer should confirm if there is any inherent uplift of the structure due to the loading calcs i.e. it may be that the loading dictates thicker floors and columns and as such these may actually provide ratings in excess of 120 mins.

5.5.5 BS 9991 permits developments with a height of less than 30m to reduce the applied structural fire resistance from 90 minutes to 60 minutes through the provision of a BS 9251 category 2 sprinkler system with a duration of 30 minutes, therefore, as we are proposing 120 minute structure together with a 60 minute sprinkler duration the structure is in excess of that required for a similar building less than 50m in height.

5.6 Sprinkler system

5.6.1 The Brill place development is to be provided with a BS 9251, 60 minute category 3 sprinkler system to the residential areas, complete with standby pump and a secondary power supply. A category 3 system is a significant increase over a 30 minute category 2 system and will provide greater time for the occupants to escape, reduce the likelihood of rapid fire spread internally and externally and also provide the fire service with greater time to establish a bridgehead to fight the fire.

5.6.2 In line with BS 16925 areas of the building that are not residential occupancies but not greater than Ordinary Hazard as defined in EN 12845 may be protected with quick response type sprinklers in accordance with EN 12259-1.

5.6.3 The sprinkler designer will need to ensure that all relevant pressures and flows are achievable and will determine if additional booster pumps are required given the height of the building.

5.7 Internal Fire Spread

5.7.1 The internal fire spread is limited by the following measures;

- Limiting the combustibility of wall and ceiling linings;
- Provision of comprehensive compartmentation;
- Presence of a BS 9251 Sprinkler system (Residential areas):
- Presence of a BS 12845 Sprinkler system (Commercial areas):
- Provision of fire stopping to service penetrations through compartmentation lines.

5.8 External Fire Spread

5.8.1 The external facades of the Brill place development are to consist of an external wall build-up of products and materials in accordance with European Class A2-s1, d0 or better and in accordance with Regulation 7(2) and 7(3).

5.8.2 It is understood that an agreement has been reached with the council that will prohibit any building works on the surrounding park area and therefore the boundary distances can be increased as to warrant 100% unprotected areas on the external façade.

5.9 Risk to Firefighting Operations

5.9.1 Due to the extended building height, if a fire was to occur on the upper floors, this would lead to an increased timeframe in which the Fire Service could commence firefighting on the floor of fire origin.

5.9.2 However, the sprinkler system has been increased to offer a 60 minute operation period, as such a fire would be controlled for at least 60 minutes allowing the fire serve to establish firefighting operations whilst the sprinkler system is still in operation.

5.9.3 The development is also served by a wet riser system, which offers a benefit over a dry riser system in that the riser does not have to be charged and the riser water supply is instantly available for operation.

5.9.4 Both the sprinkler system and wet riser system shall be provided with back-up pumps and a secondary power supply.

5.9.5 The building is also to be provided with wayfinding signage for the Fire Service, and a premises information box.

5.9.6 The development is also to be served by Fire-fighting lift enabling the Fire Service to establish a fire-fighting bridgehead on the upper levels.

6. Conclusion

6.1.1 Table 6.1 provides a summary of the fire safety enhancements present at the Brill Place development against the code compliant provisions for a development below 50m in height.

Table 6.1 Additional Measures Summary

Fire Safety Provision (Less than 50m)	Brill Place Fire Provision
120min structural fire resistance	120 min structural fire resistance and 60 min sprinkler duration (which in building below 50m can allow structural fire resistance reduction)
BS 9251 category 2, 30 min sprinkler system.	BS 9251 category 3, 60 min sprinkler system, with standby pump and secondary power supply.
Dry riser system	Wet riser system.
Provision of an escape stair.	Fire Fighting shaft complete with firefighting lift.
Smoke ventilation provision	Mechanical smoke extraction shaft complete with standby extraction fan and secondary power supply.
Residential fire Loads	Residential fire loads(no increase in fire load due to height).

6.1.2 BS 9991 places a requirement on the design team to perform a qualitative design review of the fire safety provisions where a building exceeds 50m in height. The main emphasis of this report is to identify where the increased height may lead to increase risk to the development.

6.1.3 The height of the Brill Place development does not have any bearing on the likelihood of a fire in any individual apartment, and similarly the fuel load within the apartments does not increase with building height. The main concern is to limit the impact if fire occurs, as the consequence of rapid fire spread, smoke spread or structural collapse is greater.

6.1.4 The development is compliant to BS9991 with no fire engineered solutions other than the slightly extended basement travel distances and open plan apartment CFD analysis, which will be detailed in a separate report. Therefore, the main consideration within this report is the potential increased risk from the building height in excess of 50m.

6.1.5 This report has identified areas of increased risk and identified acceptable functional objectives required to meet a level of fire safety equal to or greater than a BS 9991 compliant building of under 50m.

6.1.6 Through the recommendations made within this report, the CFD analysis of the open plan apartments and the detailed fire strategy, BB7 believe the Brill place development offers a level of fire safety commensurate of a BS991 development under 50m.

6.1.7 The qualitative analysis presented within this report represents an approvals risk, as such these should not be relied upon for design until approved by the relevant approvals body, be this the Fire Service and Building Control.

6.1.8 This report will be discussed with the appointed Building Control representative and should be issued for agreement in principle with the Fire and Rescue Service.

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Appendix 4. Boundary distance agreement

From: Oliver Jefferson <oliver.jefferson@turley.co.uk>
Sent: 06 May 2021 15:29
To: Hugh Griffiths <Hugh.Griffiths@lbsp.co.uk>
Subject: Brill Place

Dear Hugh,

I write with regards to the prospect of new built form being permitted within proximity of the Brill Place tower.

Brill Place is situated within protected Public Open Space (Purchese Street Open Space, no.88). Local Plan policy A2 states that the Council will protect all the designated public open spaces indicated on the Policies Map (which is the case in this instance). The only exception to this is where equivalent or better provision of open space is provided.

Brill Place was permitted as a development within the Public Open Space under exceptional circumstances as part of a comprehensive master-planned approach to the Central Somers Town Community Investment Programme scheme. This ensured that there was no overall loss of Public Open Space. In fact there was a slight increase and there were benefits to the quality of the space following development. The application was approved in the context of the substantial public benefits of the proposals, which included affordable housing, a school and community facilities. The development was only able to ensure no loss of open space because of the specific circumstances of the case, whereby the Local Authority was able to coordinate a masterplan across a wider area which included the release new open space through relocation and reduction of the site area of an existing school. These circumstances will not arise again.

In addition, there are other significant policy and design restrictions which would prevent new built form close to the Brill Place tower. The Local Plan (Policy A1) protects the privacy and sunlight & daylight amenity of residential occupiers. Camden Planning Guidance – Amenity (2021) sets out a minimum separation distance of 18m from residential habitable room windows and balconies to neighbouring residential or non-residential properties. There are residential windows on all facades of the building. Daylight and sunlight requirements, based on the methodology of the Building Research Establishment, would also preclude new development within close proximity to residential properties.

For these reasons we consider there is no prospect of future development close to the Brill Place tower.

Regards,

Oliver

Oliver Jefferson
Director

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