APPENDIX B DISTANCE FROM COOKING APPLIANCE

B.1 Supporting calculations and information

By using the widely adopted SFPE Point Source Model calculations[45], it is possible to predict the thermal radiation field of flames from a point source located at the centre of a real flame.

In comparison, researched information shows a clear benefit when cooking fires are controlled with an AWFSS whether that be a misting or sprinkler system. It was observed from 4no. tests performed 13 on pan fires using water mist that discharge generally occurred around 2 minutes.

The peak HRR remained below 45kW before water mist discharge, however it should be acknowledged that the flame was enhanced and, in some cases, generated a higher HRR and heat flux for a short period after the water mist was discharged. It can be seen in Figure 16 that the peak HRR spiked to approximately 630kW and 870kW momentarily for two out of the four tests performed but quickly reduced and became controlled to approximately 40kW following the transitory spike.

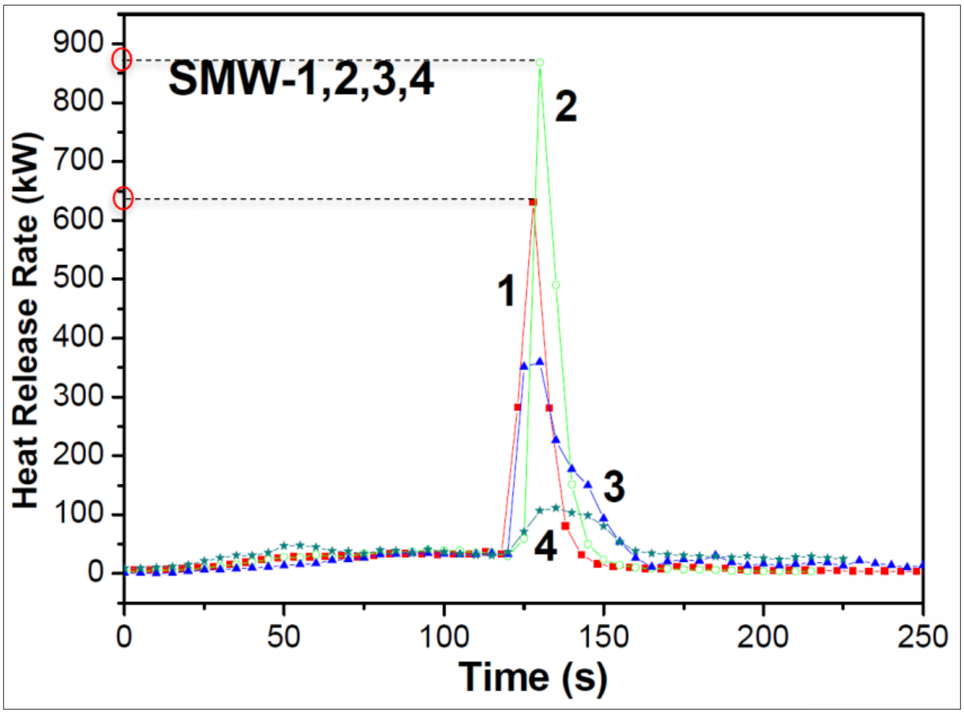

Figure 16 - Heat release rate measured for pan fire and suppression with water mist

The peak cooking oil temperature ranged between 391°C and 418°C while the recorded flame temperature ranged between 446°C and 464°C for three of the four tests. The fourth test (SMW-4) had an elevated peak flame temperature of approximately 722°C and likely attributed to having a lower pressure head with low momentum and reduced nozzle height at 1.5m in comparison to tests SMW-1 to SMW-3 at 1.8m. With reduced pressure, the water mist might not have passed the flame to reach the burning oil surface.

It was further concluded from the tests carried out that the water mist performed well in suppressing cooking oil fires, however there remained safety concerns including flame enlargement and oil spill that should also be taken into consideration.

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[45] SFPE Handbook of Fire Protection Engineering, Fifth Edition, Volume II, Chapter 66, Fire Hazard Calculations for Large, Open Hydrocarbon Fires, Page 2601-2605.

For this assessment, it is proposed that the HHR value will be 870kw.

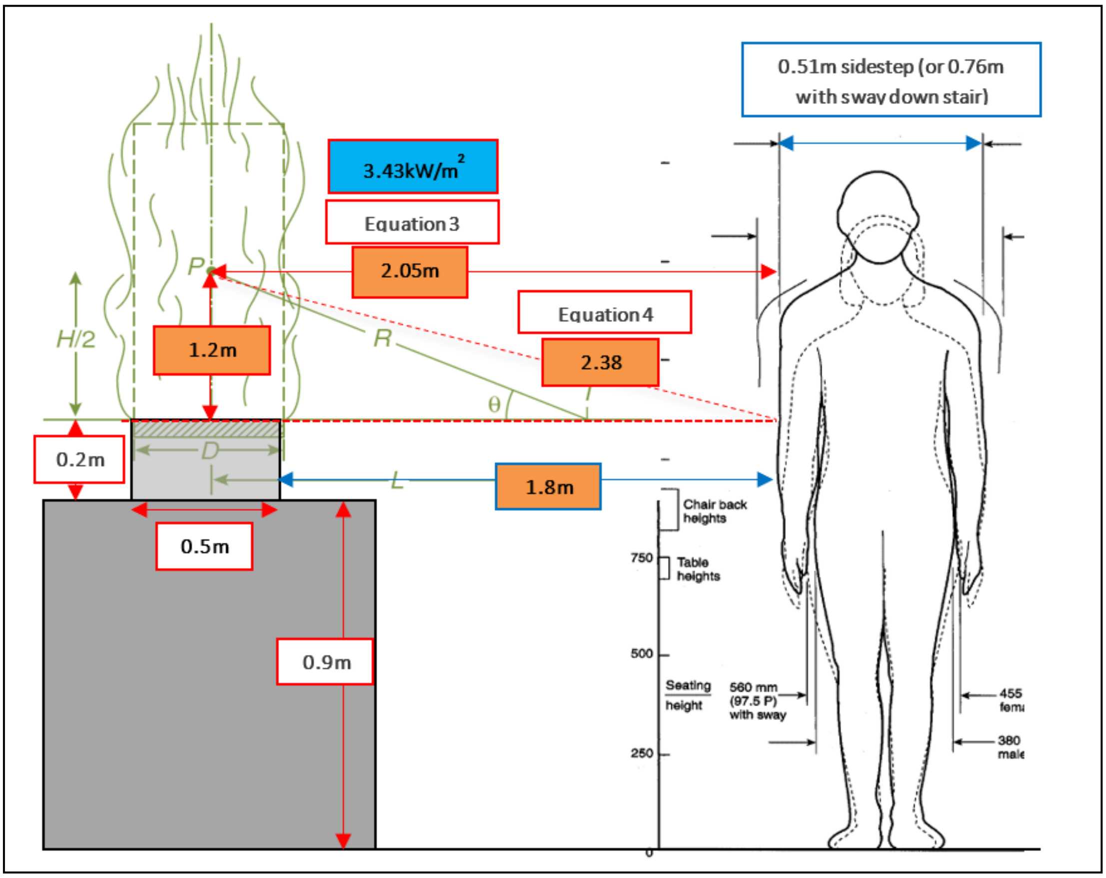

Figure 17 - Notional section through fire scenario

Notes:

- Distance between pan and occupant = 1.8m
- Midpoint of flame = 1.2m
- Calculation based on 0.51m sidestep for escape path and equation will need modification if that distance is changed.

Equation 1 – Flame height (SFPE 66.13)

$$H = 0.235\dot{Q}^{2/5} - 1.02D$$

Where:

H =	the flame height (m)	2.4 m
Q =	the heat release of the pool fire (kW)	870 kW
D =	the diameter of the pool fire (m)	0.5 m

However, H= 1.4m used for assessment based on ceiling height (Typical floor to ceiling heights within apartments is 2.5m, therefore the actual flame height would be restricted by either the cooker hood or apartment ceiling. For this reason, it is proposed to adopt a lesser flame height of 1.4m (2.5m – (900mm appliance + 200mm pan)).

Equation 2 – Radiative energy output (SFPE 66.15)

$$\dot{Q}_r = \chi_r \dot{Q} = (0.21 - 0.0034D)\dot{Q}$$

Where:

Q_r =	Total radiative energy output of the fire	181.22 kW
x_r =	0.21 – 0.0034D	0.21
Q =	the heat release of the pool fire (kW)	870 kW
D =	the diameter of the pool fire (m)	0.5 m

Equation 3 – Incident radiative heat flux (at mid point of flame) (SFPE 66.12)

$$\dot{q}'' = \frac{\dot{Q}_r \cos\theta}{4\pi R^2}$$

Where:

Q_r =	Total radiative energy output of the fire	181.22 kW
cosΘ =	1	0 degrees
R =	Distance from the point source to the target. The location of the equivalent point source, P, is at the centre of the pool fire and mid-height of the flame.	2.05 m
q" =	Incident radiative heat flux	3.43 kW/m²

Equation 4 – Incident radiative heat flux (at chest height approximately) (SFPE 66.14)

$$R = \sqrt{L^2 + {H_T}^2}$$

Where:

H_T =	The height of the target relative to the height of the equivalent point source at H/2,	1.2 m
L =	The horizontal distance from the centre of the pool to the target	2.05 m
R =	Distance from the point source to the target.	2.38 m
cosΘ =	0.95	30.3 degrees
q" =	Incident radiative heat flux	2.21 kW/m²

B.2 Results

With an applied safety factor, it can be seen from the calculations performed that the incident radiative heat flux received from a cooking oil pan fire at head and chest will be 3.43kW/m^2 and 2.21kW/m^2, respectively, where the closest edge of an escape path is at least 1.8m from the cooking hob.

A 0.51m escape path is considered to be adequately sufficient for escape purposes based on a typical shoulder to shoulder width of a person in the sidestep position. In this instance, the overall distance would need to be approximately 2.31m.

In terms of showing that passing occupants won't be adversely affected by radiant heat levels, it is reasonable to make reference to CIBSE Guide E[46]. This reference document provides various criteria for hazards associated with fire and shows that occupants should be capable of withstanding radiative heat flux up to 6.3kW/m^2 for a few seconds. It has been further acknowledged that PD 7974-6[47] provides alternative information on tenability limits for radiative heat and so summarised as follows for information:

- Occupants will have up to >5 minutes tolerance at a radiative heat intensity of <2.5kW/m2;
- Up to 30 seconds at 2.5kW/m2; and
- Up to 4 seconds tolerance at 10kW/m2.

The expectation is that cooking fires are more likely to occur when occupants are awake and alert. This is further substantiated by fire statistics provided by the Department for Communities and Local Government (DCLG)[48] which state that "While cooking appliances were responsible for more than half of accidental dwelling fires, it was not the main source of ignition that claimed most deaths. These fires caused 30 deaths in 2013-14.

For every 1,000 fires started in cooking appliances, there were only two fatalities. This could reflect the relatively minor nature of many cooking-related fires and the fact that many cooking fires occur when the victims are alert at the time of the fire.".

Using an industry recognised travel speed of 1.0m/s [49,50,51], travel time past the cooker is estimated at 2-3 seconds in which occupants will be readily capable of withstanding the more onerous 6.3kW/m^2 value specified under CIBSE Guide E (or the accepted 10kW/m^2 under PD 7974-6:2004) – i.e. 3.43kW/m^2 < 6.3kW/m^2.

B.3 Benefits of high performing fire safety systems

Each apartment is to be fitted throughout mains-powered automatic fire detection (AFD) system to a minimum Grade D Category LD1 standard in accordance with BS 5839-6:2013 and residential sprinkler system to BS 9251:2014 .

While it has been shown that occupants in the process of cooking are likely to be awake and alert, this high performing AFD system is considered to be of credible benefit and further expected to provide early fire cues and awaken possible occupants who may be sleeping.

Clause 0.2.6 of BS 9991 recognises that the installation of an automatic fire suppression system can offer designers considerable flexibility. This clause further expands and states that *"The installation of an AWFSS can offer designers considerable flexibility. An AWFSS controls a fire to a small size, reducing the production of smoke and toxic gases and preventing the fire from spreading beyond the room or dwelling of origin. This means that there can be flexibility achieved in the design of the building."*

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[46] CIBSE Guide E, Fire safety engineering, The Chartered Institution of Building Services Engineers London, Third edition, May 2010.

[47] PD 7974-6:2019 Application of fire safety engineering principles to the design of buildings. Human factors. Life safety strategies. Occupant evacuation, behaviour and condition (Sub-system 6)

[48] Department for Communities and Local Government: Fire Statistics: Great Britain April 2013 to March 2014.

[49] Predtechenskii, V.M., and Milinskii, A.I., Planning for Foot Traffic Flow in Buildings (translated from the Russian), Stroizdat Publishers, Moscow, 1978. English translation published for the National Bureau of Standards and the National Science Foundation, Amerind Publishing Co., New Delhi, India, 1978.

[50] Fruin, J.J., Pedestrian Planning Design, Metropolitan Association of Urban Designers and Environmental Planners Inc., New York, 1971.

[51] Pauls, J.L., Effective Width Model for Evacuation Flow in Buildings, in Proceedings, Engineering Applications Workshop, Society of Fire Protection Engineers, Boston, 1980.

Sprinkler systems have a well-documented reliability making them an effective fire measure. Real fire data collected by the National Fire Protection Association (NFPA) demonstrated that:

- 62.3% of reported fires were controlled by a single sprinkler head
- 96.3% of reported fires were controlled by 10 or fewer sprinkler heads.

Furthermore, the BRE experimental programme (BRE Project Report 218113) provides recorded data against Test 27 (the sprinkler protected pan fire) and occupant tenability within the same fire affected enclosure. It was concluded that the limiting value for tenability was not exceeded for convective heat or toxicity.

Taking into account the benefits and reliability offered, it is considered that the installation of a high performing AFD system and residential sprinkler system throughout the relevant apartments will reduce the risks associated with occupants having to pass by a chip pan fire or the like when making their way out of the apartment.

B.4 Design redundancy

While detailed analysis has not been carried out for ceiling jets with respect to radiated heat flux, it should be acknowledged that the calculations undertaken, and the results obtained ignore the benefit of sprinklers.

Given that the initial calculations undertaken show a noticeable margin of safety (with safety factor of 2 included), it is considered onerous to carry out relatively detailed and complex calculations to account for both sprinklers and possible consequence of ceiling jets which by virtue will be counterbalanced to some degree. This level of analysis is not proposed and considered unnecessary based on the results obtained and to account for the ability to use a crawl space well below ceiling height discussed below.

Cooking fires are generally hob or pan related. As such, the height of the fire base can be assumed to be approximately 1.1m when measured from the finished floor level – i.e. 0.9m standard kitchen counter and 0.2m pot dimension. This provides an option for utilising a crawl space below the seat of the fire in which occupants can use when making their way out of the apartment.

B.5 Conclusion

The results show that the radiation received at the closest part of travel past the cooking hob will be significantly less than the tolerable levels specified under CIBSE Guide E and PD 7974-62004.

While ignored for the purpose of the calculations, sprinklers are expected to be of benefit as they are commonly known to restrict fire growth, prevent fire spread, limit heat and smoke generation and can extinguish or at least control a fire.

The results recorded are based on a notional but reasonably selected escape width of 0.51m shoulder to shoulder distance under SFPE. The distance from the hob to the nearest part of the wall should not be less than 2.31m leaving a clear distance of 1.8m between the hob and closest part of the escape route past the cooker.

Based on the above information and subject to maintaining the clearance distances discussed, it is considered that an acceptable level of fire safety can be achieved for occupants even if the kitchen is designed as open plan in apartments sized greater than 8m x 4m.

Fire blankets in accordance with BS EN 1869:1997[52] positioned in proximity of the cooker would add benefit to the design if a recommendation was made for occupants to supply under the buildings tenancy agreement documentation, however this will be at the discretion of the building owner rather than a specific recommendation of this Fire Strategy report.

[52] BS EN 1869:1997, Fire blankets.

APPENDIX C OPEN PLAN FLAT JUSTIFICATION

BS 9991 recommends to have kitchen enclosed for open plan apartments greater than 8m x 4m. The project includes a number of cases of flat layouts/sizes that do not comply with this recommendation, a typical layout of such flat in this building is shown in Figure 18. However, it can still be possible to achieve an equivalent level of safety to a code compliant layout in IFC's opinion. Such flat cases are where the excess floor area is primarily due to the living room being relatively large. A large living area does not present a significantly increased risk to the occupants of the bedrooms. In terms of actual risk, the key issue in relation to open plan flat layouts is the route from the bedroom doors (sleeping accommodation) to the front door of the flats.

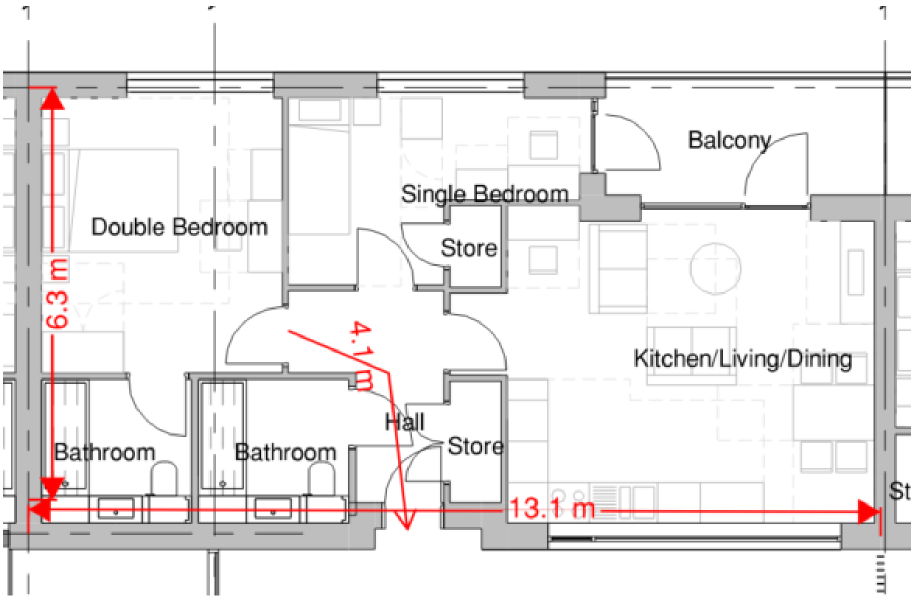

Figure 18 - Open-plan layout in Block 1

The recommendation under BS 9991 to have the kitchen enclosed for open plan apartments greater than 8m x 4m is a generic criterion and is solely based on the fact that this was the maximum size of flats that were assessed in the original NHBC research into open plan layouts. That research did not conclude that the risk was higher for larger flats, it simply did not assess them. The actual risk would depend on factors such as the location of the kitchen relative to the internal escape route(s). In addition, increasing the apartment size (floor area) does not necessarily increase the risk to occupants.

Of more importance than the total area of the apartment is the layout. For example, a one-bed apartment with a floor area of less than 32m^2 and an escape route from the bedrooms via an open lounge, away from the kitchen to the front door, represents no greater or lesser risk to the occupants than if the same apartment had two bedrooms, taking it over the 8m x 4m recommended limitation but having an identical travel distance and escape route. This is illustrated with examples in Figure 19. This shows 2 hypothetical flat layouts. Flat A is a code compliant open plan layout, no larger than 8m x 4m. Flat B on the other hand exceeds the 8m x 4m area recommended in BS 9991 but represents no greater risk to the occupants than Flat A. In fact, although the Flat A layout is compliant, it potentially poses a greater risk than the Flat B layout since the cooking equipment in Flat B can be located further from the escape route from the bedrooms, than in the Flat A layout.

This diagram is to demonstrate that flat area is not as relevant when assessing the risk to the occupants but rather the actual escape route and the hob location are important.

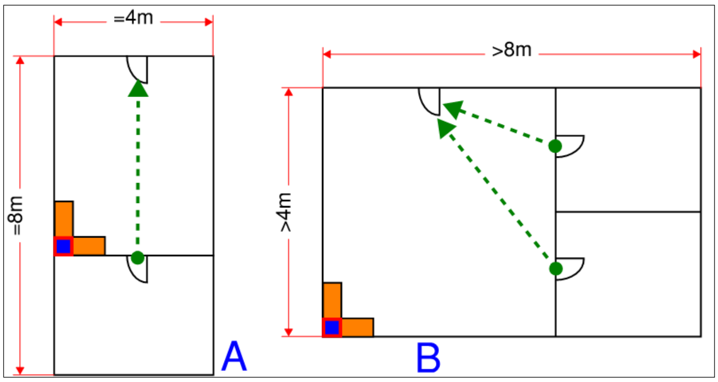

Figure 19 - Various open plan designs for comparison

As such, IFC propose to allow open plan flats, with an internal area exceeding 8mx4m, having the kitchen open on the basis that the layout of the flat results in an escape path and a kitchen hob location that pose no greater risk than a code compliant open plan flat of 8mx4m with the kitchen open. A comparative/risk assessment between a typical proposed open plan flat for the development and a code compliant 8m x 4m open plan flat should be carried out to assess the equivalency of the risk level.

The comparative assessment should show identical travel distances and equivalently safe escape paths between the compared flats.

As a general output of the comparative assessment of a code compliant open-plan layout and a non-code-compliant open-plan layout demonstrated in Figure 19 and the assessment of travel distance in Figure 20, IFC concluded that open-plan apartments with travel distances no more than 9m from the bedrooms (sleeping accommodation) present no greater risk than a code-compliant (BS 9991) open-plan apartment, as demonstrated in Figure 18.

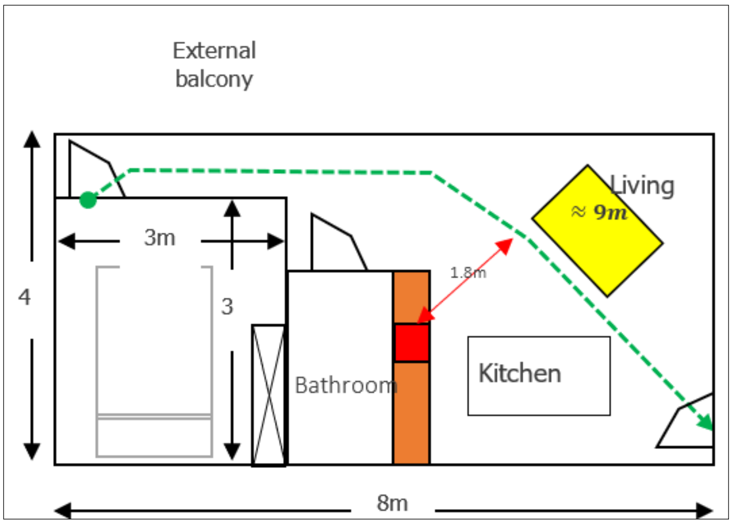

Figure 20 - Code compliant travel distance within an open plan flat with the kitchen open

Based on all of the above, IFC propose to use the below as the acceptance criteria for the design and assessment of the open-plan flats with the kitchen open for the development:

Travel distance from any sleeping accommodation (bedroom door to entrance door) should be no more than 9m (as indicated in Figure 20).

Travel distance within the apartment should not exceed 20m (as per Clause 9.4.2 of BS 9991)

Kitchen hob should be remote from any escape route (IFC propose at least 1.8m free radius as shown in Figure 20).

Grade D LD1 automatic fire alarm and fire detection system in accordance with BS 5839-6 and an Automatic Water Fire Suppression System (AWFSS) (as per Clause 9.4.2 and 9.7 of BS 9991).

Minimum ceiling height of 2.25m (as per Clause 9.7 of BS 9991).

The above recommendations are subject to Building Control approval.

APPENDIX D SINGLE STAIR CONNECTION WITH BASEMENT (TO BE UPDATED WITH CFD STUDY)

D.1 Relevant functional requirements of the Building Regulations

D.1.1 Functional requirement B1

Functional requirement B1 states *"The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material times"*.

D.1.2 Functional requirement B3

Functional requirement B3 states the following:
"(1) The building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period.
(2) A wall common to two or more buildings shall be designed and constructed so that it adequately resists the spread of fire between those buildings. For the purposes of this sub-paragraph a house in a terrace and semi-detached house are each treated as a separate building.
(3) Where reasonably necessary to inhibit the spread of fire within the building, measures shall be taken, to an extent appropriate to the size and intended use of the building, comprising either or both the following –
(a) sub-division of the building with fire resisting construction;
(b) installation of suitable automatic fire suppression systems.
(4) The building shall be designed and constructed so that the unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited."

D.1.3 Functional requirement B5

Functional requirement B5 states the following:
"(1) The building shall be designed and constructed as to provide reasonable facilities to assist firefighters in the protection of life.
(2) Reasonable provision shall be made within the site of the building to enable fire appliances to gain access to the building."

D.2 Fire hazards and possible consequences

A fire within the Basement Car Park is the key fire hazard to be assessed, whether that be a fire in a special fire hazard room with direct access from the Car Park, a car fire or multiple fire affected cars.

A fire originating within the car park area would be considered more onerous in comparison to a fire originating in one of the ancillary rooms, therefore this assessment has been developed on that basis.

A fire in the car park area could result in fire and/or smoke spread into the stair thus compromising occupant escape from the upper residential levels.

D.3 Acceptance criteria

The intent is to qualitatively demonstrate on a comparative basis that the single residential stair connections with Basement will not adversely affect the means of escape in case of fire in the event of a fire within the car park and that reasonable facilities will remain available to assist firefighters in the protection of life.

D.4 Assessment

D.4.1 Fire scenario selection

Selecting an appropriate design fire for any performance-based design is important and will be influenced by several factors including building design, environmental conditions, potential ignition sources, location, types of combustible materials, distribution and arrangement of combustible materials, ventilation conditions and other events occurring during the fire.

The number of scenarios selected is dependent on the scope of the project and the method of assessment. The expectation under PD 7974-0 when undertaking a comparative study, is to identify one or more worst case scenarios for detailed evaluation, whilst taking into account the following factors as appropriate:

- Design fire
- Fire location
- Occupant characteristics

Considering the assessment of fire hazards in Section D.2, a car fire or multiple fire affected cars in the Basement Car Park is taken as representing the worst-case scenario.

As this is a comparative assessment, it can be assumed that fire severity for both the base case and Block 1 design will be equivalent.

D.4.2 Base case for comparison

For an assessment to be undertaken, a base case design conforming to clause 30.2 of BS 9991:2015 has been established in Table 16. This Table also discusses the Block 1 design as illustrated in Figure 21 and notes key comparisons between both.

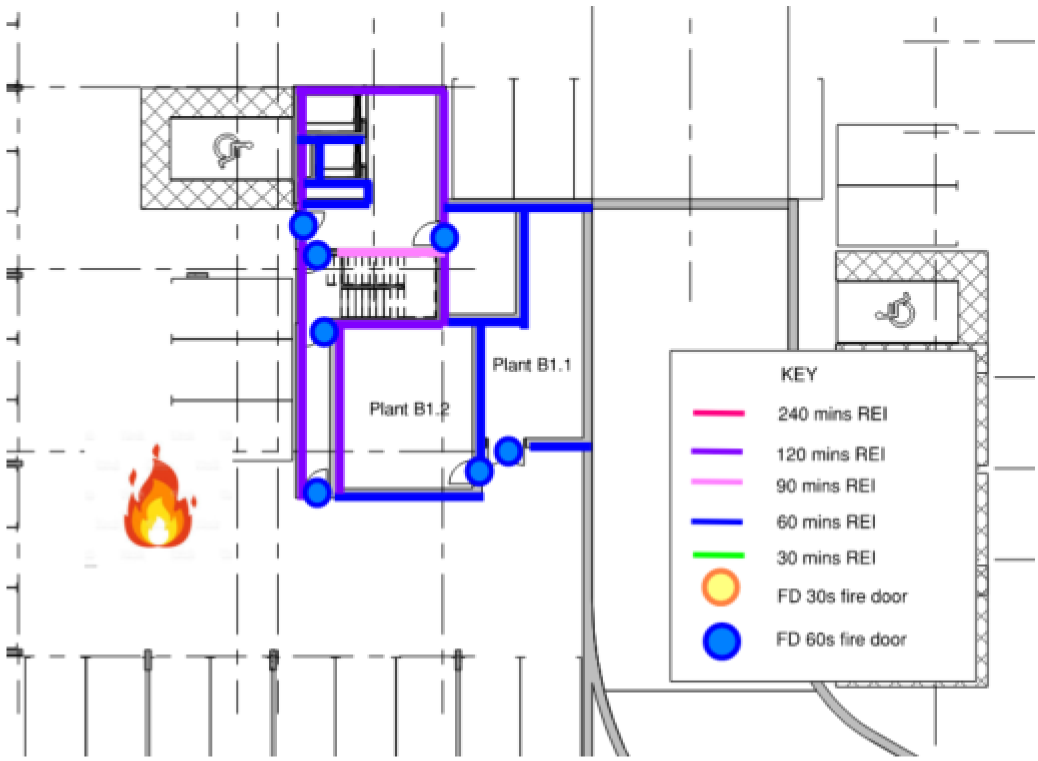

Figure 21 - Fire Resistance Arrangement at Basement Car Park

Table 16 - Comparison between base case compliant design and design adopted at Block 1

Description	Design conforming to clause 30.2 of BS 9991	Block 1 design	Comment
Building or Block height	Topmost storey <11m	Topmost storey >11m	Block 1 has taller residential Blocks
Stair core fire resistance	60 minutes	90 minutes	50% increase in fire resistance for Block 1
Stair fire door	FD30S	FD60S	
Fire resisting construction between Basement and upper storeys	60 minutes	90 minutes	
Separating fire door in stair	FD30S	FD60S	
Fire resistance for lobby at Basement level	30 minutes	120 minutes	300% increase in fire resistance for Block 1
Basement Lobby fire door	FD30S	FD60S	100% increase in fire resistance for Block 1
Lobby ventilation between Stair and Car Park	$1m^2$ automatic opening vent	$1m^2$ permanent ventilation	Comparable performance
Ventilation for ancillary areas in Basement	Natural smoke ventilation to fire risk areas	Mechanical smoke clearance system in accordance with BS 7346-7	Equivalent performance or better
Basement Car Park ventilation	Natural ventilation with distributed aggregate free vent area not less than 2.5% the floor area	Mechanical smoke clearance system in accordance with BS 7346-7	Forced negative pressure clearing smoke for Block 1

D.4.3 Fire scenario – Fire in Basement Car Park

Taking the information summarised in Table 16, it can be seen for the base case that the physical fire separating construction between the Car Park and stair is 90 minutes combined when including the lobby and protection to the stair itself. There is a further 60 minutes at Ground Floor where fire resisting construction is necessary between the Basement and upper residential storeys – i.e. 150 minutes total between Car Park and stair passageway. There are 2no. fire rated doorsets providing a total of 60 minutes.

In comparison the design at Block 1 provides 300 minutes physical fire separating construction between the Car Park and stair passageway. This is an overall percentage increase in fire resistance of 100%. The 2no. fire rated doorsets provide a total of 120 minutes which is a percentage increase in fire resistance of 100%.

This increased protection offers a significant improvement over a compliant design and an improvement considered to inhibit the spread of fire within the building for a reasonable period to facilitate escape from Blocks >11m should the need arise. The key risk is the smoke entering the ground floor lobby during firefighting intervention, and this risk is mitigated by putting the riser in the basement lobby, so it is considered unlikely evacuation will be needed at above residential floors.

While expected under general guidance, $1m^2$ permanent ventilation will be provided to the lobbies between Car Park and Stair to mitigate the risk of smoke spread. This is viewed as a secondary layer of protection for the Basement Car Park at Block 1 as this area is provided with a forced mechanical smoke clearance system which should mitigate the of adverse smoke spread into the lobbies in the first instance.

Should a fire originate within the Car Park, then fire brigade access will be provided via multiple entrances and unrestricted mitigating the risk of operational delay during fire brigade intervention activities. Attending fire-fighters can establish a bridgehead on approach to a Basement fire at Block 1 within the confines of a stair which offers superior protection when compared to a compliant design.

D.5 Conclusion

When considering fire in the Car Park, this justification demonstrates that the Block 1 design offers improved conditions when compared to the design conforming to clause 30.2 of BS 9991:2015.

This is based on the significant percentage increase in fire resistance protecting the stair(s) at Basement level and provision for a forced mechanical smoke clearance system as a primary measure mitigating the risk of adverse smoke spread into the Basement lobbies between Stair and Car Park, thus improving ventilation within the lobbies themselves.

Unrestricted access will be provided to attending fire-fighters via multiple entrances where they can establish a bridgehead within the confines of a stair which have significantly improved layers of fire protection when compared to a compliant design.

Based on the above, the design at Block 1 is considered to satisfy the functional requirements B1, B3 and B5 of the Building Regulations.

APPENDIX E PROVISION FOR CAVITY BARRIERS

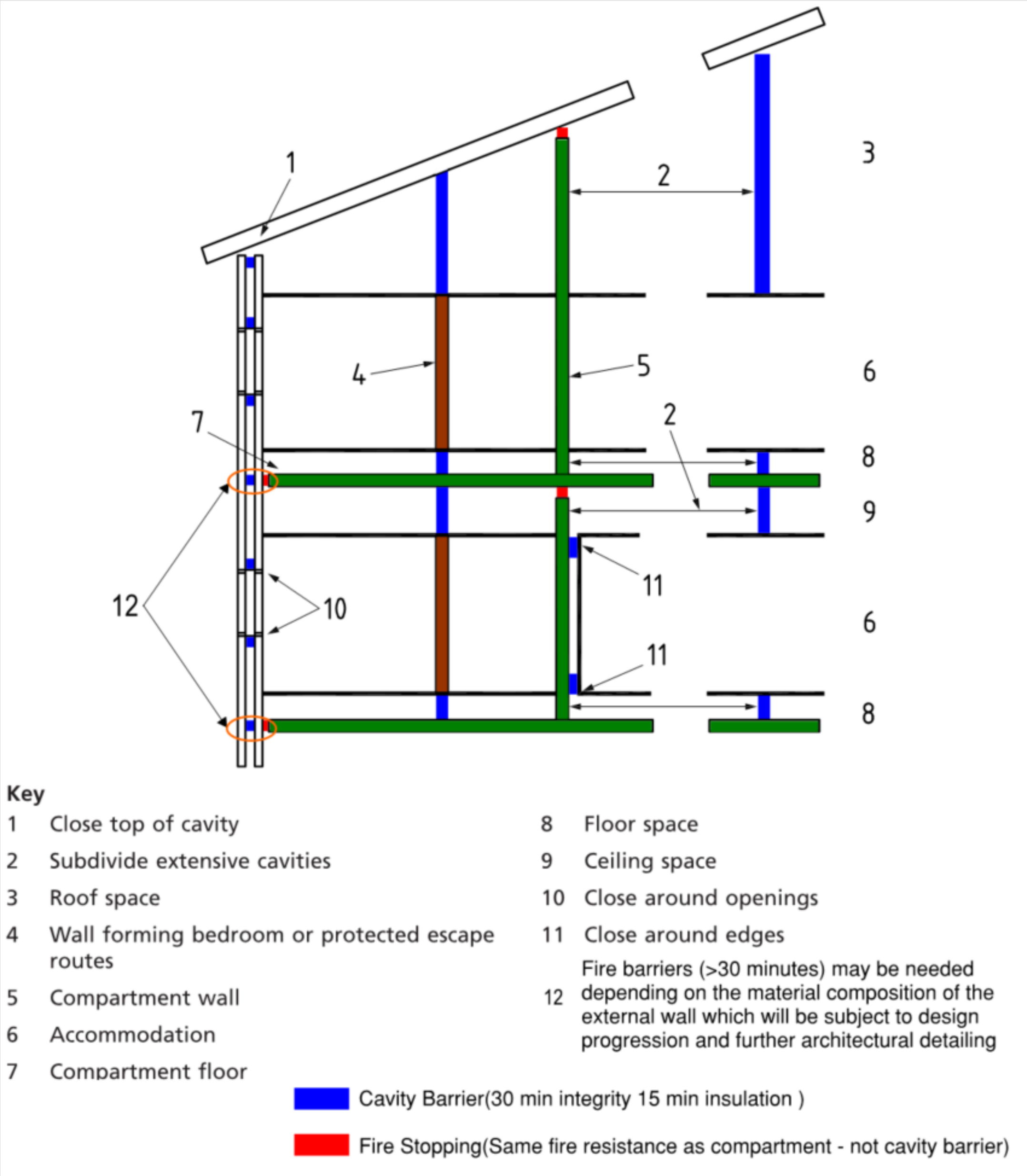

Figure 22 - Provisions for cavity barriers