APPENDIX B DISTANCE FROM COOKING APPLIANCE

B.1 Supporting Calculations and Information

By using the widely adopted SFPE Point Source Model calculations[42], 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 9 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.

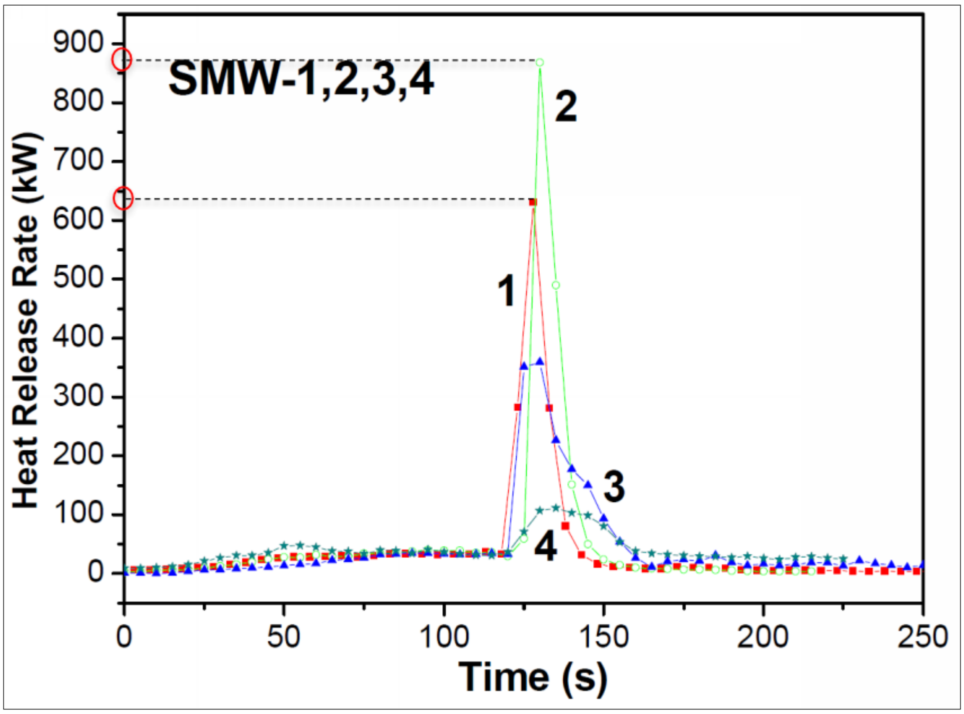

Figure 9 - Heat release rate measured for pan fire and suppression with water mist

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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[42] 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.

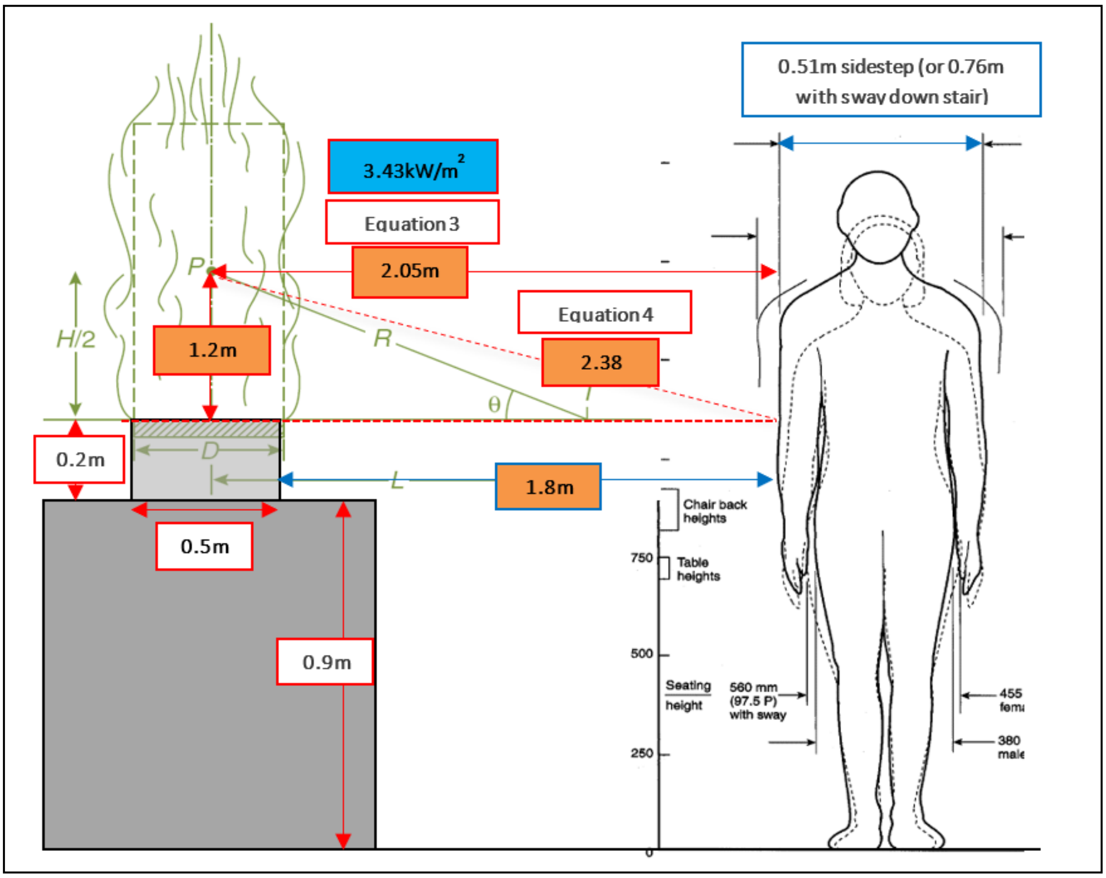


Figure 10 - Notional section through fire scenario

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 midpoint 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/m^2

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/m^2

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[43]. 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[44] 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)[45] 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 [46,47,48], 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."*

[43] CIBSE Guide E, Fire safety engineering, The Chartered Institution of Building Services Engineers London, Third edition, May 2010.
[44] 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)
[45] Department for Communities and Local Government: Fire Statistics: Great Britain April 2013 to March 2014.
[46] 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.
[47] Fruin, J.J., Pedestrian Planning Design, Metropolitan Association of Urban Designers and Environmental Planners Inc., New York, 1971.
[48] 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.

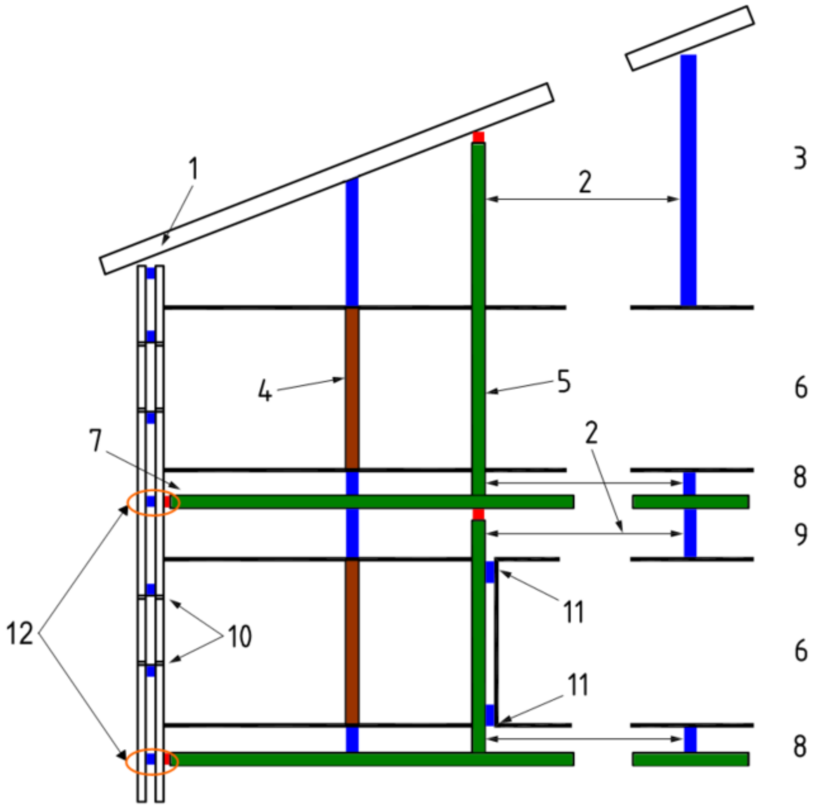
The results recorded are based on a notional but reasonably selected escape width of 0.51m shoulder to shoulder distance under SFPE. The distance from the hob to the nearest part of the wall should not be less than 2.31m leaving a clear distance of 1.8m between the hob and closest part of the escape 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[49] 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.

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

APPENDIX C PROVISION FOR CAVITY BARRIERS



Key

1 Close top of cavity
2 Subdivide extensive cavities
3 Roof space
4 Wall forming bedroom or protected escape routes
5 Compartment wall
6 Accommodation
7 Compartment floor
8 Floor space
9 Ceiling space
10 Close around openings
11 Close around edges
12 Fire barriers (>30 minutes) may be needed depending on the material composition of the external wall which will be subject to design progression and further architectural detailing

Cavity Barrier(30 min integrity 15 min insulation)

Fire Stopping(Same fire resistance as compartment - not cavity barrier)

Figure 11 - Provisions for cavity barriers