INTERIM PHASE 1 RECOMMENDATIONS FOR THE GRENFELL INQUIRY

FROM PROF ED GALEA

Final

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London
02/04/19

Signature: **Date: 02/04/19**

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SUMMARY:

Following my analysis of the evidence provided in Phase 1, my 42 interim recommendations concerning **Fire Safety, Fire Fighting Procedures and Building Regulation**, include:

1) 999 Call Handling:

This section consists of 12 recommendations based on my analysis, and that of my team, of most of the 999 calls concerning the Grenfell Tower fire. The suggested recommendations for improvements to call handling procedures and protocols include:

- Two changes related to FSG advice for 999 callers in 'high-risk' buildings, to 'get out stay out' (1a).
- Three measures to improve the questions asked by call handlers (1b).
- Two measures to improve the control centre environment (1c).
- Five measures to improve miscellaneous issues e.g. advice regarding popular belief in helicopter rescue (1d).

2) Fire Safety:

This section consists of 15 recommendations, which are based on my analysis of witness statements relating to survivor observations of the developing fire within Grenfell Tower, the descriptions they provided of the condition of their flats prior to and during the fire, and my understanding of current provisions for fire safety in residential high-rise buildings. The suggested recommendations to improve Fire Safety include:

- Four measures to improve maintenance of compartmentation (2a).
- Three measures related to alerting residents of the need to evacuate (2b).
- One measure to reduce the likelihood of fires starting (2c).
- Two measures to improve wayfinding within stairwells (2d).
- Two measures to improve the evacuation of residents (2e and 2f).
- Two measures to improve detecting and reporting problems with the life safety measures in the building (2g and 2h).
- One measure to improve smoke extraction systems (2i).

It is noted that some of the recommendations may require regulatory change.

3) Firefighting and Rescue:

This section consists of 12 recommendations, which are based on my analysis of witness statements relating to their observations of the developing fire, the descriptions from firefighter witness statements, and oral evidence provided by senior fire officers. The suggested improvements in Fire Fighting and Rescue include:

- Three measures to reduce the spread of fire and smoke within the building (3a).
- Three measures to improve rescue efforts (3b).
- Four measures to ensure safe and timely full building evacuation (3c).
- One measure to improve information flow from the control centre to the bridgehead (3d).
- One measure to deal with high volume of 999 calls (3e).

4) Regulatory Changes:

This section consists of three recommendations, which are based on my understanding of existing building regulations. The suggested regulatory changes include:

- Two recommendations restricting the use of combustible materials in the exterior construction of all buildings (4a).

- One recommendation on the introduction of sprinkler systems in all high-rise residential buildings (4b).

1 INTRODUCTION:

On 15 January 2019, I was instructed by the Grenfell Inquiry to suggest a set of interim recommendations for consideration by the Chairman. They concern **Fire Safety, Fire Fighting Procedures and Building Regulation**, and are based on my current analysis of the evidence relating to the Grenfell Tower fire. It is understood that interim recommendations suggested by the Inquiry's experts, if accepted by the Chairman, may be made by the Chairman now or following completion of his Phase 1 report.

To be accepted for consideration, suggested interim recommendations should fall into one or other of the following two categories:

1. Recommendations that are so urgent that they should be made now and prior to the completion of his Phase 1 report. To fall into this category the recommendation must be one which is:

a) obvious in the light of the evidence which has been heard at Phase 1; and

b) so urgent on grounds of public safety that it should not be deferred until either the publication of his Phase 1 report or left to be addressed as a final recommendation at the end of Phase 2.

2. Recommendations which are based on the Chairman's findings and analysis in his Phase 1 report that should not be left to be addressed as final recommendations at the end of Phase 2.

In Section 2 I have set out a total of 42 interim recommendations that I believe comply with the first of the two selection criteria. However, I am aware that the Chairman may decide that it would be premature to make recommendations where he will be hearing further evidence on those matters and considering the issues in greater detail at Phase 2. In so far as this is the case, I put them forward as points to consider at Phase 2. I have arranged the recommendations in a logical sequence, rather than as a priority list. Throughout, I define and refer to 'high-risk' buildings as those clad, or partially clad, in combustible materials, in terms of the external cladding, the external insulation materials, or both.

1.1 About the Author:

I am Professor Edwin (Ed) Galea, founding director of the Fire Safety Engineering Group (FSEG) at the University of Greenwich. I am the CAA Professor of Mathematical Modelling (a position I have held since 1992), a Chartered Fire Engineer, a Chartered Mathematician, an award-winning engineer, and a recognised expert in the field of computational fire engineering. I am a Fellow of the Institution of Fire Engineers, a Fellow of the Institute of Mathematics and its Applications, and the Vice chair of the International Association of Fire Safety Science. I have undertaken research and consultancy in computational fire engineering for over 30 years. As director of FSEG, I manage the research of 21 full-time psychologists, fire engineers, CFD specialists, computer scientists and mathematicians involved in fire science/engineering research and the development and support of the CFD fire simulation software, SMARTFIRE, and the EXODUS suite of evacuation simulation software.

I have collaborated on research projects with agencies and departments of government – British (e.g. Home Office, Department for Transport, CPNI, DSTL, SAPER, and SAGE), US and Australian – international companies (e.g. Boeing, Airbus, Multiplex, HSBC, BMT, and Clevertronics) and international regulatory bodies (e.g. International Maritime Organization (IMO), and International Organization for Standardization (ISO)).

My personal research interests include human behaviour in emergency evacuations, crowd dynamics, evacuation and crowd dynamics simulation, fire dynamics and CFD fire simulation. My recent projects include an EU Horizon 2020 project to development a VR/MR training environment for first responders involved in emergency situations in crowded places, an EU Horizon 2020 Marie Curie Rise project on wildfires, an IOSH-funded project concerned with evacuation of high-rise construction sites, an EU Horizon 2020 project concerned with urban-scale evacuation, a UK government-funded project concerning marauding armed terrorists, and a project concerned with understanding human behaviour during dwelling fires, funded by Innovate UK and the EPSRC.

As director of FSEG, I have been involved in a number of third-party technical reviews, undertaken by FSEG staff, of fire safety strategies submitted by consulting engineers to local authorities for approval, including the Royal Borough of Kensington and Chelsea Building Control (RBKCBC). The most recent review for RBKCBC was completed by FSEG on 20/07/16.

I have served on several major Inquires and legal cases as an expert in fire and evacuation, including: the Paddington Rail Crash, the Swiss Air MD11 crash, and the Admiral Duncan Pub bombing. I am a Visiting Professor at Ghent University, Belgium, and the Western Norway University of Applied Sciences (HVL). I am an associate editor of the *Royal Aeronautical Journal* and *Safety Science*. I have received numerous awards for my research work, including 2001 British Computer Society Gold Medal, 2002 Queen's Anniversary prize, 2006 and 2018 Royal Aeronautical Society Gold Award, 2008 Society of Fire Protection Engineers Jack Bono Engineering Communication Award, 2013 Royal Institution of Naval Architects Medal of Distinction, and the 2014 The Guardian University Award for Research Impact.

1.2 **Assisted By:**

In assessing the evidence from 999 calls, survivor witness statements, firefighter witness statements and video evidence, as part of my Phase 2 work, I am being assisted by my FSEG colleagues, Dr Lynn Hulse (Research Fellow, 999 calls and survivor witness statements), Mr Gary Sharp (Research Assistant, firefighter witness statements), Dr John Ewer (Reader, video evidence and building regulations) and Dr Zhaozhi Wang (Research Fellow, video evidence). My discussions of the evidence with these colleagues has assisted me in framing these recommendations.

1.3 **Statements:**

I confirm that I have no conflict of interest of any kind, other than which I have already set out in this report. I do not consider that any interest which I have disclosed affects my suitability to give expert evidence to the Inquiry on any issue on which I have given evidence and I will advise the Inquiry if, between the date of the report and any Inquiry hearings there is any change in circumstances which affects this statement.

I confirm that I understand my duty to assist the Inquiry on matters within my expertise, and that I have complied with that duty. I also confirm that I am aware of the requirements of Part 35 and the supporting Practice Direction and the Guidance for the Instruction of Experts in Civil Claims 2014.

I reserve the right to alter my opinions and conclusions in light of any further evidence or relevant information of which I am currently unaware. I will immediately inform the Inquiry should such a situation arise.

The opinions I have expressed represent my true and professional opinion on the matters to which they refer. I have had regard to the evidence that is material to my discipline (including the oral testimony) and I can confirm that I have discharged my overriding duty to the Inquiry.

Signature: **Date: 02/04/19**

2 RECOMMENDATIONS:

This section contains my recommendations based on the evidence provided in Phase 1 and my expert opinion. In most cases, a brief justification or explanation for the recommendation is provided; in the remaining cases, the recommendation is self-explanatory. I use the term 'high-risk' buildings to describe those that are clad, or partially clad, in combustible materials, in terms of the external cladding, the external insulation materials, or both. Each recommendation is bold and numbered, with the number enclosed in parenthesis of the type, (3.2). There are four broad groups of recommendations covering: (1) 999 Call Handling, (2) Fire Safety, (3) Firefighting and Rescue and (4) Building Regulations. Within each of these broad groups, recommendations are clustered in themes. For example, within group (2) Fire Safety, there are 9 themes, with the first theme being, 2a) Maintaining Compartmentation.

2.1 (1) 999 Call Handling:

The following 11 recommendations are based on my analysis, and that of my team, of the 999 calls concerning the Grenfell Tower fire.

1a) ***Call Handling advice to Callers in at risk buildings.***

> **(1.1) An up-to-date register of 'high-risk' buildings should be kept by the control centre (and Fire and Rescue Service (FRS)). Where possible, high-risk buildings should be flagged automatically to call handlers. Where this is not possible, they should have access to the register.**
>
> **(1.2) 999 call guidance for callers in 'high-risk' buildings should be to evacuate, if safe to do so. Callers should also be asked to attempt to alert their neighbours, if safe to do so.**

1b) ***Call Handling procedures, including the nature of questions asked by Call Handlers to characterise the incident.***

> **(1.3) If the FRS does not use the Enhanced Information Service for Emergency Calls (EISEC), BT operators should make it clear to the caller that they should wait until prompted to speak by the emergency service.**
> **For example:**
> **"Now calling fire and rescue. Please wait while I give them your number, then speak when they prompt you to."**

NOTE: Callers are not necessarily aware that when they dial 999, they will initially be put through to a BT operator, who may need to read out some call details to the FRS Call Handler. This may cause confusion, potentially resulting in the Caller interrupting the discussion between the operator and Call Handler. If this is already part of standard operating practice, then training of BT Operators/Call Handlers should be improved, perhaps through the introduction of recurrent training.

> **(1.4) The FRS call handler should state their region and, when answering on behalf of another region, make this clear.**
> **For Example:**
> **"London Fire Brigade. Hello caller."**
> **"Surrey Fire and Rescue on behalf of... Hello caller."**

NOTE: The Caller is unlikely to be aware that the FRS is not necessarily the one from their local region, and may not have local knowledge. It may make communication more efficient if the Caller knows from the outset that the FRS they are speaking to is from a different region. If this is already part of standard operating practice, then training of Call Handlers should be improved, perhaps through the introduction of recurrent training.

(1.5) Once the incident is identified as a fire, call handlers must establish the address, the type of dwelling, and the location(s) of the fire, the caller and the people with the caller within the dwelling. They may need to have a list of prompts to ensure that all required information is collected.

EXAMPLES/NOTES:

- **Street address – request full address with flat AND building number (if different, see below), building name (if there is one), street name and postcode.**
- **Building vs. flat number – as the building could be a high-rise, the number provided by the caller in the address may be a flat number, not the building number.**
- **Floor AND flat numbers – not always volunteered or asked for, are essential to obtain, especially for buildings where the numbering system is not wholly sequential or regular. It is essential to be clear that this is their CURRENT location, and whether they have moved from their own home.**
- **Current location – This is not simply the room e.g. living room or bedroom, but the flat location (floor and number), as the caller may have moved to another flat prior, to or during, the incident. For example:**
    - **"What is the address of the flat you are in at the moment?"**
    - **"Are you currently in your own home?"**
    - **If the caller has moved, it may be useful to establish both locations i.e. current location and then home location.**
- **People present – establish the number of people located with the caller, including number of adults, number and age of children and number of people with special needs:**
    - **"*Including yourself*, how many adults and how many children are in the flat at the moment?"**
    - **"How old are the children?"**
    - **"Does anyone have any special needs regarding their health or mobility?"**
- **Repeat back the details recorded and ask for confirmation**

NOTE: If this is already part of standard operating practice, then training of call handlers should be improved, perhaps through the introduction of recurrent training.

1c) Nature of the Control Centre environment, equipment available, information available to Call Handlers, and how this is presented.

(1.6) Call handlers should be aware of the number, location and status of multiple callers to the control centre about a particular incident.

NOTE: The rapid escalation of the Grenfell incident – the number of separate flat fires involved – was not recognised by Call Handlers for a considerable period. Focusing on the building as a whole, instead of the flats therein, contributed to an incoherent narrative and response.

(1.7) Call handlers should be provided with headsets that reduce background noise in the control centre to make it easier to hear callers.

NOTE: In some of the Grenfell Incident 999 calls, the Call Handlers appear to have had some difficulty understanding what was said by some Callers. This has a number of serious implications. In some instances, this could be due to poor connections. However, it is also possible that the difficulty in understanding these calls was due to background noise within the Control Centre, as well as at the Caller's end. Headsets provided to Call Handlers should have a noise-cancelling capability to cancel or reduce background noise in the Control Centre.

1d) Miscellaneous Call Handling procedures.

(1.8) When a call handler finds it necessary to consult with a colleague, they should always inform the caller that they are about to do so.

NOTE: It is possible that cross-conversations, between Call Handlers and colleagues may be confusing to the Caller. It is suggested that that the Call Handler always informs the Caller, when this is necessary.

(1.9) When a call handler thinks that the caller is speaking to someone else in the caller's location, they should clarify this with the caller.

NOTE: Cross-conversations, between the Caller and others may also be confusing to the Call Handler. When the Call Handler does not understand the nature of a response from the Caller, or suspects that the Caller may be talking to someone else, the Call Handler should clarify to whom the remarks are directed.

(1.10) In order to calm callers, it may be necessary to explain to them the roles of firefighters who they can see, but may not appear to be actively involved in firefighting or rescue activities.

NOTE: Callers may become frustrated if they can see firefighters from their location who appear not to be undertaking firefighting or rescue operations to save them. It is important that the Caller is reassured that the fire service is doing everything that they can to assist the Caller, so it may be necessary to explain that firefighters may be performing critical support roles.

(1.11) Call handlers must be prepared to explain to callers who suggest that they can be rescued by helicopter, that this is not possible.

NOTE: Callers may suggest that they could be rescued from the roof or windows by helicopters, especially if they hear or see them in the vicinity of the incident. This was also an issue in Lakanal House, where at least one survivor (Rasheed Nuhu [1,2]) thought that helicopter rescue was possible from a balcony. This belief, unless challenged, could encourage occupants to attempt to go to the roof of the building, or disincentivise self-evacuation attempts. It is suggested that the commonly held belief that helicopters can be used to rescue people from high-rise building fires and/or fight fires is perhaps due to their depiction in popular culture, such as Hollywood movies, and also the recent success and highly publicised actions of helicopters in fighting wildfires. It may be necessary to educate the public that this is not a plausible means of rescue or firefighting in urban high-rise building fires, through a public information campaign.

(1.12) If there is a substantial change of circumstances during a fire, such that the advice from the incident commander changes from 'stay put' to 'get out if safe to do so', call handlers should call back previous 999 callers and notify them of the revised advice as a matter of priority.

NOTE: Call handlers dealt with a large number of calls prior to the incident commander changing their advice from 'stay put' to 'get out if safe to do so'. Rather than waiting for callers to call back for further advice – as was the case at Grenfell – Caller Handlers should proactively call back each caller, reassess their situation and notify them of the change in the FRS advice.

2.2 (2) Fire Safety:

The following 15 recommendations are based on my analysis of witness statements relating to survivor observations of the developing fire within Grenfell Tower, the descriptions they provided of the condition of their flats prior to and during the fire, and my understanding of current provision for fire safety in residential high-rise buildings.

2a) Maintaining compartmentation.

NOTE: The 'stay put' principle is followed devoutly by the fire brigade, building operators and local government throughout the UK. It is based on the compartmentation principle – containment of the fire within the compartment of fire origin – and is a sound philosophy **IF (and only if)** compartmentation can be guaranteed. An essential component of the 'compartmentation' concept is that flat doors leading to the communal areas, and doors leading to the stairs (means of escape) are rated fire doors with correctly functioning automatic door closers and smoke seals. It is, therefore, essential that fire doors must meet the required industry standard when installed and that they are correctly maintained throughout their lifetime, with regular checks on their suitability.

(2.1) Composite fire doors of the specific type used within Grenfell (Masterdor Suredor made by Manse Masterdor) installed in residential buildings should be replaced immediately with a fire door that has been shown to meet the FD30S requirements.

NOTE: The Inquiry has been informed of findings that many of the composite fire doors present in Grenfell (Masterdor Suredor made by Manse Masterdor) fail to meet the industry standard FD30S fire test – with one sample glazed door substantially failing, after surviving for only 15 minutes, rather than the required 30 minutes (see Dr Lane's supplemental report at BLAS0000019_0019 at 19.5.16 and MET00019996). It has been further suggested that the Masterdor Suredor made by Manse Masterdor did not even undergo the required 'smoke' component of the test when tested originally, and so cannot be considered to provide protection from smoke leakage (BLAS0000019_0019 at 19.5.15).

(2.2) Composite fire doors installed within high-rise residential buildings should be checked to ensure that they have met the FD30S requirements (including that both faces of the door have been demonstrated to meet the appropriate standard (BS 476-22 or EN1634-1)). If appropriate documentation is not available, the doors should be tested immediately. Should the doors fail to meet the standard, they should be replaced immediately, if they are used within a high-risk residential building. Composite fire doors in other high-rise residential buildings failing to meet the standard should be replaced, subject to a risk assessment undertaken by the local authority.

(2.3) It is essential that regular checks by the appropriate authorities are undertaken to ensure that external flat doors leading to the communal areas, and doors leading to the common stair core (means of escape) of all residential high-rise buildings are appropriate functioning fire doors. This includes the integrity of the smoke seals around the doors and the presence of appropriate functioning automatic door closers. Where doors are found to be inadequate, deficiencies must be rectified, or the doors replaced, urgently.

NOTE: It is clear from many of the Grenfell witness statements that one source of smoke entering and compromising the communal areas was flat doors left open due to a lack of a door closer, a malfunctioning door closer or a disconnected door closer. Another issue highlighted by a number of witness statements was smoke from the communal area entering their flats from around the door jamb area, suggesting a possible failure or inadequacy of door smoke seals on the external flat doors leading to the communal areas. Regular checks are required to ensure that the smoke seals are not damaged or compromised. Ideally, such checks should be unannounced, so that residents do not have the opportunity to reconnect door closers in advance of a scheduled visit. It may be necessary to provide checking authorities with the legal authority to gain entrance to a private flat to make such a check. It is suggested that the checks should be undertaken at least twice per year. While this is an essential recommendation for high-risk buildings, this measure should ideally be applied to all high-rise residential buildings.

(2.4) It is essential that building residents are made aware of the critical importance to their safety and that of others, of maintaining the integrity of fire doors and automatic door closers on their external flat doors, and the doors leading to the common stair core. They also need to be informed how they can report and request corrective measures, not only for their flat/communal area, but also for other flats/communal areas within the same premises. To ensure awareness, it is recommended that the following measures are taken:

1. **Information leaflets (in English, plus other languages, where appropriate) distributed to each residence in high-rise buildings.**
2. **Annual safety briefing to residents, with safety briefing for all new residents on moving in.**
3. **Regular agenda item for residents committee meetings.**
4. **Posters within buildings (in English, plus other languages, where appropriate).**
5. **National safety advertising campaign similar to the successful 'smoke detector' and 'smoke kills' campaigns.**

NOTE: It is essential that residents are encouraged to take ownership of this issue, based on the pivotal role they play in their own safety and the safety of their neighbours. They need to understand the role and importance of functioning door closers in fire safety, so that they do not disengage them. While this is an essential recommendation for high-risk buildings, this measure should be applied to all high-rise residential buildings.

2b) Ability to alert residents of the need to evacuate.

NOTE: The evacuation process has two key phases: the evacuation response phase, and the evacuation movement phase. In the evacuation response phase, occupants are alerted to the need to evacuate through a traditional bell alarm, for example, or, more effectively, by a modern voice alarm system. This phase is of fundamental importance because if occupants are not aware of the danger, they cannot take appropriate action, and will not start to evacuate. Early, clear and unequivocal warning of a life-threatening fire is of critical importance in residential dwellings and hotels, as occupants, such as those in the Grenfell Tower fire, may be asleep during the incident, or may require more time to evacuate, due to age or disability. Many fatalities in fires are the result of occupants delaying their initial response to the incident and their evacuation.

While each of the flats within Grenfell Tower had localised smoke detectors and fire alarms, there were no communal alarms. So, while a resident could be alerted about a fire in their own flat, they had no idea if there was a serious fire within the building that could potentially threaten their safety and require them to evacuate. If there is an urgent need to evacuate the building – because the first line of defence, compartmentation, has failed – currently door knocks (by the 'waking watch', residents or firefighters), or occupant calls to 999 are the only way to alert occupants of the need to evacuate, in the absence of a building-wide alarm system. Clearly this will waste precious minutes that would be better spent actually evacuating.

As evidenced by Grenfell Tower and Lakanal House, there is currently insufficient resilience in the fire safety strategy for high-rise residential buildings, as we rely solely on compartmentation and 'stay put'. Should a full-building evacuation be necessary (e.g. due to failure of compartmentation), there are no adequate means to notify occupants of the need to start the evacuation.

> **(2.5) A building-wide alarm system should be installed in residential high-rise buildings, which can be selectively activated (manually or by automatic detection), should a building-wide evacuation be necessary. The proposed system should be installed immediately in all high-risk high-rise residential buildings; however, it is suggested that in time, the recommendation should apply to all high-rise residential buildings. The alarm system should be tested on a regular basis.**

NOTE: The activation of the alarm system needs to be considered carefully. Ideally, it should happen automatically (via an automated detection system); however, frequent, unnecessary automatic alarms arising from real but small, manageable fires (not impacting the safety of those outside the compartment of fire origin), false alarms (resulting from non-fire events) and malicious false alarms, must be avoided. This is because needless evacuations would result in a significant nuisance to the residents, may be hazardous to the very young, elderly and People with Reduced Mobility (PRM), and would eventually render the alarm system ineffective, as it became increasingly ignored by the residents. Manual alarm systems that can be activated by any resident, while quick, may also result in a high frequency of unnecessary and malicious false alarms.

The means of alarming the entire building must therefore be considered carefully. To reduce false alarms, the automatic detection system could be based on heat (rather than smoke) detection, with some form of manual activation of the building-wide alarm system. The activation of a single detector would initially alert the occupants of the flat where the fire was detected. This would allow them to investigate and (if not a false alarm) attempt to suppress the fire, if it is sufficiently small. If the fire cannot be tackled safely, they would evacuate and call 999. At this point, there are several options to alert the entire building, with each successive option involving more of a delay:

- The building-wide alarm system could have a manual operation capability, allowing the flat occupant who has evacuated to activate the alarm. A disadvantage of this option is that it is liable to frequent genuine and malicious false alarms.
- If a responsible person (waking watch) were available, the system could alert them, along with the resident, on the first alarm. The responsible person could then investigate and decide whether or not to call 999. The responsible person would also have the ability to manually alert the entire building. The disadvantage of this option is that it is reliant on the presence of a responsible person.
- On arrival, the FRS could manually activate the alarm system, alerting the building. The disadvantage of this option is that it is reliant on the timely arrival of the FRS; however, it is noted that in Grenfell, the fire brigade were on the scene at 00:59 and so could have manually instigated a building-wide alarm as early as 5 minutes after the first 999 call (at 00:54).
- The internal automatic fire detection system could rely on a ‘double knock’, in which at least two detectors in two flats must be activated before the entire building is alerted. The disadvantage of this option – demonstrated by Grenfell – is that an external fire could spread for some time before the second knock occurs. The fire in Flat 16, floor 4 was reported at 00:54 and it is not until 01:24 that a 999 call from Flat 96 on the 12^{th} floor reports another internal kitchen fire some 30 minutes after the first call and some 10 minutes after the spread of the internal fire to the external cladding. Ideally the building would have been alerted, and the evacuation started, well before the second flat fire had activated the building-wide alarm.

(2.6) Residents in ‘high-risk’ high-rise residential buildings should be offered training in first aid firefighting using hand-held fire extinguishers, fire-blankets, etc., and appropriate fire suppression equipment should be provided to each flat.

NOTE: Having detected a small fire in a flat, a resident needs to be able to suppress it. The initial fire in Flat 16 of Grenfell Tower was detected quite early, while the fire was reasonably small and potentially manageable. Had the person who was alerted been trained to extinguish a small fire, and in possession of the appropriate equipment, he may have been able to do so. Furthermore, given the number of high-rise residential buildings within the UK with combustible cladding, and the time that this situation has existed, it is likely that there have been hundreds of fires within these types of premises, many of which were controlled by residents before escalating to life-threatening situations requiring external intervention. Appropriate training of residents and the provision of appropriate equipment is likely to address the vast majority of typical fires within these buildings. The training must include identifying the type of fires that can and cannot be tackled, as well as how to tackle the former.

(2.7) An annual evacuation drill should be conducted in all ‘high-risk’ residential high-rise buildings in order to test the detection, alert and evacuation process.

NOTE: While resident participation in the drill would not be compulsory for residents, the alerting system must be demonstrated, which may require the involvement of the local fire brigade. It is suggested that a drill be conducted on at least an annual basis.

2c) Electrical and Gas Appliance Inspections

(2.8) There should be an annual inspection of all electrical and gas appliances in ‘high-risk’ high-rise residential buildings.

2d) Safety-related markings within evacuation stairs.

(2.9) Floor numbering in all residential high-rise buildings to be marked clearly (e.g. 0.5 m lettering in photo-luminescent paint) on each landing at two heights within the evacuation stairs. In addition, tactile numbering should be located on the internal surface of each door leading out of the stairwell.

NOTE: Firefighters and evacuating residents had difficulty identifying precisely where they were during the evacuation of Grenfell Tower. Floor numbering, if it exists, may be obscured by smoke, or poor lighting, or may simply be too small to see. This can have serious consequences for communicating essential information, such as the location of people requiring rescue and fire-related events, to firefighters, particularly if they are then dispatched to the wrong floor. As part of this recommendation it is suggested that:

- The floor numbering should be located in a standard location, so that firefighters and residents know where to expect it e.g. the main landing on each floor. In addition, tactile numbering should be located on the internal surface of each door leading out of the stairwell to provide an additional means of identifying the floor, should the numbering not be visible, and to aid the visually impaired.
- The floor numbering should be marked in large lettering, approximately 0.5 m in height.
- The floor numbering should be located at two heights: head height, clearly visible in good lighting and smoke free conditions, and near the floor, so that there is a chance that the numbering can be seen if the stair begins to fill with smoke.
- The floor numbering should be marked in photo-luminescent paint so that it can be seen easily in low lighting conditions.

(2.10) The nosing of the stairs and the edges of the stairs should be marked with photo-luminescent paint in all residential high-rise buildings.

NOTE: Many residents reported evacuating down the stairs within the Grenfell Tower in darkness, due to the presence of smoke, the failure of the emergency lighting, or both. These conditions slow the progress of evacuation, which identifying the nosing and edge of each step will help to mitigate. It is noted that this measure was introduced in the World Trade Center building following the experience of occupants during the first terrorist attack on the buildings. The introduction of the photo-luminescent paint on the stairs made a significant difference during the evacuation following the second terrorist attack.

2e) Personal Emergency Evacuation Plan

(2.11) A Personal Emergency Evacuation Plan (PEEP) should be prepared for all residents of high-rise residential buildings who cannot self-evacuate.

NOTE: Witness and firefighter statements from the Grenfell Tower fire indicate that a number of Grenfell residents were unable to self-evacuate, due to a permanent condition that reduced their mobility (e.g. a disability or an age-related condition), or a temporary condition that reduced their mobility (e.g. injury, illness or pregnancy). In some of these cases, the person with reduced mobility (PRM) was able to evacuate with significant assistance from residents or firefighters, who lacked training, equipment and/or procedures that would have reduced the jeopardy to their safety and that of the PRM.

In office buildings, this issue is addressed through the PEEP, a specifically designed evacuation plan tailored to the specific needs of the PRM. Should the PEEP require specific equipment (e.g. smokehoods (see 2.12), evacuation chairs (see 3.6), etc.), training or procedures, these are the responsibility of the building management. The PEEP is developed and agreed with the PRM – it is not imposed – to provide a systematic way to meet their requirements for safe and timely evacuation.

2f) Smokehoods for Residents of High-Risk buildings

(2.12) In 'high-risk' high-rise residential buildings, a risk assessment should be undertaken to determine if some or all residents should be provided with personal smokehoods.

NOTE: In all fires, the presence of toxic smoke is the primary reason why occupants are unable to evacuate safely. Witness and firefighter statements from the Grenfell Tower fire indicate that a number of people had difficulty in self or assisted evacuation, due to the presence of smoke in the communal areas, on the stairs, or both. To address this danger, the provision of smokehoods for residents of high-risk residential buildings should be considered. Within the UK, smokehoods have been readily available (for purchase by the public) for over 30 years, and are even provided in hotel rooms in some hotels around the world (e.g. Japan, Korea and China). They are small, compact and light, and can pack down to a very small package, making them easy to store and carry. The decision to provide occupants with smokehoods should be based on a risk assessment, taking into consideration other mitigation measures, such as the type of building-wide alarm system, the inspection regimes for fire doors, automatic door closers, electrical and gas appliances, firefighter rescue equipment, etc. The risk assessment should also consider maximum travel distances from the flat door to the escape stair door.

2g) Fire Safety Fault Reporting System for Residents

(2.13) In high-rise residential buildings, procedures should be put in place for residents to easily report faults and problems associated with (a) flat fire doors, (b) fire doors to the emergency stairs, (c) lifts that are designated as firefighting lifts, and lifts that may be used as part of the building-wide alerting strategy. Once an issue has been reported, the local authority must undertake an inspection and, if required, take remedial action within a specified set period of time. Failure to complete required remedial works within the required time should be reported to the local Fire and Rescue Service (FRS).

2h) Regular Inspection of Lifts associated with Fire Safety

(2.14) In high-rise residential buildings procedures should be put in place to allow the regular inspection of lifts that are designated as firefighting lifts, evacuation lifts and lifts that may be used as part of the building wide alerting strategy. Once an issue has been identified, the local authority must undertake remedial action within a specified period of time. Failure to complete remedial works within the required time should be reported to the local Fire and Rescue Service (FRS).

2i) Review and Regular Inspection of Smoke Extraction Systems

(2.15) There should be a review of the operational capabilities of smoke extraction systems in high-rise residential buildings, to ensure that they are able to function appropriately when dealing with fires on multiple floors. Furthermore, consideration should be given to the installation of a manual override, allowing the fire service, in the event of fires on multiple floors, to activate smoke clearance on any selected floor. In addition, while regular testing of the smoke extraction system is a current requirement, this should be extended

to include an annual cold smoke test of the system to ensure that fire dampers work as intended.

NOTE: Smoke extraction systems used in residential high-rise buildings are currently designed to deal with a fire on one floor only.

2.3 (3) Firefighting and Rescue:

The following 13 recommendations are based on my analysis of witness statements relating to their observations of the developing fire, and the descriptions from firefighter witness statements and oral evidence provided by senior fire officers.

3a) Reducing fire/smoke spread during firefighting operations.

NOTE: Should evacuation prove necessary in residential high-rise buildings the single common stairwell is the only means by which the occupants can evacuate. It is thus essential to keep it clear of fire effluent. During firefighting operations, firefighters lay hose, usually from one floor below the floor of fire origin, bringing the hose up the stairs and onto the fire floor, and necessitating the opening of the fire door into the stair core. As the hose blocks the door – effectively wedging it open – any smoke present in (or that subsequently leaks into) the communal area is then free to spread into the stair core. This was reported to be an issue in Grenfell, where a number of witness statements and firefighter accounts suggest that at least on floors 4 and 5, smoke from the communal area spread into and smoke logged the emergency escape stair in the vicinity of these floors, at some time(s) during the incident. Furthermore, if firefighting activities are abandoned without successfully dealing with the fire, the hose may be left in the doorway, allowing smoke to continue to spread into the stair core. If the presence of smoke on the stairs results in a significant reduction in visibility, hose may also become a serious trip hazard. In addition, when attacking the fire within the flat of fire origin, it is again necessary to open the fire door from the communal area leading into the flat. This fire door is also necessarily left open – effectively wedged open by fire hose – allowing smoke to spread from the flat of fire origin into the communal area (and from there into the emergency stair).

The challenge, therefore, is to give fire hose access between compartments, whilst minimising the impact on the integrity of fire barriers, such as fire doors. As smoke is a hot, buoyant, gaseous particulate-laden flow, it tends to rise, filling a fire compartment from the top down. An open door within the compartment will allow smoke to spill into a neighbouring compartment, as the hot buoyant gases descend to the bottom of the door soffit and intercept the top of the open doorway. Closing the door will prevent the smoke spreading to the neighbouring compartment, but a door wedged open by fire hose will allow the smoke to spread.

(3.1) To avoid firefighters wedging-open fire doors to the stair core through their use of hoses, modifications should be implemented to the stair fire door (e.g. introduction of a hinged door flap in lower part of door) or a common wall between the communal area and the landing (e.g. introduction of fire hose couplings). These measures would maintain an effective barrier to the ingress of smoke from the common lobby into the stair core during firefighting operations.

NOTE: If the fire door could be modified to enable the top part of the door to remain closed, while the bottom part was open, this would delay the spread of the smoke into the neighbouring compartment, while allowing the hose to pass through. Clearly, the smaller the vertical extent of the open bottom part, the longer the neighbouring compartment is likely to remain free of smoke. The stair door could be modified by introducing a hinged flap in the lower part of the door (see Annex 1 Figure 1). The flap could extend the entire width of the door (as shown in Annex 1 Figure 1a), allowing multiple hose lengths to be introduced (see Annex 1 Figure 1b), or it could only extend for part of the width of the door, improving the integrity of the door, while reducing the number of hose lengths that could be accommodated.

Alternatively, the wall between the stair core main landing and the common area could be modified to allow the insertion or through-connection of hose couplings (as shown in Annex 1 Figure 2). This would preferably be in the wall containing the door, if there were sufficient space; however, if this were not possible, the wall adjacent to the fire door could be utilised. Several couplings could be introduced to allow more than one length of fire hose to be connected (as shown in Annex 1 Figure 2b). When not in use, the coupling would have a cap similar to that on current dry- or wet- riser fittings.

(3.2) In order to maintain an effective barrier to the ingress of smoke from the flat of fire origin, into the common lobby and/or from the common lobby into the stair core, during firefighting operations, firefighting operating procedures should be modified to allow firefighters to cut a portion of the lower part of the firedoor out, allowing the passage of fire hose without necessitating the fire door to be wedged open, OR to make use of a fire/smoke curtain to prevent the spread of smoke through open doors.

NOTE: The use of deployable fire/smoke curtains (as shown in Figure 3 Annex 1) is a common and successful firefighting tactic in mainland Europe. Fire/smoke curtains take seconds to install and can be carried easily on fire appliances. The concept was developed by Dr Michael Reick (who is also a senior German fire officer (Regional Fire Commander)) in 2005 [3, 4].

(3.3) The use of Positive Pressure Ventilation (PPV) should be considered for residential high-rise buildings to reduce smoke ingress into the stair core, and to potentially clear the stair core of smoke.

NOTE: PPV is a common tactic in fighting fire in Europe and the USA [5]. Its use is complex, and depends on a number of factors, including size of the stair, size of the opening into the stair where the fan is placed, size of the fan, nature of openings on the stair (e.g. windows, vents, open doors, use of fire/smoke curtains), nature of external wind conditions, etc. The fire service should explore the experience of using PPV in other countries, and develop operating guidance for use in UK conditions through both experimentation and computer modelling.

3b) Measures to improve firefighter rescue efforts.

NOTE: Current procedures and equipment used by firefighters do not protect rescued residents from breathing toxic smoke during assisted evacuation. During rescue operations, firefighters were often faced with assisting Grenfell residents to pass through thick toxic smoke in the common lobbies, the stairs, or both. In some cases, firefighters removed their own face masks to provide air for victims – which is strictly against firefighter operational protocols – potentially endangering their own lives and the lives of the people they are rescuing.

In a number of cases reported in Grenfell firefighter witness statements, firefighters had to carry or assist victims down the stairs because the lifts were not available for use during the fire. Given the width of the stairs in residential buildings (about 1 m), the size and weight of the victims and the nature of the Personal Protective Equipment (PPE) and Breathing Apparatus (BA) that the firefighters wear, it can be extremely difficult to carry unconscious or semi-conscious casualties, PRM or those injured by the incident. The difficulty of the task meant that progress down the stairs was slow (endangering both the firefighters and the rescued) and in some cases, the victim may have been injured during the process.

(3.4) A smokehood should be included in the equipment carried by all FRS BA crew (not just those on Fire Survival Guidance (FSG) jobs) to protect the rescued survivor from the smoke and toxic gases they may need to pass through during the assisted evacuation. Additional smokehoods should be available in incident command units.

NOTE: Smokehoods (i.e. air filter smokehoods – see recommendation 2.12) have been used by fire brigades in Europe (e.g. Germany and Austria) to assist in the rescue of trapped occupants for a number of years, with success. Indeed, in Germany, fire appliances have been required to carry smokehoods (Fluchhaube) as part of their normal equipment for a number of years, to assist in rescue operations [6].

(3.5) Additional Extended Duration Breathing Apparatus (EDBA) should be made more widely available for BA crew undertaking FSG jobs and potentially for fire crews undertaking firefighting activities. Each firefighter within BA teams undertaking FSG jobs, should also carry an additional face mask (in addition to the smokehood) that can be plugged into the EDBA to provide rescued victims with a supply of air, should it be needed. However, in using EDBA it is essential to closely monitor firefighters to ensure that safe working physiological limits are not exceeded before the air supply is expended.

NOTE: The use of EDBA in firefighting and search and rescue is a complex issue, as extended operations may result in the development of life-threatening heat fatigue. It is not only the amount of air that dictates how long a firefighter can operate safely on the fire ground, while wearing Personal Protective Equipment (PPE); other key factors are heat strain, physical exhaustion and dehydration. By its very nature the PPE is designed to protect the wearer from the heat of a fire environment; but in providing insulation protection from the exterior heat, it prevents the dissipation of the internal heat generated by the wearer while 'working hard'. Examples of 'working hard' include wearing (carrying) EDBA (greater weight than SDBA) while carrying hose and kit, climbing multiple floors and then undertaking firefighting or search and rescue activities. The trapped heat generated from this physical activity results in an increase in core body temperature. The greater the rate of work, the more rapid the increase in core body temperature.

A key physiological limit on working duration is the core body temperature. When core body temperature exceeds 40^0C, heat stroke can occur, which is life threatening, and requires immediate remedial attention. The challenge is that it is difficult to predict when a firefighter is likely to succumb to heat fatigue, as this depends on a number of factors, including, ambient temperature, type of PPE and BA worn, the nature of the activities undertaken, physical load carried (including the BA), age and gender, personal attributes such as stature, body composition, strength and aerobic fitness, etc. It is also difficult for the firefighter to know when they are succumbing to the effects of heat fatigue e.g. adrenaline generated by firefighters responding to the incident can mask the physiological impact of heat fatigue.

These points were demonstrated in a series of trials conducted by UK firefighters. The trials required firefighters to undertake firefighting and search and rescue activities in a four-storey building under ambient conditions (i.e. not operating within an environment that has been heated by a fire). The majority of EDBA teams undertaking the trials were forced to withdraw early by trial officials due to core body temperatures reaching critical levels (core temperatures were remotely monitored, with an imposed critical limit of 39.5^0C) [7].

One of the complications associated with heat fatigue (and dehydration) is impaired judgement, making it difficult to self-diagnose its onset and recognise errors arising from its influence.

In terms of search and rescue, the primary purpose of the EDBA would be to provide additional air for the rescued casualty, should it be required. While this recommendation suggests wider use of EDBA, it is also strongly suggested that the extensive use of EDBA should be monitored carefully. Ideally, firefighters should be equipped with a means to monitor core body temperature, alongside respiration rates (which are currently monitored), with an alarm triggered if core body temperature approaches critical safety levels, which is the current practice for air levels [8].

It is also noted here that repeated wear of BA, as occurred during the Grenfell Tower fire, is not desirable (unless core body temperature and hydration levels are known), as the starting condition of the firefighter is not known with any certainty i.e., they may be starting the second wear at already elevated core body temperatures, and in a state of dehydration which can severely limit the safe duration of the second wear.

(3.6) Firefighters undertaking Fire Survival Guidance (FSG) jobs should be equipped with a means to assist in the extraction of casualties unable to self-evacuate, such as a carry sheet or an evacuation chair.

NOTE: The carry sheet is both inexpensive and light (see Annex 1, Figure 4a), but requires at least two firefighters to operate, and the task can be difficult, particularly carrying a heavy individual down the stairs; and, if more firefighters are required, the narrow stairs found in residential high-rise buildings will make this difficult or impossible. The evacuation chair, in contrast, is a device that can be operated by a single trained person (see Annex 1, Figure 4b), to take a PRM down multiple flights of stairs, though several people may be required to transfer the PRM to the device initially. Research conducted by Prof Galea suggests that an evacuation chair allows the handler and PRM to descend the stairs at a speed equivalent to that of an able-bodied person walking down the stairs [9]; however, given the confined nature of the stairs and associated landings in high-rise residential buildings, it is essential to ensure that the evacuation chair is able to navigate the stairs and make the tight turns required on the landings. The chair depicted in Annex1 Figure 4c (Evac-Chair Model 300H MK4 – note evacuation chair is a generic term, while Evac-Chair is a product name) is an example of a light-weight, narrow chair suitable for use in the tight confining space of stairs found in residential buildings. The chair is 0.52 m wide, weighs 9.5 kg, and is capable of carrying a person weighing 182 kg [10]. The chair depicted in Annex 1 Figure 4c has carried the depicted person down a 0.97 m wide stair and is negotiating a turn on a landing that is only 1.02 m deep, at its deepest point. As a result, it is suggested that this device is likely to have been able to negotiate the narrow stairs in the Grenfell Tower; however, it is noted that obstacles, such as hose in the stairwell, may make it difficult for the device to pass, and the presence of an evacuation chair on the narrow stairs may create conflict with other stair users.

3c) Measures to ensure safe and timely full building evacuation.

NOTE: As already described, the 'stay put' principle is a sound philosophy to follow **IF (and only if)** compartmentation is maintained, and the fire is contained within the compartment of fire origin (see Recommendations in 2a). Lakanal House and Grenfell Tower demonstrate the catastrophic consequences of failing to identify when the first line of defence (compartmentation) has failed, and also the fatal consequences of not having an alternative strategy to replace 'stay put'. It is not sufficient to simply recognise that, given the current evolving situation, the 'stay put' strategy is likely to be inappropriate; it is also necessary to have an alternative strategy to fall back on i.e. how to instigate and manage a partial- or full-building evacuation. It will be extremely difficult for an Incident Commander to come up with an alternative on the spot, so it is critical that the FRS develop plans for how they would manage a full-building evacuation in high-rise residential buildings, should this prove necessary – they must have a 'Plan B'.

> **(3.7) Fire and Rescue Services (FRS) must develop procedures and plans for how they will recognise the need for, instigate and manage a partial or full evacuation of 'high-risk' buildings within their regions, should 'stay put' prove to be inappropriate, or the temporary fire safety measures put in place prove to be ineffective.**

NOTE: The FRS should be aware of all 'high-risk' buildings in their area and the temporary measures put in place to mitigate the risk e.g. Waking Watch and temporary fire detection/alarm systems. However, in addition, the FRS must develop contingency plans for how they would instigate and manage a full-building evacuation, should this prove necessary. The FRS cannot simply rely on 'stay put' or the temporary measures recently introduced. A key issue to be addressed is how to alert the occupants of the need to evacuate. This may be achieved through a firefighter instigated door knock, which may require the availability of considerable human resources in the initial response, and the use of building lifts to speed up the process. The plans should also include the use of equipment such as smokehoods and evacuation chairs/carry sheets to assist in rescue operations. While this recommendation relates to 'high-risk' buildings, it would, ideally, also be applied to all high-rise residential buildings.

> **(3.8) FRS must develop an appropriate initial mobilisation response to reported fires (predetermined attendance) in high-risk buildings, so that they have sufficient resources available from the outset to instigate and manage full-building evacuation.**

NOTE: The FRS predetermined attendance should be appropriate to FRS plans to instigate and manage a full-building evacuation. This includes not only human resources, but additional resources, such as smokehoods and evacuation chairs/carry sheets, which may be required as part of the FRS evacuation strategy. This recommendation applies to all high-risk buildings, not just residential buildings. It is noted that the local FRS response to a recent fire in a residential high-rise building in Melbourne involved 80 firefighters and two of the largest ladder platforms in the city. It is reported that these resources were available on the fire ground within minutes of the reported fire. The fire occurred in the early hours of the morning of 04/02/19 within a 40 storey high-rise building recently classified as a 'moderate risk', due to the presence of some combustible cladding [11].

> **(3.9) If the building lifts or other on-site facilities/equipment are part of, or impact on, the FRS full-building evacuation plan, the FRS should make regular**

inspection checks to ensure that they are available and serviceable, should they be required. If remedial actions are necessary, the FRS should be empowered to order them, and require them to be actioned, immediately.

NOTE: The frequency of the FRS visits should be considered in conjunction with the requirements specified in recommendations 2.13 and 2.14.

(3.10) Training for senior fire officers should be expanded to include:

- **Aspects of the construction of high-rise buildings that may impact fire development and firefighting e.g. the nature, type and flammability of any cladding, and their likely impact on the behaviour of the fire.**
- **An understanding of the concepts of compartmentation and 'stay put', not simply from a regulatory and policy point of view, but also in terms of the scientific and engineering principles that underpin them. The training should enable the incident commander to identify when compartmentation is at risk of failing/is failing/has failed and the impact that this will have on 'stay put'.**
- **Alternative tactics, should a full-building evacuation be required.**

NOTE: It is clear from the oral evidence provided by senior fire officers that the training of fire incident commanders does not currently include (a) details of serious cladding fires in residential buildings in the UK and around the world and the lessons learnt from these fires, (b) an understanding of modern construction of high-rise buildings and the implications that the widespread use of cladding has on fire development and firefighting, and (c) how to recognise and respond to a failure of compartmentation arising from a cladding fire or other causes. As a result, incident commanders have no contingency planning to accommodate a failure of compartmentation on such a large scale as at Grenfell, and how to instigate and manage a full building evacuation. The proposed enhanced training should extend to officers who may be in command during the early phases of a fire.

3d) Measures to improve the flow of information between the control centre, fire ground and the bridgehead.

(3.11) The FRS should develop a digital recording system that enables FSG information to be entered into a digital record by the call handler, which is transferred automatically to the Incident Commander, and the Command Unit, once one has been mobilised. The digital record should have a facility to be updated by the Incident Commander (who may wish to prioritise particular FSG). A two-way digital link should also be available between the Incident Commander and Bridgehead (to record deployment and updates).

NOTE: From evidence provided by the Call Handlers and the firefighters, it is clear that the communication of Fire Survival Guidance (FSG) information between the Control Centre, fire ground and Bridgehead can be slow and potentially error-prone. The fastest technology currently available should be utilised to relay information and maintain a current record, accessible to those who need an up-to-date picture.

3e) Dealing with a high volume of 999 Calls.

(3.12) The FRS should develop an enhanced capability to expand the local call centre capacity by, for example, bringing in additional call handlers, when dealing with a high volume of calls associated with a major incident. Recourse to using other FRS call handling facilities should be considered a backup.

NOTE: On the night of the Grenfell Tower fire, the London FRS Control Centre received an unprecedented number of 999 calls. While there is a system in place to pass on calls to other FRS Control Centres around the country, there should also be a capability and capacity to bring in additional resource at the centre local to the major incident. The required additional capability may mean:

1. Bringing in additional trained staff to assist with the handling of calls related to the incident
2. Bringing in additional trained staff to assist with the handling of other calls not related to the incident.
3. Adding additional lines into the Control Centre.
4. Opening a backup Control Centre.

2.4 (4) Regulatory Changes:

This section consists of three recommendations which are based on my understanding of existing building regulations.

NOTE: In this section, the focus is on specific safety-related changes to the regulations that have not already been made indirectly in the other recommendations. It should be noted that the regulatory changes suggested here do not relate to the issue of whether or not the façade materials used in Grenfell Tower were compliant with the Approved Document B (AD B). Furthermore, the suggestions made here relate to new build construction, not existing buildings.

4a) Use of combustible cladding materials in the façade of buildings.

> **(4.1) The UK should adopt the more stringent European test methods to measure fire resistance of building materials, in preference to older UK test methods, when undertaking bench-scale fire tests (small sample fire tests).**

NOTE: Part of the difficulty with the current AD B is the confusing use of both UK and European fire resistance material testing, which are considered to be equivalent, but may not necessarily result in the same fire rating for a given material. This is because they may subject the test sample to slightly different fire conditions, such as testing only a surface, compared with testing a surface and an edge of a test sample, or testing if any individual component of a composite material is flammable.

> **(4.2) All materials (each separate material) used within the construction of the external wall (including the façade) of ALL buildings of greater than two floors should have a European fire resistance of limited combustibility or better, and so be classed as A2 or better (i.e. A1). A 'desktop study' should no longer be considered a viable approach to demonstrate compliance with this requirement.**

NOTE: Another area of concern is the fire resistance rating of cladding materials that is considered appropriate. The guidelines (AD B) are not sufficiently clear on this point, and so are open to interpretation. The suggested changes to AD B make the choice of material unambiguous and in-line with the intent of the British Building Regulations. This requirement should apply to all buildings of more than two floors, in particular, residential buildings, schools, hospitals, care facilities, etc., irrespective of height. It is noted that the requirements at the time of the Grenfell fire concerning use of combustible cladding materials in the façade had a threshold height of 18 m. It is also noted that the recent proposed amendments to the Scottish regulations/guidance reduces the threshold height to 11 m. In my professional opinion both figures (18 m and 11 m) are 'magic' numbers and until a sound fire engineering basis is provided to justify the threshold height, it should be set to the equivalent of greater than 2 floors (approximately half the proposed Scottish threshold).

4b) Introduction of sprinklers in residential high-rise buildings.

(4.3) Domestic sprinkler systems should be mandatory in all new residential buildings (of greater than two floors), and all existing residential high-rise that are undergoing extensive refurbishment.

NOTE: Given the nature of the kitchen fire in Flat 16 at Grenfell Tower (which is currently believed to have been located initially behind the fridge, adjacent to the window), it is not clear whether a domestic sprinkler would have been able to suppress the fire and prevent it from spreading to the exterior cladding (as the fire was shielded by the fridge from the influence of a kitchen sprinkler head, which would likely have been located in the centre of the ceiling). Furthermore, given that the fire took hold in the external cladding, an internal domestic sprinkler system would have been unable to prevent the rapid external spread of the fire, and it is unlikely that a domestic sprinkler system would have had the capacity to prevent the internal spread of the external fire over multiple floors. Nevertheless, a domestic sprinkler system, if correctly maintained, is likely to prevent the spread of most internal fires, reducing the likelihood that a fire may spread to the exterior, or spread to the interior of the building, and so endanger those in other parts of the building.

3 REFERENCES TO EXTERNAL MATERIAL CITED IN THIS REPORT.

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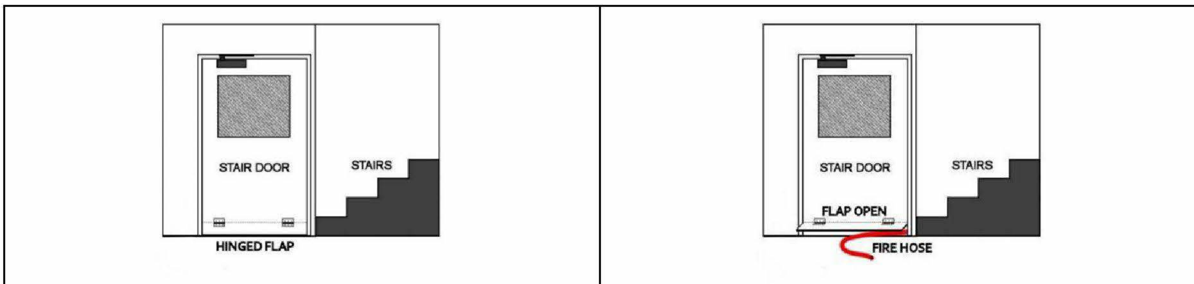
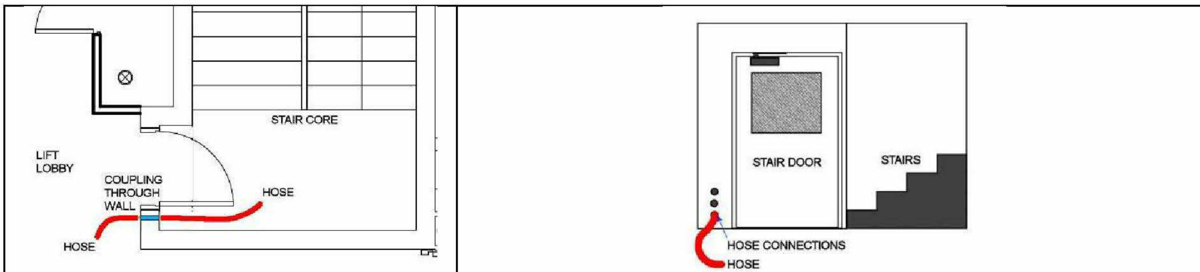
4 ANNEX 1: FIGURES ASSOCIATED WITH RECOMMENDATION 3.1, 3.2, 3.6



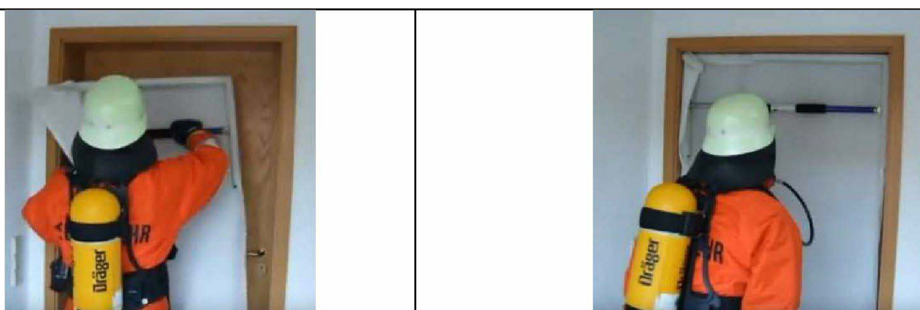
a) Hinged flap in the lower part of the door | b) fire hose protruding through open flap

Figure 1: Introduction of hose flap at the bottom of a fire door.



a) hose passing through coupling | b) hose passing through coupling with several couplings available.

Figure 2: Introduction of hose coupling between stair core and common lobby



a) firefighter begins installation | b) fire/smoke curtain is installed and door can now be opened

Figure 3: Installation of fire/smoke curtain (from https://www.youtube.com/watch?v=XitfIq7pnjM).

a) Typical carry sheet | b) Typical evacuation chair | c) Evacuation chair turning on a narrow landing

Figure 4: Aids that can be used to assist non-ambulant people down stairs

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