

**Grenfell Tower – fire safety investigation:
The fire protection measures in place on the night of the fire, and conclusions as to:**

**the extent to which they failed to control the spread of fire and smoke;
the extent to which they contributed to the speed at which the fire spread.**

**Phase 1 Report – Section 2
Conclusions and Next Steps**

REPORT OF

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**Fire Safety Engineering
5th November 2018**

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On behalf of	:	Grenfell Tower Inquiry
On instructions of	:	Cathy Kennedy, Solicitor, Grenfell Tower Inquiry
Subject Matter	:	To examine the circumstances surrounding the fire at Grenfell Tower on 14 June 2017
Inspection Date(s)	:	6 th October, 1 st November, 7-9 th November 2017

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Issues and Methods

2.1 Instructions

2.1.1 On the 16th November 2017 I was instructed as an Expert Witness and to do the following.

2.1.2 To provide reports, for the purposes of Phases 1 & 2 of the Inquiry, which address the following issues:

1. Design and construction of the building and decisions relating to modification and refurbishment;
2. Fire prevention and fire safety measures in place at Grenfell Tower on 14th June 2017;
3. Whether regulations, legislation, guidance and industry practice were complied with in the case of Grenfell Tower and the fire safety measures adopted in relation to Grenfell Tower;
4. Recommendations about what, if any changes could be made to the regulatory regime and industry practice to prevent a similar incident from happening in the future.

2.1.3 Specifically, for this Phase 1, I am instructed to provide a preliminary report on the identification of the active and passive fire protection measures within Grenfell Tower on 14th June 2017, including preliminary conclusions (where possible) as to the extent to which they:

- a) failed to control the spread of fire and smoke; and
- b) contributed to the speed at which the fire spread.

2.1.4 In Phase 2, I am instructed to provide a report on:

- a) The design and construction of Grenfell Tower and the decisions relating to its modification, refurbishment and management (so far as is relevant to the events on the night of 14 June 2017);
- b) whether such regulations, legislation, guidance and industry practice were complied with in the case of Grenfell Tower and the fire safety measures adopted in relation to fire and
- c) final conclusions on the active and passive fire protection measures within Grenfell Tower on 14th June 2017 and the extent to which they: (1) failed to control the spread of fire and smoke and (2) Contributed to the speed at which the fire spread.
- d) Recommendations about what, if any changes could be made to the regulatory regime and industry practice to prevent a similar incident from happening in the future.

- 2.1.5** I am therefore to make the necessary technical investigations and to express my opinion with full reasons on each of these issues.

2.2 Statements considered

- 2.2.1** I have been provided with witness statements given by the London Fire Brigade (LFB) to the Metropolitan Police Services (MPS). Where I have referred to the content of these witness statements, I have referenced the witness statement accordingly. I have also referred to transcripts of oral evidence of firefighters during the Public Inquiry hearings. Transcripts are referenced by name and date of hearing.
- 2.2.2** I have been provided with two types of statement from firefighters: formal witness statements and contemporaneous notes prepared after the fire. By way of shorthand, I refer to both as firefighter witness statements.
- 2.2.3** I have been provided with witness statements from a number of the residents of Grenfell Tower. I expect further evidence from residents to become available to me as a result of residents providing oral evidence to the Public Inquiry Hearings.
- 2.2.4** I will need to update my work and make final changes, in particular to the timings and conditions for escape and resident experience of rescue, and the operation of the lobby smoke control system during the fire, once this oral evidence becomes available to me.
- 2.2.5** For the avoidance of doubt, I have not been provided with any witness statements that the Inquiry has obtained (and is in the course of obtaining), for its Phase 2 work. I will consider those (to the extent they are relevant to my work) at Phase 2.

2.3 Documents considered in forming my opinion

- 2.3.1** The Inquiry is using an online document management platform called Relativity. I have been provided with access to my own workspace on Relativity, which contains documents provided to me by the Inquiry. Additional documentation has been provided to me by the Inquiry as and when it has been disclosed by document providers. From time to time, I have also made my own requests to the Inquiry for specific documents and, where available, these documents have been provided to me.
- 2.3.2** I have reviewed an extensive number of relevant documents relevant to the Issues forming the basis of this report. Where I have relied on documents that are material to my opinions, I have referenced them specifically in the body of this report.
- 2.3.3** I am aware that disclosure to the Inquiry is ongoing and that further documents, witness statements or information may become available in the future. Further, in some places in this report I say that certain documents have not been disclosed. This means that, at the time of writing my report, I have

not seen such a document. If I need to revise the views expressed in this Report in light of further disclosure, I will inform the Inquiry.

2.4 Site investigations

- 2.4.1** In preparing this Phase 1 report I have carried out a series of post-fire site inspections at Grenfell Tower. The purpose of my site inspections was to identify the active and passive fire protection measures, as were present within Grenfell Tower on 14th June 2017.
- 2.4.2** I also recorded post-fire damage, and explored as built construction detailing. These investigations are summarised in Appendix C.
- 2.4.3** All my photographic evidence has been uploaded into Relativity.
- 2.4.4** I provide photos throughout my Report and its Appendices, and I make clear where they are Arup photos, and so taken by me or a member of the Arup team, who attended site with me.
- 2.4.5** I explain the methodology I applied on site in Section 6, and I explain the role of each member of my team when we were on site.

2.5 Outstanding information

- 2.5.1** There is still information I would like to be provided to me, as part of my work for the Public Inquiry. Where I require further information, I have made this clear within this report. I have also provided the Inquiry with details of the information I will require in Phase 2.
- 2.5.2** I will update my report when evidence is provided to me that requires me to change any of my assumptions, analysis or conclusions. I have all the substantial documents I needed to rely on, in writing this Phase 1 report.

2.6 Issues addressed in my report

- 2.6.1** This is my Phase 1 report. I have investigated the following issues, insofar as the evidence is available to me:
 - 1. the design and construction of the building and decisions relating to modification and refurbishment since 2005;
 - 2. the fire prevention and fire safety measures in place at Grenfell Tower on 14th June 2017; and
 - 3. whether regulations, legislation, and guidance were complied with in the case of Grenfell Tower and the fire safety measures adopted in relation to Grenfell Tower.
- 2.6.2** The remainder of my report is split into eighteen technical sections, and addresses the following issues:
 - Section 3 Building description including fire safety requirements

Section 4 Description of the refurbishment works

Section 5 The observed events of 14th June 2017

Section 6 Investigating how this happened – the physical evidence at Grenfell Tower

Section 7 Where the fire started

Section 8 The Building Envelope – materials and construction

Section 9 Resulting routes for fire spread out and in through the window openings

Section 10 Resulting routes for vertical and horizontal fire spread throughout the Building Envelope

Section 11 Construction of the external walls – the provisions made at Grenfell Tower to comply with Building Regulations

Section 12 The significance of the building envelope fire

Section 13 Critical times during the fire event

Section 14 The performance of the protected stair and lobbies

Section 15 Construction of the common lobbies – the provisions made at Grenfell Tower to comply with Building Regulations

Section 16 Construction of the single protected stair – the provisions made at Grenfell Tower to comply with Building Regulations

Section 17 External firefighting – the provisions available at Grenfell Tower

Section 18 Communicating with residents in an emergency

Section 19 How the protected stair and lobbies failed for firefighters and for residents

Section 20 The consequences of the failures in Grenfell Tower

Section 21 Experts Declaration

2.6.3 I have provided additional supporting information in the following series of Appendices:

Appendix A: Experience, Qualifications, Appointments, Speciality of the Expert and of those who have assisted in the preparation of the report

Appendix B: Texts and published material referred to

Appendix C: Excerpts from Site inspection records from Grenfell Tower

Appendix D: Legislation, Regulations and Guidance relevant to Grenfell Tower

Appendix E: Compliance Assessment - External Fire Spread Regulation B4

Appendix F: Reaction to fire tests and classifications

Appendix G: Compliance Assessment means of warning and escape Regulation B1

Appendix H: Compliance Assessment - access and facilities for the Fire and Rescue Services Regulation B5

Appendix I: Flat Entrance fire doors and Stair fire doors – requirements and provisions

Appendix J: Lobby smoke control – requirements and provisions

Appendix K: Gas supply – fire safety requirements and provisions

Appendix L – Lift installations – fire safety requirements and provisions

Appendix M – Applicable historic guidance on fire door design, specification and testing

Appendix N – Collated evidence relevant to conditions in the stairs and lobbies

Appendix O – Review of the BBA certification for Reynobond Architecture Wall Cladding Panels

2.7 Overview of my approach

- 2.7.1** Using my site observations, and based on the documentation available to me, I have analysed how the fire spread from Flat 16, how it spread around each elevation of the building, and the timings of this fire spread (Section 5, 13).
- 2.7.2** I analysed the evacuation times of all residents who left the Tower (Section 14). I analysed the movement within the Tower of those residents who did not get the opportunity to evacuate, and died at the Tower (Section 20).
- 2.7.3** I analysed the London Fire Brigade (LFB) response with respect to critical times only, as I explain in Section 5, 12, 17 and 20. Their chain of command and critical decision making and processes are the subject of expert evidence by others in this Public Inquiry. I am interested only in the intersection with, and reliance on, building design features including the active and passive fire protection measures.
- 2.7.4** I carried out an assessment of compliance with the relevant legislation at the time of design and construction of Grenfell Tower: Section 20, 34 and 98 of the London Building Acts (Amendment) Act 1939. I have assessed compliance by reference to the GLC Code of practice for buildings of excess height (1970), *British Standard Code of Practice CP3: Chapter IV Part 1 Flats and Maisonettes (in blocks over two storeys), 1971* (referred to as CP3 herein) and the London Building Constructional Amending Bylaws 1952 (as amended 1964, 1966 and 1970) respectively. (Appendix D and Section 3). I carried out an assessment of compliance with the Building Regulations by reference to *Approved Document B Fire Safety Volume 2 – Buildings other than Dwelling Houses 2006, incorporating 2013 amendments* (referred to as

ADB 2013 herein) - the statutory guidance which applied at the time of the main refurbishment works from 2012-2016 (Section 11, 15, and 16).

- 2.7.5** In my Conclusions section (Section 2.9 - 2.34) I provide my preliminary conclusions as to the extent to which the active and passive fire protection measures within Grenfell Tower on 14th June 2017:
- (a) failed to control the spread of fire and smoke; and
 - (b) contributed to the speed at which the fire spread.
- 2.7.6** I am aware of a range of opinion as to ways of complying with Building Regulation B4 External Fire Spread, specifically regarding the application of the words *Filler material* to Aluminium Composite Panels (ACP), and regarding the appropriate reaction to fire tests relevant to the fire performance of External Surfaces and relevant to the fire performance of Insulation (as relevant to Section 12 in ADB 2013).
- 2.7.7** I have set out herein, and in detail in my Report, my analysis of this subject (carried out since the Grenfell fire – Appendix F). I have also included my own conclusions regarding whether the cladding system installed at Grenfell Tower complied with the Building Regulations (Section 11 and Appendix E).
- 2.7.8** I have carried out an assessment of the BBA Certificate (BBA00000047) for Reynobond Architectural Wall Panels, as was available at the time of the construction of the primary refurbishment (Appendix O).
- 2.7.9** In due course I intend to produce an additional detailed report on the subject of the overall culture of compliance, regarding the B4 requirement. This will include industry guidance – I have not incorporated industry guidance in this Phase 1 report.
- 2.7.10** Regarding the performance of the cladding system, I have shown the scale of internal fires caused as a result of the major external fire the cladding materials and their arrangement created. I have explained the consequential effects that must then be considered for residents and fire fighters (Section 12).
- 2.7.11** From my review of design guidance and the corresponding fire and rescue service operational response policies, I consider that the Stay Put strategy and the Defend in Place firefighting tactic have remained as the foundation for the statutory requirements regarding the design and construction of high rise residential buildings since 1971 (Section 3 and Appendix D).
- 2.7.12** The Stay Put operational policy of the LFB relies on this building design condition also (Section 18).
- 2.7.13** I have analysed the performance of the active and passive fire protection measures which are provided to support this single safety condition (Section 14). Failure in this building design condition has an impact on what is required by way of an operational response. So they must be considered together.

- 2.7.14** Therefore, in order to understand the extent to which the fire protection measures failed, it has been necessary for me to analyse the timing of resident evacuations, timing of fire fighter entry and occupation of the Tower, timing and scale of FSG calls, as well as the timing around the change in the operational policy regarding Stay Put guidance through *Fire Survival Guidance/999* calls. I have then considered these timings and compared them with the timing of the spread of the external fire, the timing of the spread of the internal fire and smoke in flats, and the timing of the observed conditions in the stairs and the lobbies.
- 2.7.15** In a single stair building, this stair is the only means of access for rescue and fire fighting. And it is the only means of escape. Therefore, the conditions in the stair and the lobbies, for the time period of the fire, represent the consequences of the active and passive fire protection measures provided, and how they performed during the fire.
- 2.7.16** What the residents experienced in the lobbies and the stairs, and how this impacted their ability to self-evacuate, is one consequence of the performance of the active and passive fire protection measures.
- 2.7.17** I have therefore provided my opinion and a preliminary conclusion on the subject of the timing of the change to the Stay Put strategy and what this meant for the life safety of the residents, when they were required to self-evacuate as the only way out, as a result (Section 20).
- 2.7.18** Additionally, what the fire fighters experienced in the lobbies and the stairs, and how this impacted their ability to rescue and to carry out internal and external fire fighting is another consequence of the performance of the active and passive fire protection measures. I have therefore incorporated my review of firefighting activities in my report and have provided some preliminary conclusions on this subject (Section 17).
- 2.7.19** Because there is no building design function provided to enable fire fighters in the UK to communicate any change in their evacuation or rescue guidance from within the building, I have incorporated a review of means of communication with residents in my report (Section 18).

2.8 Building Description and the key fire safety requirements

- 2.8.1** Grenfell Tower was a twenty-five storey residential block built in the early 1970's, located in the Lancaster West Estate in North Kensington, London. This Estate is located in the Royal Borough of Kensington and Chelsea (RBKC). The 67.30-metre (220 ft 10 in) tall building originally contained 120 one- and two-bedroom flats (six dwellings per floor on twenty of the twenty-five storeys) with Ground, Level 1, 2 and 3 assigned to non-residential purposes. These non-residential purposes were altered to provide an additional 9 flats during the 2012-2016 refurbishment program.

2.8.2 Grenfell Tower was subject to a number of refurbishment activities between construction and the fire of 14th June 2017. Of these, I have concluded the most significant were the lift replacement works in 2005, the fire door replacement program of 2011-2012, the main refurbishment of 2012-16 which included the installation of a new external rainscreen cladding system, and the gas supply refurbishment works 2016-17 (still in progress at the time of the fire).

2.8.3 On the 18th June 2018 I provided the following summary presentations to the Inquiry:

No.	Presentation Title	Purpose
1	The original building construction and layout	To describe the original building designed and constructed between 1968 and 1974.
2	Fire Safety in high rise residential buildings in England. Part 1	Presenting the requirements of the Building Regulations and the guidance that exists to help designers comply with those requirements. Presenting the concept of the Stay Put evacuation strategy for residential buildings and the fire protection measures in building design that the strategy relies upon. Presenting the Defend in Place fire fighting tactics that buildings are designed to support, and the associated fire protection measures.
3	Fire Safety in high rise residential buildings in England. Part 2	Presenting further details on the fire safety measures required in buildings to support the Stay Put evacuation strategy and the Defend in Place fire fighting tactics. Identifying that these fire protection measures provide layers of safety to the occupants.
4	Summary timeline	Introducing the different items of work recorded as having been undertaken in Grenfell Tower between 1974 and 2017

No.	Presentation Title	Purpose
5	The Lift Replacement Works 2005 & 2012-2016	<p>A description of the original lifts.</p> <p>Describing the works that had been undertaken on the lifts in Grenfell Tower in 2005 and in the main refurbishment works between 2012 and 2016.</p> <p>Identifying the 2 types of fire fighting lift that have been required by fire safety design guidance.</p>
6	The Fire Door Replacement Works 2011	<p>Describing the specific functions required of a fire door.</p> <p>Describing the fire doors required for Grenfell Tower.</p> <p>Describing the fire door replacement works and the products chosen as part of those works.</p>
7	The Gas Supply replacement works 2016	<p>Describing the original gas supplies in Grenfell Tower.</p> <p>Describing the refurbishment and replacement works undertaken in Grenfell Tower from 2016 onward.</p> <p>Describing the impact that those works had on the fire protection measures in the building and the condition of the gas supply works on the 14th June 2017.</p>
8	Primary Refurbishment 2012-2016: Overview	<p>Providing a high level description of the works, demonstrating that all parts of Grenfell Tower were impacted by the refurbishment.</p>

No.	Presentation Title	Purpose
9	Primary Refurbishment 2012-2016: Other works	Providing details of the refurbishment works, specifically related to: External works; Reconfiguration of Ground Level to Level 3; Works to the fire fighting main; Works to the smoke control system; Works to the heating/hot water and cold water systems; Works in each of the existing common lobbies from Level 4 to Level 23 to fit service cupboards and suspended ceilings.
10	External Wall Primary Refurbishment 2012-2016	<p>Presenting the function, purpose and typical construction for a ventilated rainscreen type façade systems.</p> <p>Presenting the requirements of the Building Regulations and Statutory Guidance for construction of external walls.</p> <p>Describing, in detail, each component and material that was installed internally and externally to Grenfell Tower as part of the external wall refurbishment.</p>

Table 2.1: Expert Witness presentations delivered 18th June 2018

Conclusions

2.9 The primary failure - the Rainscreen cladding system

- 2.9.1 A high degree of compartmentation forms the most important basis of the single building safety condition Stay Put.
- 2.9.2 ADB 2013 states there are two main objectives for compartmentation:
- “a. to prevent rapid fire spread which could trap occupants of the building; and b. to reduce the chance of fires becoming large, on the basis that large fires are more dangerous, not only to occupants and fire and rescue service personnel, but also to people in the vicinity of the building.”*
- 2.9.3 Compartmentation relied on the performance of the external wall at Grenfell Tower, because the external wall connected every flat, and every flat must be a separate compartment.
- 2.9.4 The external walls were required to comply with Regulation B4 External Fire Spread: *“The external walls of the building shall adequately resist the spread of fire over the walls...having regard to the height, use and position of the building.”*
- 2.9.5 In Section 8 and 11, of my Expert Report, I have identified the materials forming the rainscreen cladding system, and assessed their compliance with the relevant statutory requirements.
- 2.9.6 Based on the relevant test evidence submitted to the Public Inquiry, the construction materials forming the rainscreen cladding system, when either considered individually or when considered as an assembly, did not comply with the recommended fire performance set out in the statutory guidance of ADB 2013 for a building with a storey 18m or more above Ground Level.
- 2.9.7 These materials as installed on Levels 4-23 were:
- a) Aluminium windows supplied by Metal Technology Ltd;
 - b) Insulating core panels as infill between windows, formed of combustible Styrofoam (extruded polystyrene) supplied by Panel Systems Ltd;
 - c) Window fan inserts specified as the combustible Kingspan TP10 insulation;
 - d) 100mm thick Celotex RS5100 combustible PIR insulation board applied to columns;
 - e) 80mm thick Celotex RS5080 combustible PIR insulation board (two layers) applied to the spandrels between floors;
 - f) Kingspan K15 combustible phenolic foam insulation (two layers) applied to the spandrels between floors;

- g) Arconic Reynobond 55 PE Cassette system ACP (smoked silver metallic);
- h) Arconic Reynobond 55 PE Cassette system ACP (pure white) – Level 3 only;
- i) EPDM weatherproof membrane between the new windows and the existing concrete structure;
- j) Siderise Vertical cavity barriers on the columns;
- k) Siderise Horizontal cavity barriers;

2.9.8 Additionally, I conclude the entire system could not adequately resist the spread of fire over the walls having regard to height, use and position of the building. Specifically, the assembly failed adequately to resist the spread of fire to an extent that supported the required Stay Put strategy for this high-rise residential building. The assembly failed adequately to resist the spread of fire to an extent that supported the required internal fire fighting – Defend in Place fire fighting regime.

2.9.9 There were multiple catastrophic fire-spread routes created by the external wall materials, the arrangement of the materials, as well as the construction detailing of those materials.

2.9.10 In addition, as I have explained in Section 9, the construction detailing created to seal the gap between the old and new windows, in each flat, meant that the materials and the arrangement of those materials, increased the likelihood of a fire breaking out of the flat and into the large cavities contained within the cladding system surrounding those windows. Those cavities were formed of and contained combustible materials.

2.9.11 Attempts had been made to subdivide the column cavities, and to provide vertical and horizontal fire stopping at key compartment lines. However, both the horizontal and vertical fire stopping were defective in their installation, but more importantly there is no evidence these fire stopping products have ever been proven, by fire test, to perform in an ACP based rainscreen external wall system of the type installed at Grenfell Tower.

2.9.12 The window openings were not provided with fire resisting cavity barriers. These unprotected openings themselves were instead surrounded by combustible materials, which acted as a means of fire and smoke spread.

2.9.13 There were combustible lining materials located within the flats, above and below the window openings. These materials support the spread of fire and smoke, from an incident adjacent to a window, also.

2.9.14 Therefore, in the event of any internal fire starting near a window, there was a disproportionately high probability of fire spread into the rainscreen cladding system.

- 2.9.15** This was also true in the event of a fire remote from the window, unless the fire brigade extinguished it early enough to prevent heating of the rainscreen system via the window openings or via the window opening surrounds; or the fire was prevented by some other means from developing into a scenario which could cause the heating of the window opening or the heating of the materials surrounding those openings in a flat.
- 2.9.16** The interface between the kitchen window, and the window reveal lining materials, in Flat 16 and (a) the column rainscreen system and (b) the above window horizontal rainscreen system, was the primary cause of the early stages of fire spread.
- 2.9.17** The type of window reveal lining materials and how they were arranged around the window provided no means to control the spread of fire and smoke, from the small kitchen fire which was the source of the fire.
- 2.9.18** In addition, the type of materials in the rainscreen system and how they were arranged around the windows in the kitchen, contributed to the speed at which the fire spread from the flat of fire origin to a multi storey external fire within the rainscreen system.
- 2.9.19** Once the fire entered the rainscreen system outside Flat 16 on the East elevation, the Reynobond 55PE rainscreen cladding panel coupled with the ventilation cavity backed by the Celotex insulation or Kingspan K15 insulation, incorporating defective vertical and horizontal Siderise fire stopping material, and missing cavity barriers around the window, failed to control the spread of fire and smoke.
- 2.9.20** The Reynobond 55PE contributed to the most rapid of the observed external fire spread.
- 2.9.21** There were also Aluglaze extruded polystyrene core insulating panels installed between every window, in front of the existing window infill panels. Polystyrene produces large quantities of black toxic smoke; and supports rapid fire spread as evidenced during the fire.
- 2.9.22** The assembly - taken together with the insulation material on the existing external wall, the missing and defective cavity barriers - became part of a successful combustion process. This process generated substantial fire spread over 6 distinct pathways. A full geometric grid was created by means of the construction materials, which connected (in the event of an internal fire, cavity fire or external fire) every flat on a storey; and every storey from Level 3 to roof Level. These pathways also supported the spread of external fire back into the building, through the windows, and created a series of internal fire events.
- 2.9.23** The consequence of this was that any individual flat of fire origin was no longer in a separate fire rated box as is required. The compartmentation required in the building was breached by the ability of the fire to spread on the external wall from that compartmented flat to the next.

2.9.24 I conclude that the required single building safety condition Stay Put, was not provided for, as was required, as a result of the rainscreen system installed during the primary refurbishment.

2.9.25 As a result, the arrangement and type of construction materials in the rainscreen system caused:

- (a) A rapidly advancing and continuous external flame front which impacted flats on multiple stories;
- (b) The generation of large quantities of polymeric based smoke which entered many flats;
- (c) The flame front caused additional internal fires, many of which underwent a flashover fire (this in general occurred where external firefighting was not possible by LFB); these internal fires also produced smoke;
- (d) The external fire and internal fires then affected the active and passive fire protection measures in the building.

2.9.26 The rainscreen system, installed during the refurbishment in 2012-2016, was therefore non-compliant with the functional requirement of the Building Regulations.

2.9.27 In my Phase 2 report I will investigate how this state of affairs came to exist at Grenfell Tower.

2.10 The failure of the early external firefighting activity

2.10.1 I do not consider it reasonable that in the event of the installation of a combustible rainscreen system on a high rise residential building, the fire brigade should be expected to fully mitigate any resulting fire event. That is particularly so in circumstances where the fire brigade had never been informed that a combustible rainscreen system had been installed in the first place. Further, there are so many combinations of events, that could fall entirely outside the reach of external firefighting activity. This is important when only internal firefighting arrangements are made for high-rise residential buildings by statutory guidance at this time.

2.10.2 I have found no evidence yet that any member of the design team or the construction team ascertained the fire performance of the rainscreen system materials, nor understood how the assembly performed in fire. I have found no evidence that Building Control were either informed or understood how the assembly would perform in a fire. Further I have found no evidence that the TMO risk assessment recorded the fire performance of the rainscreen system, nor have I found evidence that an LFB risk assessment recorded the fire performance of the rainscreen system. I await further evidence on these matters, which I will explore in my Phase 2 report.

- 2.10.3** I have considered the early firefighting activity which took place, in my Expert Report in Section 17. I have summarised my analysis below.
- 2.10.4** The fire and rescue services arrived at Grenfell Tower and entered the secure main entrance door which was held open by a resident. They then attempted to gain entry to the secure lift lobby at 01:01. A fire switch installed at the main door entry was an Entrotec FS4. Their website describes it as being operated by a fire fighters drop-key. I do not know why LFB did not attempt to use the key to cut the locks to the main entrance doors and secure internal doors to the staircase and lift lobbies, or why they asked a resident for their fob instead.
- 2.10.5** Also at 01:01, they attempted to take control of the lifts.
- 2.10.6** It is important to note that fire fighting lifts were not provided at Grenfell Tower. Such lifts allow fire fighting personnel to access any storey in a building, during rescue and internal fire fighting, to allow the transport of equipment, personnel, and transport residents who require assistance. Both lifts at Grenfell Tower were categorised by the TMO and their fire risk assessor Carl Stokes as fire fighting lifts.
- 2.10.7** Instead, on arrival at Grenfell Tower, LFB were unable to control the lower standard fireman's lifts which were installed at the Tower, and this appears to have caused a short delay arriving at Flat 16. These lifts should only be used to transport equipment, as they are not sufficiently robust enough to transport people during a fire.
- 2.10.8** More substantially this failure to control the fire lifts meant residents could continue to use the lifts during the fire, which was a serious risk to life. Additionally, it meant the fire brigade could not use the lift any further during the fire, for transporting equipment.
- 2.10.9** LFB entered Flat 16 and successfully dealt with the internal flat fire – they controlled the internal flat fire using the internal firefighting equipment provided to them.
- 2.10.10** However, the pre-flashover fire in Flat 16 had already spread easily into the rainscreen system, and evidence shows this had occurred by 01:08. This meant that the LFB were very quickly put in a position where two forms of fire fighting were needed – the external fire in the rainscreen system beside the Flat 16 kitchen window and Flat 16 itself.
- 2.10.11** The earliest positive visual evidence of external firefighting water applied to the building is at 01:15:50.
- 2.10.12** This is approximately 2 minutes after thermal images show BA crews in Flat 16 applied an internal firefighting jet within the kitchen (01:14).
- 2.10.13** I have observed through photographic and video evidence that a water jet was intermittently applied to the East elevation of Grenfell Tower, and to burning debris at Ground Level, between 01:15 and 01:25 by use of a handheld hose.

- 2.10.14** I have been unable to find positive evidence of water being applied at or above the level of the Flat 16 kitchen window in my review of photographs and videos between 01:15:50 and 01:25.
- 2.10.15** At 01:21 CM Batterbee reports to the bridgehead by radio that the fire in Flat 16 has been extinguished.
- 2.10.16** However ultimately the initial external firefighting was not successful as the fire had spread beyond Level 7 and up to Level 11 (32m above Ground Level) by 01:21.
- 2.10.17** The first call for an aerial appliance, which can provide a water supply from about 30m above Ground Level, occurred at 01:14. That arrived at the scene at 01:32. A hose stream was being applied to the East elevation of the building envelope from this aerial appliance by 01:47.
- 2.10.18** The fire spread to Level 23 by 01:26. In approximately 18 minutes, the fire had spread up 19 storeys on the outside of the building.
- 2.10.19** It is for other experts to comment on the potential to extinguish a rainscreen system fire, using hand held equipment from the ground, within a time frame of minutes, when the external surface is formed with an ACP.
- 2.10.20** As is the matter of what prior planning should have occurred to implement effective external firefighting using an aerial appliance in the very early stages of the fire.
- 2.10.21** However, it is relevant for my report to record that there is no provision made for external firefighting as the primary source of firefighting in high rise residential building design. The primary source of firefighting is internal firefighting by means of a protected shaft with water mains, firefighting lift, and smoke extract from the lobby to the stairs.
- 2.10.22** In the absence of notification of the risk the external wall posed, by the relevant stakeholders to London Fire Brigade, I am unclear what prior planning could therefore have occurred.
- 2.10.23** Therefore, at this stage, I consider the rainscreen system non-compliance with the Building Regulations, to have been the primary cause of the failure of the early external firefighting at Grenfell Tower.

2.11 The external flame front and its impact on flats beyond Flat 16

- 2.11.1** The external walls of Grenfell Tower could not adequately resist the spread of fire over the walls, so once the fire entered the external wall outside Flat 16, it continued to spread and also caused the involvement of other flats through the ignition of a series of internal fires, on multiple stories in the Tower.
- 2.11.2** The particular construction of the external cladding (as well as the infill panels, and the window construction within it), provided multiple pathways for fire spread back into the flats.

- 2.11.3** Because the external wall of Grenfell Tower provided a medium for fire spread it was a risk to health and safety.
- 2.11.4** Within minutes of the fire spreading to the external building envelope outside Flat 16, it spread across multiple levels on the exterior East elevation, of Grenfell Tower. The affected flats were then at high risk of additional internal fire scenarios. They were also impacted by the polymeric smoke produced by the burning rainscreen system, all around them.
- 2.11.5** The fire had broken out of Flat 16 into the rainscreen system by 01:08 and the fire had spread to Level 5 above by 01:13.
- 2.11.6** There is evidence of the first internal flat fire beyond Flat 16 between 01:14 - 01:22, multiple reports of internal fires up to Level 22 by 01:30 and photographic evidence of multiple internal fires burning by 01:44. These also exposed more and more residents to the effects of fire and smoke.
- 2.11.7** Table 2.2 shows the cumulative number of flats affected by the external fire flame front, based on my analysis of photographs in Section 12 of my Expert Report. There was a total of 120 flats in Grenfell Tower from Level 4 - 23.

Time	Cumulative number of flats affected by flame fronts
01:08	1
01:21	8
01:26	20
01:36	20
01:52	26
02:10	34
02:23	53
02:34	56
02:53	61
03:09	70
03:21	73
03:43	92
04:03	98
04:31	103
04:44	106

Table 2.2: Cumulative number of flats affected by flame fronts

- 2.11.8** As the fire entered each of these flats, these occupants were no longer safe to remain where they were, which undermines the basis of the single building safety condition provided for.
- 2.11.9** By 01:26, 20 flats were impacted by the external flame front. This increased to 56 flats by 02:35.

- 2.11.10** Within 2 hours of the fire starting in Flat 16, 50% of the flats from Level 4 up, were impacted by the external flame front.
- 2.11.11** There is only one statutory provision made for occupants of high rise residential buildings in England. ADB 2013 states “*The provisions for means of escape for flats are based on the assumption that: a. the fire is generally in a flat; b. there is no reliance on external rescue (e.g. by a portable ladder); c. measures in Section 8 (B3) provide a high degree of compartmentation and therefore a low probability of fire spread beyond the flat of origin, so that simultaneous evacuation of the building is unlikely to be necessary; and d. although fires may occur in the common parts of the building, the materials and construction used there should prevent the fabric from being involved beyond the immediate vicinity (although in some cases communal facilities exist which require additional measures to be taken).*”
- 2.11.12** With regard to these assumptions, the flame front progression analysis shown above allows me to conclude that:
- a) the fire did occur within a flat;
 - b) the flat *did not* have a high degree of compartmentation due to the failure of the building envelope around that flat, to adequately resist the spread of fire;
 - c) because of the ease of fire spread through the materials used to form the rainscreen system, *there was not* a low probability of fire spread beyond the flat of origin, and so
 - d) simultaneous evacuation of the building *became highly likely to be necessary* as a result.
- 2.11.13** The statutory design guidance advises simultaneous evacuation is “*unlikely to be necessary*” **only** where there is a high degree of compartmentation and so a low probability of fire spread beyond the flat of origin. The spread of fire and smoke through multiple compartments (flats) as well as out into the lobbies (which I address later) meant this high degree of compartmentation was not available and fire spread beyond the flat of origin had occurred.
- 2.11.14** This represents a total failure of the design principles of the Stay Put evacuation regime.
- 2.11.15** I conclude therefore that Grenfell Tower should never have been handed over with this rainscreen system, in circumstances where a Stay Put evacuation strategy was in place for the residents.
- 2.11.16** In addition, this information was needed by London Fire Brigade, such that they could consider their fire fighting and rescue tactics, as well as their evacuation guidance to residents of Grenfell Tower. No such opportunity was provided to London Fire Brigade.
- 2.11.17** It is important to note that this quantity of flats impacted by the external flame front does not reflect the actual number of flats impacted by the resulting

internal conditions. Within those 2 hours, the majority of the lobbies and the full height of the stairs had become a serious risk to life.

- 2.11.18** There were therefore serious consequences as a result of the internal spread of fire and smoke, caused by the main external wall fires, as I conclude below.

2.12 The significance of the building envelope fire

- 2.12.1** Because the single safety condition designed for i.e. the Stay Put evacuation regime, was rendered ineffective, this created serious consequences for the resulting need for an evacuation.

- 2.12.2** I have therefore explored, from a building design perspective:

- a) what provisions were available for communicating when and how to evacuate, to all the residents;
- b) what provisions were available at Grenfell Tower, during this external and internal fire event, for self-evacuation;
- c) what provisions were available to facilitate rescue by LFB.

- 2.12.3** However, the spreading fire also created substantial consequences regarding firefighting access and facilities, and caused the failure of the Defend in Place firefighting that is an essential component of the Stay Put design condition.

- 2.12.4** It is therefore necessary for me to explore what facilities were made in and around the building, and actually available to the LFB at Grenfell Tower, to deal with the unfolding events, including the failure of the Defend in Place firefighting that supports the Stay Put safety condition:

- a) What internal firefighting was required for the fire scenario created and what provisions were available at Grenfell Tower?
- b) What external firefighting was possible for the external fire scenario created at Grenfell Tower and what provisions were available at Grenfell Tower?
- c) What preparations had been made, and what was possible, to enable the use of standard processes, procedures and equipment during an unfolding extreme event?
- d) What communication from the LFB was needed regarding the failure of the Stay Put condition for the residents and how could this be done?

- 2.12.5** In order to explore these issues, I have carried out a range of investigations.

- 2.12.6** In Section 13, I present my analysis of critical times during the fire event. This forms the basis for my analysis of the performance of the protected stair and lobbies (in Section 14), during this multi storey external fire. I have considered the timing of the evacuation of the residents, and their dependence on the decision making and actions of the LFB.

- 2.12.7** I have considered what was required of the LFB as a result of the failures in the design and construction of the rainscreen system during the fire. I address this in Section 17.
- 2.12.8** I have provided my analysis of the methods available for communicating with the residents of Grenfell Tower once the operational Stay Put policy was changed, in Section 18.
- 2.12.9** Finally, in Section 19 I have considered what role, if any, the active and passive systems in Grenfell Tower played in failing to control the spread of fire, or the role they played in the speed at which the fire spread.
- 2.12.10** In Section 20, I have considered what was required of the residents to protect themselves, as a result of the failures in the design and construction of the rainscreen system during the fire.
- 2.12.11** I have considered what was required of the fire brigade and what they had available to them in the early, middle and late stages of the fire. Specifically, what they could ever have done to slow down or prevent the fire and smoke spread; and what they could ever have done about giving evacuation advice, and exercising rescue.
- 2.12.12** In Phase 2, I will consider whether the life safety of the residents, became too dependent on the decision-making and actions of LFB, on the night of the fire, because of the failure of the building envelope, and the resulting failures of active and passive systems in Grenfell Tower.
- 2.12.13** Additionally, in Phase 2 I will consider if once the fire started and spread in to the external wall system:
- (a) If it is the case that the only layer of safety remaining for building occupants was the fire and rescue services actions (regarding evacuation, rescue and fire fighting);
 - (b) if it is reasonable to require a fire and rescue service to mitigate the consequences of total building failure; and
 - (c) if a building system causes a failure at a scale that only a single layer of safety remains, is this a breach of statutory duties regarding life safety.
- 2.12.14** However, due to the severity of the consequences of the fire at Grenfell Tower, it is important I make clear that I consider the building design condition for stay put to have failed substantially by 01:26.
- 2.12.15** I conclude therefore that all events after that time occurred in the context of the total loss of the only safety condition provided for.

2.13 The role of the active and passive fire protection measures

- 2.13.1** The presence of these active and passive fire protection measures is intended to create a layered safety approach.
- 2.13.2** They provide the means for early internal firefighting. They provide the means to limit fire and smoke spread from a dwelling fire, or from a small common lobby fire. They ultimately create the “high degree of compartmentation” to support the Stay Put strategy in a high rise residential building.
- 2.13.3** Once the fire broke into the rainscreen system, the remaining active and passive fire protection measures within the Tower were then required to perform during an extraordinary event – a multi storey fire. The high degree of compartmentation had suffered its primary failure, caused by the fire spreading through the rainscreen system. The Stay Put strategy was therefore already in jeopardy.
- 2.13.4** The remaining active and passive fire protection measures within the Tower were required to mitigate the effects of the resulting fire and smoke spread from that rainscreen system fire. These measures were required to mitigate those effects on many floors.
- 2.13.5** In terms of understanding the role of the active and passive fire protection measures, their primary purpose was first to limit fire and smoke spread from a flat. Most importantly, their purpose was to prevent fire and smoke spread to the lobby outside the flat.
- 2.13.6** There are two distinct components to planning means of escape from buildings containing flats: escape from within each flat and escape from each flat to the final exit from the building. At Grenfell Tower to reach the final exit, only one staircase was provided. This stair was provided with a protected lobby at every storey.
- 2.13.7** The majority of the fire protection measures were passive, and intended to protect the lobbies; prevent the spread of fire and smoke from a flat into the lobby; and also from one lobby to the next. The automatically opening vents in the lobby smoke control system, an active system, play a key role in protecting the lobbies, as they close off the 4 builders ducts that connected every lobby in the Tower.
- 2.13.8** These measures protect the lobby but in doing so, their primary function is to protect the single stair.
- 2.13.9** Active systems including the fire lifts, the lobby smoke control, and the dry riser were there to enable early internal firefighting and support the Defend in Place firefighting tactics.

2.13.10 I have identified in Sections 14-18 of my Expert Report what those active and passive fire protection measures were and their compliance with the relevant standards. These as summarised in Table 2.3 below.

2.13.11 I have also identified in Sections 14 -18, and in the supporting Appendices G, H, I and J, a number of deficiencies with many of the active and passive measures provided in Grenfell Tower. It is important to acknowledge that some of these deficiencies may not have played a significant role in terms of the spread of smoke and fire, given that there was a fire of this magnitude. For other protection measures the failure to resist smoke or fire played a role on the night of the fire. I explain each in turn in the following sections.

Passive Systems	Active Systems
Fire rated stair of a specific width and head height	Fire alarm for individual flats.
Fire rated lobbies of a specific travel distance Included protected risers for any services passing through the lobbies	Interface between fire detection and fire alarm systems and other systems. Automatically closing fire and smoke dampers to seal services opening onto the lobby.
Fire doors	Smoke control in the lobby with smoke control dampers (automatically opening vents).
Fire protected gas service and installation pipes	Emergency lighting
Flights and landings constructed of materials of limited combustibility	Permanent vent for refuse chute lobby
Protection to critical electrical circuits	Fire main
Refuse chute separated from the lobby by fire resisting construction	Firefighting lift; [fire man's lift] Including lift controls
Protected stair way with nothing other than lift well or electricity meter within	Minimum of one hydrant
Vehicle access to fire main	Environmental fan auto off in the event of fire
Fire protection to any riser in the common lobby	Vent at the head of the stair
The external walls of the building shall adequately resist the spread of fire over the walls having regard to the height, use of the building.	Emergency lighting and signage
The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building.	
The loadbearing elements of structure of the building are capable of withstanding the effects of fire for an appropriate period without loss of stability; Structural Stability	
The building is sub-divided by elements of fire-resisting construction into compartments; Compartmentation	

Any openings in fire-separating elements (see Appendix E) are suitably protected in order to maintain the integrity of the element (i.e. the continuity of the fire separation); Fire stopping	
Any hidden voids in the construction are sealed and sub-divided to inhibit the unseen spread of fire and products of combustion, in order to reduce the risk of structural failure and the spread of fire, insofar as they pose a threat to the safety of people in and around the building. Cavity barriers	Open state cavity barriers which intumesce in the event of fire

Table 2.3 Active and Passive fire protection measures

2.13.12 First I explain my findings regarding my investigation into the condition in the lobbies and the stairs during the fire.

2.14 Progression of conditions during the fire within the protected stair and lobbies

2.14.1 Methodology and assumptions

2.14.2 I have considered carefully how the protected stair and lobbies performed on the night of the fire (Section 14) and I have concluded that overall they failed (Section 19).

2.14.3 I relied on two sources of evidence in my analysis. The first was the evidence I found from my own post-fire site inspections in Grenfell Tower. I carried out these inspections at the start of my work for the Public Inquiry, with a team of fire and systems experts from Arup acting under my supervision.

2.14.4 The second source of evidence is from eyewitness sources. This consists of the London Fire Brigade witness statements; and resident witness statements provided to me. I have been provided with witness statements from a number of the residents of Grenfell Tower. I expect further evidence from residents to become available to me as a result of residents providing oral evidence to the Public Inquiry Hearings.

2.14.5 I will need to update my work and make final changes, to the timings and conditions for escape and resident experience of rescue, once this oral evidence becomes available to me.

2.14.6 As I have explained in Section 14, the lobbies were compromised by smoke and heat. The stairs appear to have been compromised by smoke, and eventually by heat. The lobbies were compromised much earlier than the stairs.

2.14.7 The lobbies and the stairs appear therefore to have created particularly challenging conditions for anyone seeking to evacuate from floors, particularly above Level 13. Fire fighters also found conditions in the lobbies and stairs challenging.

- 2.14.8** I note here that there are some differences between fire fighters and residents, in the evidence available to me, as to the timing of when conditions deteriorated.
- 2.14.9** For example, from fire fighter witness statements the stairs were clear of smoke until approximately 01:35-01:40. However there is evidence from Resident statements that there was sufficient smoke in the stair between 01:21 and 01:35 to lead to some residents on upper floors, moving up the building to Level 23, to try to take refuge away from smoke.
- 2.14.10** Fire fighters were not accessing above Level 12, from approximately 03:00; but residents from Levels 13, 15, 16, 18, 21 and 22 escaped during that time period.
- 2.14.11** I am particularly interested in:
- (a) the time between 00:55 and 01:40 and the smoke conditions in the stairs during early firefighting;
 - (b) the hour between 01:40 and 02:40: the time when conditions in the lobbies appear to have greatly deteriorated, until the time the operational Stay Put guidance was changed; and
 - (c) the differences in the evidence about the conditions in the stairs when I compare the firefighter progress up the building and the self-evacuation of residents as late as 04:20.
- 2.14.12** A timeline of firefighter activity is being prepared by the expert to the Inquiry Steve McGuirk in Phase 2. This work will inform my assessment of the timings at which stair doors were open in the early stages of the fire.
- 2.14.13** An emerging piece of witness evidence regarding smoke leaking out of the smoke extract dampers in the lobbies requires careful consideration and analysis. I will complete that work after the resident evidence is completed in full.
- 2.14.14** The single stair and lobbies, and the fire safety provisions therein, were not ever designed to create a safe escape route or safe working environment in a multi-storey building fire. The design approach for high rise residential buildings is based on inhibiting that from occurring.
- 2.14.15** However, because of the external wall fire, a multi storey building fire occurred, and so the single escape stairs and its lobbies became the single most important life safety feature.
- 2.14.16** Smoke is reported in lobbies at times that correlate closely with the times at which the fire in the external façade reaches those floors. For example, by approximately 01:23, smoke is first recorded in the lobby at Level 22. The external wall fire reached the top of the building at approximately 01:26.

- 2.14.17** For some protection systems however the multi-storey fire condition is not relevant to how they performed and so their statutory performance remains relevant. For example, fire doors to the flats.
- 2.14.18** For others they were impacted by an un-designed for multi-storey condition. For example, the lobby smoke control system operates on a single floor only regardless of multi-storey smoke spread.
- 2.14.19** I make this difference clear, if it is relevant, when I address each of the active and passive fire protection measures later.
- 2.14.20** As I have explained in the specific sections of my Report, I have considerable concern as to the standards of fire safety provision in the lobbies and the stair, whilst acknowledging the extreme and primary hazard the rainscreen system presented.
- 2.14.21** **Timeline of external fire spread**
- 2.14.22** I have derived the time each external wall elevation ignited and the time that elevation was fully involved in fire and I have then compared this data with the number of remaining occupants in Grenfell Tower in Figure 2.1.
- 2.14.23** The solid coloured bars on the top of the figure represent the duration from ignition of an elevation to its full involvement.

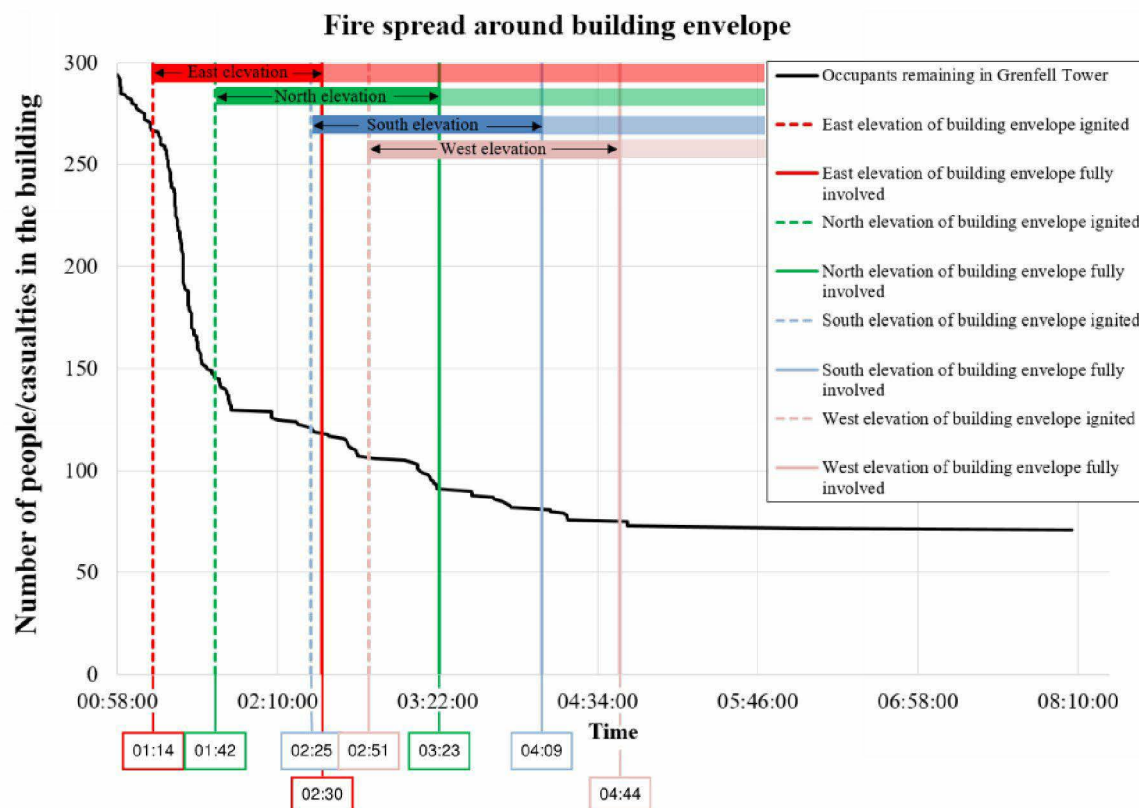


Figure 2.1: Critical times of fire spread around building envelope and remaining occupants in building (based on data extracted from MET000080463, updated in MET00016072 and MET00012593) at those times

2.14.24 At 02:06, a Major Incident was declared by the LFB. At that time, both the East and North elevation had ignited and 164 occupants, approximately 56% of the total building occupants, had evacuated.

2.14.25 At 02:35, LFB began to change guidance for people still within Grenfell Tower from “stay put” to “evacuate if possible”.

2.14.26 At that time, the East elevation was fully involved and the North and South elevation had ignited. Approximately 60% of the total building occupants, or 177 occupants, had evacuated.

2.14.27 Timeline of conditions in the lobbies and the stairs

2.14.28 In this section, I set out the key conclusions from my analysis of the evidence of the progression of smoke and heat through the lobbies and the stairs at specific times during the fire on 14th June 2017 (references to the evidence are included in section 14 and 19 of my Expert Report). My analysis of the evidence can be summarised as follows:

2.14.29 00:59 – 01:18 [Figure 2.2 (a)]:

2.14.30 Smoke is described as entering the Level 4 lobby through the open door of Flat 16; by 01:13 the smoke colour is described as black.

- 2.14.31** The stair is described by fire fighters and residents as being clear of smoke.
- 2.14.32** **01:19 – 01:38 [Figure 2.2 (b)]:**
- 2.14.33** Smoke reported is reported in 14 out of 20 lobbies (L4-23) by this time. The smoke report in these 13 lobbies is described as ranging from hazy and light on Level 22 to thick and black on Level 16.
- 2.14.34** The first evidence of thick black smoke flowing into the stair at Level 4 is reported. Near the top at Level 22 the stair is described as having some ‘hazy’ smoke only. Residents who escape from Levels 17, 19 and 20 during this period describe the smoke thickening progressively within the stair as they descended.
- 2.14.35** **Note:** it is during this period that some residents were observed walking up the stair as a result of conditions lower in the stair being perceived as “*too smoky*” or being told by others to “*go back*”.
- 2.14.36** **01:39 – 01:58 [Figure 2.3 (a)]:**
- 2.14.37** The number of lobbies reported to be affected by smoke has increased to 15 out of 20; in 10 of these the smoke is described as thick and black.
- 2.14.38** There are limited resident observations in this time period, due to no evacuations being recorded from above Level 11 between 01:41 and 02:25, with the situation worsening even further by 01:49 with no evacuations above Level 3 between 01:49 and 02:18.
- 2.14.39** Firefighter evidence describes thick black smoke in the stairs, from Level 3 up to Level 21.
- 2.14.40** **01:59 – 02:38 [Figure 2.3 (b)]:**
- 2.14.41** The number of lobbies affected by smoke has increased to 19 out of 20; in 17 of these the smoke is described as thick and black. Severe temperatures are described in the lobbies at Levels 6 – 10.
- 2.14.42** There is no resident evidence for the first half of this period, due to no evacuations from above Level 3 up to 02:18. Firefighter evidence from this time describes the stair as being full of thick black smoke with poor visibility up to Level 21.
- 2.14.43** However, this conflicts with slightly later Firefighter evidence (at 02:13 - 02:20) where clearer conditions are reported in the stairs above Level 10 and also at 15 and above.
- 2.14.44** Residents escaping in the second half of this period from 02:18 to 02:28 describe increasing heat in the stair: a resident escaping from Level 19 describes the stair as progressively hot and the handrail as too hot to hold. A resident who is overcome in the stairs is carried out by fire fighters.

2.14.45 02:39 – 02:58 [Figure 2.4 (a)]:

2.14.46 The number of smoke affected lobbies remains at 19 out of 20; conditions are thick, black smoke with high temperatures.

2.14.47 From Level 23 down, in the stairs, residents describe zero visibility and residents at Level 12 and 14 describe extreme heat, with conditions described as “roasting” or “sweltering”.

2.14.48 **Note:** It is shortly before (Jo Smith at 2.35) and during this period (Roe at 2.47) that the stay put guidance to 999 callers/FSGs is changed by the LFB.

2.14.49 After 02:59 [Figure 2.4 (b)]:

2.14.50 The number of smoke affected lobbies remains at 19 out of 20; conditions are thick, black smoke with high temperatures. Temperatures in 2 lobbies (L10 and 11) are described as extreme as to be inaccessible by fire fighters.

2.14.51 Fire fighters and residents describe the stair conditions deteriorating from Levels 5 – 7 upwards. The smoke in the stair is described as thick black with zero visibility. Residents and fire fighters describe intense heat within the stair *“like the heat that comes out of an oven and blasts you in the face”*.

2.14.52 The last FSG call active above Level 13 concludes at 03:33 and the last evacuation of a resident from above Level 13 occurs at 03:55.

2.14.53 By 04:15 the LFB appear to have been unable to access floors above Level 11.

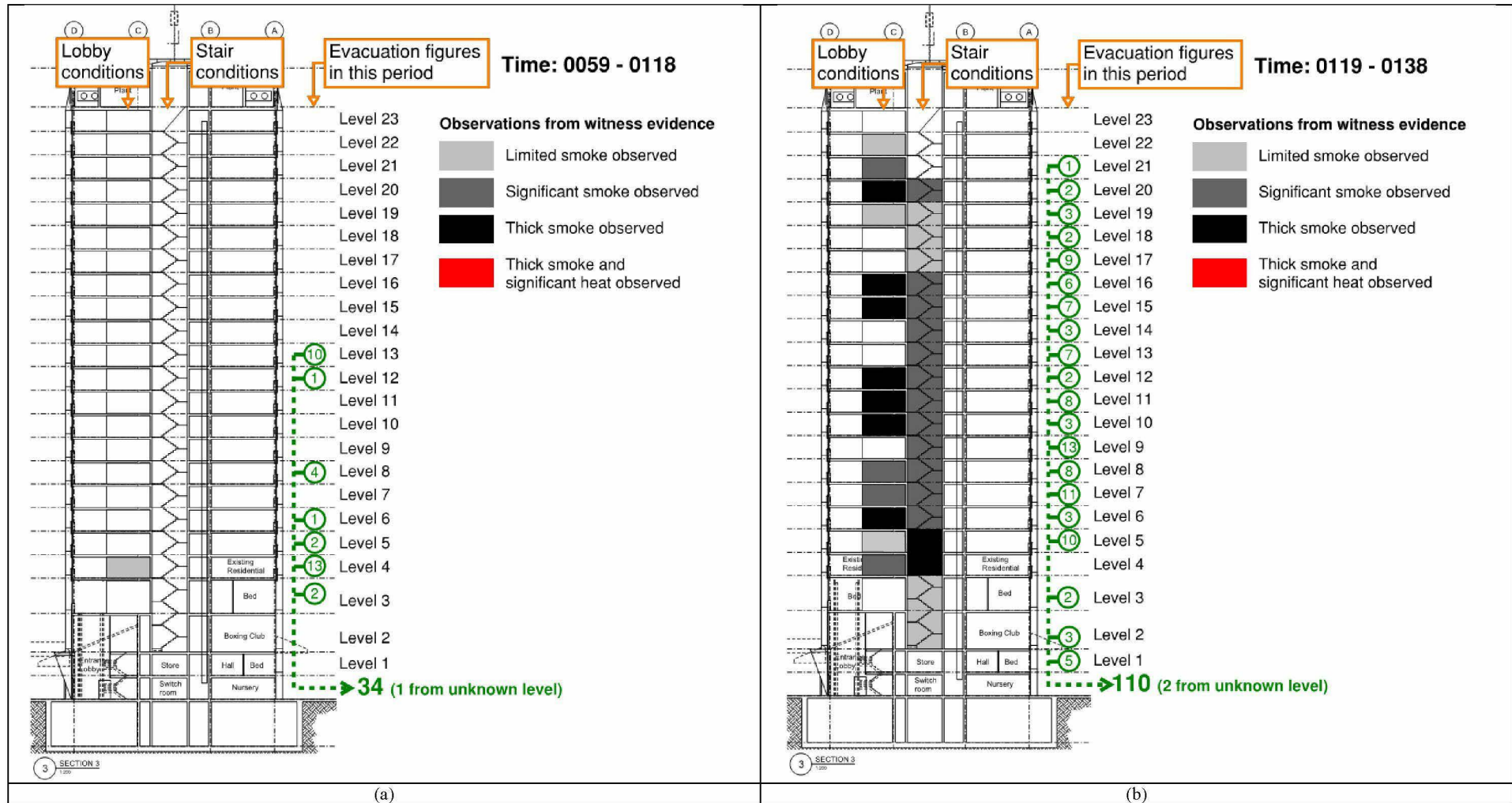


Figure 2.2 Summary description of the conditions within the stairs collated from resident and fire fighter witness evidence between (a) 00:59 -01:18 and (b) 01:19 -01:38

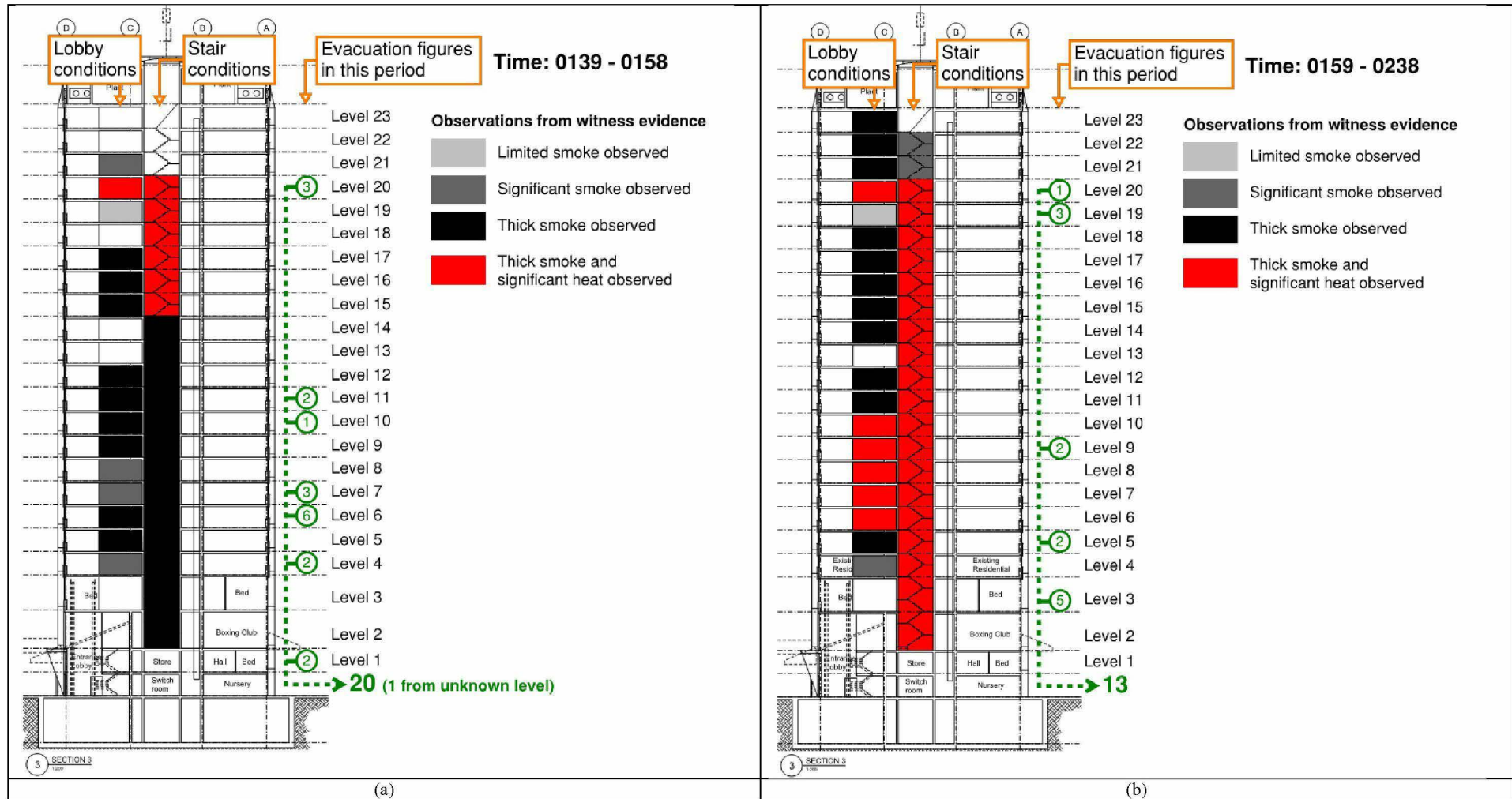


Figure 2.3 Summary description of the conditions within the stairs collated from resident and fire fighter witness evidence between (a) 01:39 - 01:58 and (b) 01:59 - 02:38

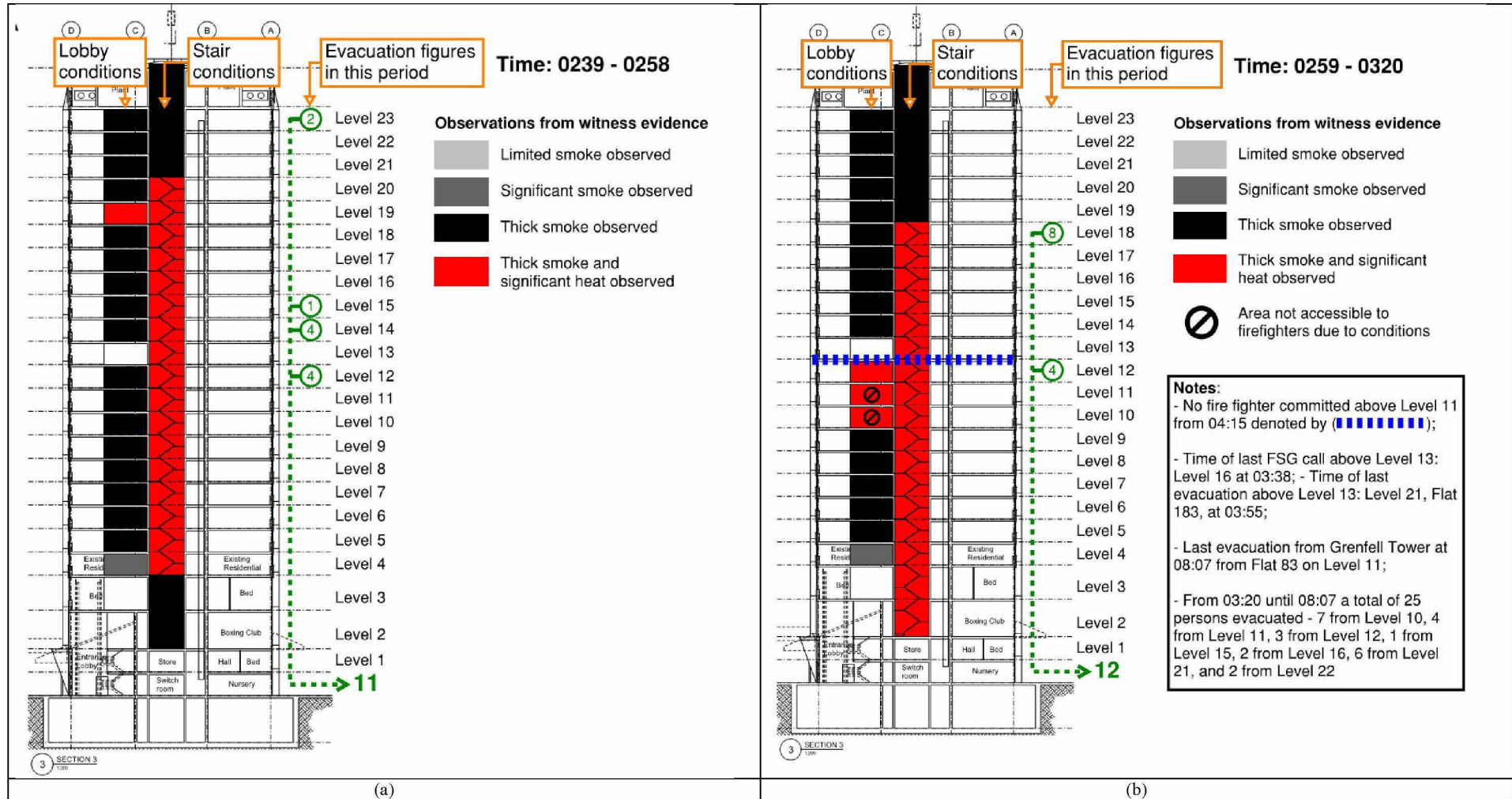


Figure 2.4 Summary description of the conditions within the stairs collated from resident and fire fighter witness evidence between (a) 02:39 -02:58 and (b) 02:59-03:20

2.14.54 Resulting damage within the protected stair and lobbies

2.14.55 Regarding the resulting damage to the stair and protected lobbies I conclude from my on-site observations that:

- a) Heavy damage in all lobbies from Level 10 – 23; heavy damage to the north side of the lobby (Entrances to flats 4, 5 and 6); and light to medium in the south side of the lobby (Entrances to Flats 1, 2 and 3) on Levels 5, 7 – 9. There was no damage in the Level 6 lobby.
- b) The stair shows light smoke damage from Level 4 to Level 9.
- c) The stair shows consistently heavy smoke damage from Level 10 to Level 23.
- d) From the evidence of the melted / destroyed polycarbonate light fittings, the temperature in the stairs was highest on floors 13 to 16. Polycarbonate softens above approximately 150°C, as described above. This was unique to these four levels.
- e) Damage to light fittings is most likely a characteristic of smoke in the stair reaching temperatures higher than 150°C, and potentially from a lower lobby, rather than direct flame impingement through the door opening into the stair. The half landing lights between each of 13 – 16, were also melted.
- f) I did not observe any evidence which indicates extensive damage associated with a fire in the stair. The only surface damage was from smoke deposition.

2.14.56 Additionally, I found no evidence of substantial amounts of combustible materials being stored within the lobbies that contributed materially to fire conditions in the lobby.

2.14.57 Fire damage to the lobbies was concentrated around the flat doors, as can be seen in the floor by floor analysis in Appendix C. Smoke and heat from the flat entrance doors was vented to the lobbies, evident from the severe damage in the narrow corridors the doors opened onto.

2.14.58 The fire main was located within the narrow enclosure, 5.7m from the stair door and directly outside the entrance door of Flat 3 on each level. Therefore, smoke and heat venting from a flat entrance door because of a flat fire, vented directly in front of the fire main. I have recorded severe damage around the fire mains on multiple levels.

2.15 Effect of the stair and lobby conditions on the evacuation potential from Grenfell Tower

2.15.1 I conclude that the deterioration in first the lobbies and secondly the stairs impacted the evacuation rates of the residents. This impact is summarised as follows.

- a) Before 01:18, occupants were escaping from all floors up to Level 13 only.
- a) Between 01:19 and 01:41, the largest number of evacuations occurred (114). Residents of every floor escaped during this time, except Levels 4, 22 and 23. Out of the 114 residents that escaped in this time period, 31 of them were from Flat “6”, above Flat 16 on Level 4. Residents reported smoke in the stair as early as 01:20 and poor visibility in the stair by 01:40.
- b) 144 people in total left the building by 01:38. During this time the stair progresses from clear on all levels to thickening smoke at the lower levels, starting from Level 4. Smoke is also reported by this time in 13 lobbies. The rate of evacuation between 00:58 and 01:40 is 3.5 persons/min. By 01:40 there were still 149 residents inside the building.
- c) At 01:40 there were still 150 residents inside the building. This includes the people observed to be walking upstairs in this time period. I have provided my analysis the upward movement of residents in Section 20 of my report. Between 01:21 and 01:49, several residents moved from lower levels of the building to higher levels.
- d) Between 01:39 and 01:58 the number of smoke affected lobbies increased to 15. Thick smoke with low to zero visibility is described as filling the stair. It is described as becoming increasingly hot below Level 20. Additionally, lobbies on levels 5-6, 9-12 and 20 are all described as being filled with thick black smoke. Further:
 - i. The rate of evacuation from all floors of the building slows substantially between 01:39 and 01:58 (inclusive). A total of 20 people evacuate from Levels 1 to 20 in this ~20minute window (1 person/min) compared to 3.6 persons/min up to 01:38. The flow rate is therefore 72% less than before 01:38.
 - ii. The people who do manage to evacuate at this time come from Levels 1, 3, 6, 7, 10, 11 and 20 only. Therefore, they evacuate through lobbies described filled with black smoke, and for Levels 15-20, that portion of the stair described as hot. A total of 130 people remained inside the building at 01:58.
- e) Between 01:42 and 02:24, 24 people escaped. All residents that escaped in this time period were from Level 11 or below, which is below the hot zone. There were between 8 and 28 firefighters in the building in that time frame, on several different floors. A total of 46 firefighters were committed beyond the bridgehead during this time period.
- f) At this time, some lobbies, in particular Level 10 are described as *‘incredibly hot’*. Lobbies on Levels 6 - 10 are described as containing smoke hotter than the stair. The stair at Level 10 is also described as *‘boiling hot’* with thick heavy smoke and severe heat reported between Levels 2 to 20. The people who were able to evacuate, and importantly

willing to evacuate in such conditions, came from multiple floors, from Level 3 to 11.

- g) The heat and smoke in the lobbies particularly, created a barrier to residents on any level and so impacted on their ability and/or willingness to move from their flats over to the stair.
- h) At some time between approximately 02:00 - 02:30, a door was held open for several minutes while FF Desforges (MET00008013) searched a lobby somewhere between Level 10 to Level 14, which was severely affected by heat and smoke. Based on witness statements from firefighters and residents, the stair was affected by smoke and heat at this time.
- i) There was other activity in this time – for example, on Level 14, at approximately 02:00, fire fighters moved residents from Flats 111, 112 and 115 into Flat 113 to shelter there.
- j) It now seems likely that residents above Level 11 could not escape in this time period, due to the resulting conditions in the stair in that time period. Conditions on the stair appear to have been such that the stair lights on Level 13 -16 were melting. Temperatures of 150°C would have caused melting of the lights and immediate pain to exposed skin. Therefore, it would likely have caused a physical and psychological barrier to escape.
- k) While the precise timing and wording of the orders given by the relevant commanders will be a matter for the Chairman to consider (as well as what advice was actually given by CROs), the existing evidence indicates that at 02:35 Jo Smith instructed the control room officers to change advice to FSG callers from stay put to leave (Transcript of 11th/12th July 2018). I have calculated that before the operational stay put guidance began to change at 02:35, 177 occupants evacuated independently, some with LFB assistance. At that time, there were 117 occupants remaining in the building, and ultimately only 46 of these occupants were able to evacuate.
- l) Between 02:59 and 03:55, 5 people escaped from below the hot zone (all from Level 12) and 19 people escaped from above. This indicates that conditions on the stair could not have been such that the stair lights on Level 13 -16 were melting at that time. I consider this supporting evidence that the hot zone may have been a temporary condition around 02:00 – 02:30.
- m) Regarding the 19 people from above Level 12:
 - i. The 8 people escaping from Level 18 were from 3 flats (152, 153 and 155) and all exited between 03:12 and 03:18 (6 minutes), this was a group of neighbours moving together, rescued by multiple firefighters.
 - ii. The 2 people from Level 22 were from the same flat (195) and both exited at 03:31.

- iii. The 6 people on Level 21 were from 2 flats (Flat 183 and 186) and all exited between 03:37 and 03:55 (18 minutes).
- iv. The 2 people escaping from Level 16 were both from Flat 133 and exited 03:47;
- v. 1 person escaped from an unknown floor.
- n) After 03:55, 11 more people escaped but from Levels 10 and 11 only. However, I note the lobbies on these Levels were described as inaccessible by the LFB prior to this time (Level 10 around 02:58 and Level 11 around 03:20). Based on the MET record of CCTV footage (MET00016072), 9 out of these 11 residents were escorted or carried through the main entrance foyer by firefighters.
- o) Between 03:56 and 04:47, 6 residents escaped from Level 10 in 2 distinct groups, the first (Flat 74) leaving at 04:12 and the second (Flat 73) leaving around 04:20. Three people from Level 11 also evacuated, and these were a single family group all leaving at 04:47.
- p) At approximately 04:15, Gallagher (transcript 10th September 2018, p31) reported that firefighters were not able to pass Level 12.
- q) After 04:47 there are 2 individuals that escaped independently, from Level 10 at 06:05 and Level 11 at 08:07, both below the hot zone.
- r) Therefore, between 03:00 and 08:07 when the last person escaped, a total of 35 people evacuated the building:

2.15.2 Based on the evidence contained in the CCTV review document (MET00016072) I understand the following:

- a) 9 residents used the lift to evacuate the building.
- b) 187 residents self-evacuated, down the stairs.
- c) 25 residents are recorded as being escorted by firefighters as they escape.
- d) 28 residents are recorded as being assisted or carried out of the building by firefighters (note that this includes the 7 residents that were pronounced deceased outside the tower).

2.15.3 “Escorted”, “assisted” and “carried” are terms used in CCTV review document (MET00016072). I have assumed that they mean the following:

- a) Escorted – a firefighter was near the resident; however, the resident was moving unassisted.
- b) Assisted – a firefighter was supporting the resident in some way.
- c) Carried – the resident was physically carried by the firefighter.

2.16 Evidence of people moving up the stairs rather than exiting to a place of safety

2.16.1 From the MPS record of the locations of deceased persons recovered in Grenfell Tower (MET00012529), a number of people had left their floor of origin and moved up the building instead of escaping downwards.

2.16.2 The data provided in MET00012529 shows the following movements:

- a) 41 fatalities were recovered on their floor of origin, with 29 recovered from within their flat of origin.
- b) 7 fatalities were recovered on a lower floor than their floor of origin or outside the building.
- c) 15 fatalities were recovered on a higher floor than their floor of origin.
- d) 7 fatalities were recovered outside of Grenfell Tower.
- e) A further two fatalities occurred in hospital at a later date.

2.16.3 The highest number of fatalities (24) on a single floor were recovered from the 23rd floor. This included 5 residents from floor 18 and 9 residents from floor 19, 1 resident from Level 20 and 2 residents from Level 22. Only 9 of the fatalities recovered from floor 23 had originated from that floor.

2.16.4 The 6 fatalities of residents from floor 18, and the 8 fatalities from floor 19, had moved away from their floor of origin.

2.16.5 All fatalities originating from floors 15, 16 and 21 had remained on those floors, with all but one from floor 17 remaining on that floor.

2.16.6 None of the fatalities discovered below their floor of origin were located within a flat. These fatalities were all located within a lobby, the stair, or outside the building.

2.16.7 Residents on each floor appear to have made different decisions as to whether to stay in their flats, to move to higher floors or to attempt to escape from the building. I analyse their movements in detail in Section 20 of my report.

2.16.8 However, based on resident witness statements, there were several potential reasons people moved up the building, including:

- a) LFB and/or other residents told them to move up the building; or
- b) They saw other residents moving up the building; or
- c) The stair at Level 22/23 was perceived to be full of people and so was not considered a safe escape route.
- d) Several witness statements mentioned a common belief that a helicopter was going to rescue residents from the roof, however none of the other evidence I have reviewed to date, has indicated that the LFB told residents to go to the roof for a helicopter rescue.

- 2.16.9** Evidence from resident's Li (transcript 29th October 2018, p168) and Mekonnen (transcript 9th October 2018, p47) identifies that residents were moving up the stairs at some time between 01:21 and 01:32.
- 2.16.10** Mekonnen states: *"I got to the top of the stairs on my floor. I did not want to go back into my flat, so I decided to ignore the advice that had been shouted in the stairwell, to go back up, and I headed back down the stairs with my daughters. There was no one on the stairwell at this point. As we were walking down the stairs, the smoke was becoming thicker and thicker. It was dense and dark grey but I could see through it. I was able to breathe without any difficulty."*
- 2.16.11** This upward movement may therefore have originated because of smoke experienced in the stairs at lower levels. This is supported by evidence from the 999 call transcripts of residents in Flat 192 (level 22) as one example, at 01:35, who stated *"We couldn't get down the stairs, because the stairs is full of smoke"* (LFB00000315).
- 2.17 FSG calls – analysis and trends**
- 2.17.1** In total there were 154 Fire Survival Guidance (FSG) calls (including duplicates) made between 01:15 and 05:05. Please refer to Section 14.4.172 for my definition of FSGs and my analysis of the call data.
- 2.17.2** Figure 2.5 shows the total number of FSG calls which ended during 18 No. fifteen minute intervals between 00:45 and 05:15. For each interval the proportion of FSG calls made from above and below Level 13 is also shown.
- 2.17.3** The number of firefighters deployed beyond the Bridgehead in Grenfell Tower during these intervals is also plotted.

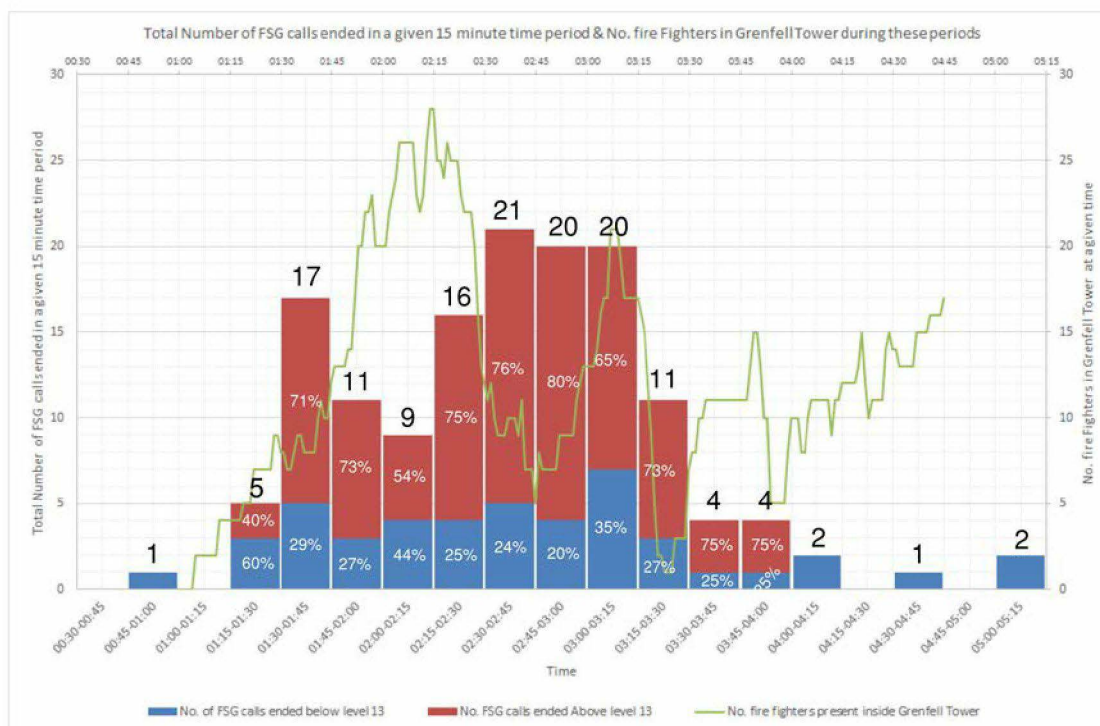


Figure 2.5 The number of FSG calls (by end time in 15 min intervals) and number of fire-fighters beyond the Bridgehead of Grenfell Tower

2.17.4 The pattern observed in the total number of FSG calls is as follows in Section 2.17.5 – 2.17.13).

2.17.5 An increase from 5 FSG calls during 01:15-01:30 to 17 FSG calls 01:30-01:45. This coincides with:

- The ignition of multiple internal fires beyond Flat 16 which residents reported through 999 emergency calls; and
- The period between 01:21 and 01:49 when people were observed on the upper levels of Grenfell Tower to be moving up the building instead of escaping down due to the stair being perceived as “*too smoky*” or being told to “*go back*” by other residents.

2.17.6 There is also a significant increase in the proportion of the total calls made from above Level 13, from 40% of total calls during the interval 01:15 - 01:30 to 71% of total calls during 01:30-01:45. This may be explained by the increasing number of residents becoming aware of the fire and the people who have attempted to escape already but are unwilling to escape through the conditions in the stairs and lobbies at that time.

2.17.7 Callers during this time are still being advised to stay put where they are not directly affected by fire and to call back should their conditions change.

2.17.8 After 01:45 there is a decrease in the total number of FSG calls to 11 and 9 during the 01:45-02:00 and 02:00-02:15 intervals respectively. The majority of calls are still being made from above Level 13. This decrease also

coincides with a period where no people evacuated the building from above Level 11 (01:49 – 02:25).

2.17.9 From the evidence I have collated in Section 13, 14 and 20 of this expert report, this may be explained by:

- a) The operational stay put policy was still being applied. During this period, those residents who reported not being directly affected by fire were advised to stay put. There is also evidence that residents who were being directly affected by fire during this time with flats, perceived they were unable to escape (Section 20).
- b) The largest number of firefighters were working inside Grenfell Tower. There is evidence during this time of firefighters moving people between flats (Level 14) or reaching people within their flats and advising them to stay put (Level 18), and therefore fewer residents may have felt the need to call 999 for assistance.

2.17.10 After 02:15 the total number of FSG calls increases again. It rises to 16 during the 02:15-02:30 interval and plateaus at 20-21 between 02:30 and 03:15. During these FSG calls (from around 02:35) residents are advised to leave their flats. This increase in FSG calls coincides with:

- a) The conditions with the lobbies and stairs deteriorate further. Thick black smoke is present in the majority of lobbies and starts to spread into flats via the flat entrance door. The stair is filled with thick black smoke and significant heat. An increasing number of flats, particularly on Levels 18 - 23 are being affected by the external fire spread. These changing conditions may have prompted residents to call 999 particularly where they had previously been advised to call back should their condition change.
- b) The number of fire fighters working in Grenfell Tower also declines from 28 at 02:15 to 5 at 02:45. Therefore, fewer residents can be reached by firefighters in their flats at this time. Where they have been advised during an earlier FSG call the fire service shall get to them for rescue they are likely to call 999 if the fire service have not reached them after a period of time.

2.17.11 After 03:15 there is a sharp decrease in FSG calls to 11 between 03:15-03:30 and 4 between 03:30 and 04:00. The number of fire fighters deployed internally has risen again to a peak of 15 around 03:50. During this period, residents still remaining within the building have either attempted to escape or were unable or unwilling to attempt to escape through the substantially worse conditions in the stairs and lobbies.

2.17.12 This decrease in FSG calls also coincides with the external fire spreading to affect all flats on all four elevations above Level 13 by 03:43. Therefore, the decrease in FSG calls during this time is likely to be reflective of the decision of residents on the upper levels to leave, or residents becoming incapacitated within their flats due fire and smoke spread.

2.17.13 After 04:15 there are a small number of intermittent number of FSG calls: 2 between 04:00 - 04:15, 1 between 04:30-04:45 and finally 2 during the 05:00-0515 interval. I have no evidence of further FSG calls from within Grenfell Tower after this time.

2.18 Impact of the stair and lobby conditions on fire fighting tactics including rescue

2.18.1 In total there were 154 Fire Survival Guidance (FSG) calls (including duplicates) made between 01:15 and 04:45, each one would in principle require an active rescue plan.

2.18.2 The conditions in the stair and the lobbies provided significant complications regarding active rescue as being a viable means to evacuate residents.

2.18.3 After 01:40 conditions in the stairs and lobbies started to deteriorate and just became worse with time. At 01:40, 149 residents remained in Grenfell Tower, within 37 flats.

2.18.4 It is my opinion therefore that the conditions in the stairs and lobbies were reducing the rescue potential. My conclusion is based on the evidence below.

2.18.5 Scale of the fire sector – location of the bridgehead

2.18.6 The times at which LFB were required to move their operational positions within the building is relevant evidence of the conditions within the stairs and lobbies of Grenfell Tower. The internal fire-fighting control point is called the Bridgehead.

2.18.7 I have explained in detail where the Bridgehead was located in Section 14 of my report. In summary, at Grenfell Tower, the LFB initially established the Bridgehead at Level 2. By 02:17, they moved it up to Level 3. However, by 03:08, they were forced to move it down to the Ground Level. Please refer to Section 14 for additional information on the Bridgehead and the reasons it had to be moved during the fire event.

2.18.8 In accordance with the guidance in the Incident Command manual, the fire sector is defined as the floors involved in fire, plus one floor above and one floor below.

2.18.9 In Grenfell Tower, as of approximately 02:17 all floors from the Bridgehead, at this time on Level 03, up to the top of the building were defined by the Incident Commander (O'Loughlin, MET00005213) as the fire sector.

2.18.10 By approximately 08:30, the LFB were able to move the Bridgehead to Level 4, and it was reported to be at Level 8 by 13:25.

2.18.11 The low location of the bridgehead creates a high reliance on breathing apparatus for accessing any floor for rescue or fire fighting.

2.18.12 The last FSG call from above Level 13 ended by 03:33.

2.18.13 Number of fire fighters entering the Tower

2.18.14 I have analysed the data available regarding fire fighter entry to the Tower, during each of the Incident Commander time slots.

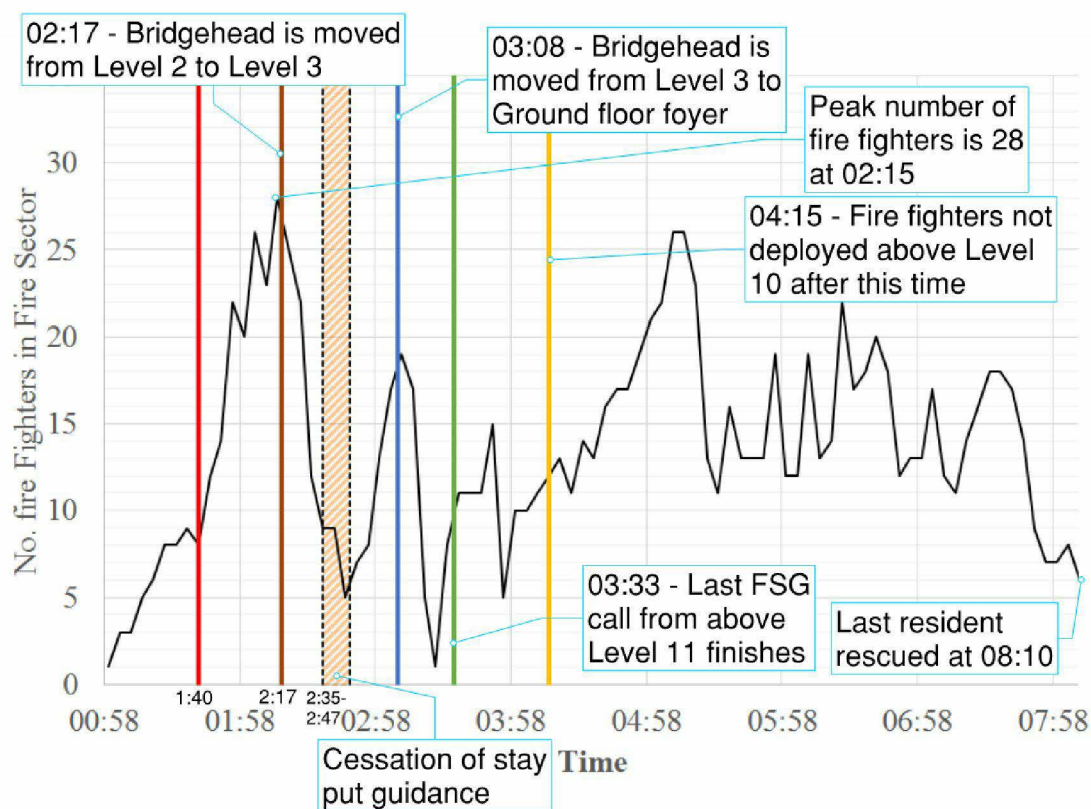


Figure 2.6: Active resources available to the LFB in the Fire Sector

2.18.15 Figure 2.6 shows the active resources available to the LFB in the Fire Sector and therefore available for internal fire-fighting and search and rescue operations (i.e. operations beyond the Bridgehead).

2.18.16 I note that firefighters were committed in teams numbering between 2 and 5 fire fighters.

2.18.17 Between the initial arrival of fire fighters to Grenfell Tower at 00:58, and 01:40, a total of 14 fire fighters in BA were committed into the Fire Sector. Because of the working duration of BA sets, there were never any more than 9 fire fighters in the fire sector at any one time in this period.

2.18.18 Between 01:40 and 02:35 the number of fire fighters present in the Fire Sector rose to a peak of 28 at approximately 02:15, before dropping again to 9, by the time control room staff were beginning to change the advice being given to FSG callers at 02:35.

2.18.19 The peak of 28 at 02:15 represents the largest number of fire fighters present at one time in Grenfell Tower between 00:58 and 08:00.

- 2.18.20** During this period the number of FSG calls recorded as finishing increased from 12 between 02:15 and 02:30, to 20 between 02:45 and 03:00.
- 2.18.21** The number of firefighters increased again from 5 at 02:45 to 19 at 03:09.
- 2.18.22** From 03:09 to 03:24 the number of firefighters reduced from 19 to 1. During this period the number of FSG calls reduced from 20 to 11. The number of FSG calls then further reduced to 0 calls from above Level 13 and 2 from below Level 13 between 04:00 and 04:30.
- 2.18.23** Prior to 03:58 the number of firefighters peaks at 15 before reducing to 5 03:58. After 03:58 the number of firefighters increases upwards.
- 2.18.24** **Comparing rescue needs with available fire fighters as the conditions worsened**
- 2.18.25** I have provided the data I have derived for those time slots regarding FSG calls received, the evacuation rate of residents, and the witness evidence regarding highest floor reached by a fire fighter in that time frame.

Time	Incident Commander	Bridgehead Commander	FSG calls received	Max firefighters beyond bridgehead	Highest floor FF reached	Residents evacuated
00:58-01:50	WM Michael Dowden	O'Keefe	33	14	20	164
01:50-02:15	SM Andrew Walton	O'Keefe	16	28	20	5
02:15-02:44	DAC Andrew O'Loughlin	Welch	33	25	22	14
02:44-04:15	AC Andrew Roe	Welch/ Goulbourne	60	19	19	31
04:15-07:30	AC Andrew Roe	Welch/ Goulbourne	3	26	12	8

Table 2.4 Results from an analysis of FSG calls, fire fighter numbers and location, as well as evacuation times; throughout each Commander time period

- 2.18.26** The FSG call rate was about the same in the second hour from 01:50 – 02:50 however the problem in that hour was the ever worsening conditions in lobbies, and then the stairs.
- 2.18.27** A crisis point was clearly reached after 02:44 with a peak number of FSG calls. At that time, there were 117 occupants remaining in the building.
- 2.18.28** The number of lobbies reported to be affected by smoke was 19 out of 20; witnesses have described the conditions as thick, black smoke with high temperatures. The stairs had zero visibility and residents at Level 12 and 14 describe extreme heat, with conditions described as “roasting” (Smith) or “sweltering” (Oweyole) in the stair.

- 2.18.29** There was therefore a need to reduce reliance on rescue and advise residents to self-evacuate, much earlier than 02:35, as the conditions in the stairs and lobbies were worsening with time, and the bridgehead was too low to effect a sustained rescue effort, particularly on the floors from Level 13 and above where the majority of the FSG calls were under way.
- 2.18.30** The conditions in the stairs and lobbies posed a serious risk to life, and proved fatal for ten residents. But those conditions posed a relatively lower risk to life when compared with the catastrophic conditions now occurring in an increasing number of flats as a result of the external flame front. The conditions on the stairs were life threatening but in relative risk terms – a lower risk to life than certain death from remaining in a flat once the flame front entered it.
- 2.18.31** To explain my opinion, I have provided detailed analyses of the flame front and the 999 calls received from some specific groupings of residents, in Section 20 of my report.
- 2.18.32** One example is from the residents who took shelter in Flat 201 on the 23rd floor. This was the second flat, after Flat 206 on the 23rd floor, to which the external fire spread. Seven residents of Grenfell Tower were recovered from this one bedroom flat, including the resident of Flat 201.
- 2.18.33** Flat 201 sits between column C5 and B5. It has only one external wall between these two columns on the east elevation. The external wall contains three windows and two insulating core panels. The only rooms within the flat which are not bounded by the external wall are the corridor and bathroom.
- 2.18.34** The external fire reached the top of Grenfell Tower by 01:29 by spreading vertically up column B5 on the east elevation. By approximately 02:05 the external fire had spread the full length of the external wall of Flat 201 to column C5. This is 34 minutes after the fire first reached column B5.
- 2.18.1** There were FSG calls with three separate people sheltering inside Flat 201. The first FSG call started at 01:30 reported smoke in the lobby of Level 23. All three people in the FSG calls refer to smoke within Flat 201 at the start of the calls. All three people in the FSG calls refer to the external fire spreading into Flat 201 during the calls. It is not possible to define a precise time for this, as the call durations were long.
- 2.18.2** All three people in the FSG calls indicate the person was unable to make themselves leave Flat 201, even whilst the external fire spread into the flat. The last FSG call ended at 02:24. From my investigation of the external fire spread, fire had spread the full length of the Flat 201 external wall by around 02:05.
- 2.18.3** Similarly, at Level 23, four persons were recovered from the Flat 2 including two persons from lower levels, and four persons were recovered from the Flat 5, all of whom were from lower levels of the building. The external fire had spread to Flat 2 and Flat 5 on Level 23 by 02:10.

2.18.4 The other occupants of Flat 205, who made the very difficult decision to get over to the stair, survived the fire.

2.19 The timing of the change to LFB's operational policy to provide Stay Put guidance to 999/FSG callers

2.19.1 The conditions in the lobbies created intense fear amongst the residents which is likely to have affected the ability of many of them to leave their flat and descend the stair. As the fire progressed, and conditions worsened in the lobbies, but also directly on the external wall of their own flat, and adjacent flats, it was even more difficult to overcome this fear, even when they were eventually instructed to do so.

2.19.2 The evidence from the residents has emphasised this stark dilemma for them all too clearly.

2.19.3 The residents were left in conditions that appeared life threatening to them. So much so that even with a flame front entering their home or neighbour's home, entering the staircase was believed to be a fatal option. In some cases, this belief appears to have seriously impacted their decision making process with respect to self-evacuation. It is my opinion they required very specific advice tailored to overcome their fear of the lobby conditions, and to be informed, for example, that there was a concerted effort to meet and rescue people in the stairs.

2.19.4 Their experiences created a belief that entering the staircase was a fatal option, specifically:

2.19.5 For some residents they had already experienced conditions in the stairs and considered them to be life threatening and so turned back.

2.19.6 For other residents, they had entered the stairs or approached the stairs, and heard instructions not to go down the stairs at all, and again had turned back.

2.19.7 Many residents had been told it was safer not to self-evacuate for up to an hour, and the change seemed to overwhelm those that ultimately stayed in place.

2.19.8 There were substantial signals of danger to residents, and to firefighters. This included large quantities of thick smoke impacting sight and breathing immediately outside flat entrance doors, intense heat outside flat entrance doors, heat and smoke within the stair itself, rapidly advancing fire and smoke entering flats from the external wall, and ultimately horrific and rapidly increasing numbers of fires for the residents to attempt to escape away from within their own flats.

2.19.9 It is my opinion that the conditions created difficult, and at times life threatening conditions, for the LFB. The conditions greatly restricted their ability to implement their standard processes and procedures, regarding firefighting once the fire spread beyond Flat 16.

- 2.19.10** The LFB appear to have stopped attempting to fight the multiple and ever increasing flat fires and focused on attempting rescue activities.
- 2.19.11** The conditions caused the requirement for a scale of rescue that overwhelmed the LFB's standard rescue processes. The details of this are being addressed by other experts to the Inquiry.
- 2.19.12** Because of the external wall fire, a complex building fire occurred, and so the single escape stairs and its lobbies became the single most important life safety feature. As I explain further in later sections, I have considerable concern as to the standards of fire safety provision in the lobbies and the stair, whilst acknowledging the extreme and primary hazard the external wall presented.
- 2.19.13** The failure of this life safety feature meant that after 01:40, and particularly after 02:00, worsening conditions limited the ability for rescue to occur, and created more and more barriers, or perceived barriers, for residents to overcome in order to safely self-evacuate. Ultimately, 71 persons were not able to do so.
- 2.19.14** The timing of this decision is relevant to my work because the active and passive fire protection measures are required to provide a safe working environment for the fire and rescue services. However, their failure cannot be considered in isolation, because the LFB continued to invest in rescue after the building safety condition failed.
- 2.19.15** I consider the Stay Put strategy required from the Building condition, to have effectively failed by 01:26; the Defend in Place fire fighting upon which it relies had also failed – there was no ability to extinguish the external fire early as became required.
- 2.19.16** Therefore, there was a need for the LFB to recognise this building failure by 01:26, when the fire had spread up to Level 23 from Level 4, and to recognise the impact this building failure was having, and would continue to have, on standard fire fighting and rescue processes and procedures.
- 2.19.17** There was a particular need to recognise this failure by the time the major incident was declared at 02:06, in order improve the means available to residents to self-evacuate, as this had now become the most likely method to mitigate the risk to their lives, as I explain below.
- 2.19.18** There is a need to recognise now, if interventions could have been made before 02:06, and then before 02:35, in order to prevent such a tragedy happening in the future.
- 2.19.19** An important topic also for investigation is residents who could not evacuate without assistance (residents who could not walk down stairs). I will incorporate the final numbers of persons requiring assistance when that evidence is finalised. There was no active facility available to them for self-evacuation (this is dealt with in detail in Section 15, 16 and 18 of my report).

2.20 Communicating the change from rescue to the need for self-evacuation

2.20.1 The DCLG publish the Fire and Rescue Authorities Operational Guidance: Generic Risk Assessment GRA3.2 *Fighting fires in high rise buildings*. It advises contingency plans for “particular premises” including:

- (a) fire spread beyond the compartment of origin and the potential for multiple rescues; and
- (b) an operational evacuation plan being required in the event the Stay Put strategy becomes untenable.

2.20.2 However, any change in Stay Put is not easily dealt with in the UK, where there is no statutory requirement to provide an automatic detection and alarm system in high-rise residential buildings for the purposes of warning all occupants that an all building evacuation is required.

2.20.3 There was no fire alarm panel provided with controls for the LFB or responsible persons, to raise an all-out alarm within Grenfell Tower.

2.20.4 In Section 18 of my report I have identified the current forms of communication available for residents and firefighters when (a) there is no automatic communication provision in a building and (b) the operational guidance to Stay Put needs to change.

2.20.5 However, at this stage, I note the following key matters:

- (a) The current approach in the statutory guidance is that blocks of flats are not provided with an automatic or manual means of raising an alarm sounder or providing voice alarm announcements. Where there is a large fire in a high-rise block of flats, such as at Grenfell Tower, it is not possible to easily communicate changes in advice (e.g. from Stay Put to “all out”).
- (b) Where there is no central alarm system to alert residents to the need to evacuate, firefighters are dependent on loudhailers, 999 calls, Fire Survival Guidance calls (FSG) and directed evacuation of every flat individually by fire fighters knocking on doors. These methods have significant limitations, especially in a major multi storey fire, such as that at Grenfell Tower.
- (c) The limitations on communication caused difficulty on 14th June 2017, especially when the Stay Put guidance was changed. It is not clear at this stage how the “all out” message was communicated to residents who were still in the Tower after 02:35.

2.20.6 Between 01:40 and 02:35 the number of fire fighters present in the Fire Sector rose to a peak of 28 at approximately 02:15, before dropping again to 9, by the time control room staff were beginning to change the advice being given to FSG callers at 02:35.

2.20.7 At 02:35 there remained 117 people in Grenfell Tower – now the guidance was, in general, to get out, but the fire fighter numbers present in the building were down at 9, making self-evacuation the only viable option, and so communication of this fact was required. At Grenfell Tower, the provisions in the building were such that the only means of communicating this, was if a resident phoned 999, and this then relied on control room staff being provided with a clear understanding of conditions in the stairs from the fire ground.

2.20.8 I wish therefore to raise the matter of the type of guidance required for the residents of Grenfell Tower, once the end of Stay Put occurred. In the time frame after the Stay Put guidance changed (02:35-02:47), it is important that the Public Inquiry analyses what guidance was given to the residents remaining in the Tower. That would include if that guidance was relevant to helping those residents understand the conditions in the stairs and lobbies, if it was relevant to help them overcome any fear of entering such conditions without rescue assistance, and if the guidance provided location-specific information on how to reach a place of ultimate safety outside the Tower.

2.21 Failure of the protected lobbies

2.21.1 In this section I summarise my conclusions about the performance of the protected lobbies on the night of the fire. Where I have been able to, I also express my opinions on compliance of the active and passive measures with the relevant legislation and guidance.

2.21.2 Lobby Enclosure

2.21.3 The enclosure of the lobbies of Grenfell Tower, that is the walls separating it from the flats, were required to be fire resisting. Openings for flat entrances were required to be protected by doors with fire resistance and smoke leakage performance.

2.21.4 Risers (vertical shafts) penetrating the lobbies were also required to be protected shafts and so enclosed by fire resisting walls. The required protected risers in Grenfell Tower included the smoke control system ventilation shafts, the lift shafts and the refuse chute. Openings in the walls of the protected risers were required to be protected by fire resisting construction with additional smoke leakage prevention, where applicable.

2.21.5 Lobby Enclosure -Lobby fire doors (flat entrance doors)

2.21.6 During my site inspection I found that the flat entrance fire doors, which in general were of composite form, were destroyed or partially destroyed where an internal flat fire had occurred. I also observed heavy spalling to the surface of the concrete ceiling directly in front of these doors, on the flat side, and in many locations on the lobby side also.

2.21.7 I have assessed the Masterdor Suredor composite door flat entrance doors, currently understood to have been installed to 106 flats on Level 04 -23 in 2011-2012 (MAS00000003) as non-compliant with the current statutory guidance (Section 15.5 and Appendix I).

- 2.21.8** Their non-compliance would have contributed to the failure to prevent the spread of:
- a) fire and hot smoke from the internal flat fires ignited by the external fire; and
 - b) hot smoke from the lobbies to flats not yet affected by the external fire or smoke.
- 2.21.9** I have shown that the installed doors differed substantially in their assembly from the door for which the FD30 BS476-22 test report relevant at the time of installation, has been disclosed. No test report to certify cold smoke leakage performance has been disclosed.
- 2.21.10** As I identified in Appendix J, Grenfell Tower was not installed with a pressure differential system compliant with BS EN 12101-6. Smoke leakage performance was therefore required on all doors to flats opening directly onto every lobby. I have not seen any evidence that the doors had any smoke leakage performance.
- 2.21.11** The installed doors contained different locks, hinges, letter plates and self-closers. These metal fittings, which are embedded into the door, can significantly affect the performance by reducing the time to burn through the door. Therefore, the installed doors may have prematurely burnt through around these untested fittings.
- 2.21.12** The installed doors contained glazing not included in the disclosed fire door test report. This untested glazing could fail prematurely allowing fire and smoke to vent directly through the door.
- 2.21.13** The installed doors contained different intumescent seals. These seals are intended to seal the gaps between the door leaf and its frame to prevent passage of smoke and flame. This is in addition to the lack of certification for cold smoke leakage performance. This means that it may have been possible for fire and smoke to vent through the gaps in the door set in the early stages of the fire.
- 2.21.14** BRE Global, on behalf of the MPS, conducted a fire resistance test of a Masterdor Suredor flat entrance door from Grenfell Tower on 13/02/2018 to BS EN 1634-1:2014 (MET00019996). The sample door tested included a glazed panel. In this retrospective test the door achieved 15 minutes integrity fire resistance; this is half the required duration for compliance with ADB 2010.
- 2.21.15** This therefore confirms my assessment that the differences between the door assembly tested in the original fire test report and the doors installed in Grenfell Tower, resulted in a lower fire resistance performance.
- 2.21.16** For 14 flats (12 leaseholders and 2 tenanted) on Levels 8, 9, 11 – 14 and 17 – 23, it is believed the original fire doors were retained. The performance of

these doors is unknown. All of these doors were destroyed during the fire, therefore it was not possible for me to survey their construction.

- 2.21.17** Concealed door closers were noted on all eight of the flat main doors surveyed by my site inspection team. These were all disconnected at the time of our survey.
- 2.21.18** Resident and caretaker evidence states that faulty door closers were frequently disconnected and never replaced. This is corroborated by photographs disclosed by the MPS dated 17/06/2017 (three days after the fire) which show that door closers were disconnected (on every flat on Level 4, Flat 35 on Level 6 and Flats 41, 42, 43 on Level 7).
- 2.21.19** One overhead door closer and one concealed door closer were observed in photographs disclosed by the MPS dated 17/06/2017 (three days after the fire) for Flats 23 (MET00018892) and Flat 34 (MET00018847) respectively. This is the only evidence I have to date that any door closers on Levels 4-23 were connected on the night of the fire.
- 2.21.20** The lack of effective door closers is non-compliant with ADB 2010 (and the LGA guidance). The evidence suggests this was a post-handover maintenance issue and I will incorporate that aspect in my investigations in Phase 2.
- 2.21.21** Self-closing devices that were not installed, disconnected or not maintained would result in flat doors not closing automatically behind escaping occupants.
- 2.21.22** The operation of these fire doors was therefore reliant on the escaping person closing the door behind them. I have found evidence of some residents closing doors behind them and other residents not closing doors behind them as they escaped from the building (Section 15).
- 2.21.23** Fire doors are required to perform when closed, and to perform when opened – i.e. to close automatically. Both performances are important during a fire for limiting fire and smoke spread from a flat out to the lobby, and from a lobby into other flats.
- 2.21.24** If a resident left early and the door did not close behind them, this would have consequences for the conditions in the lobby on that floor and those conditions impact any fire fighters or residents on that floor particularly.
- 2.21.25** Additionally, any resident who did not self-evacuate, for example before 01:40, became reliant on their flat entrance fire door to protect them from ever increasing quantities of fire and smoke that could leak into their flat from the lobbies.
- 2.21.26** Therefore, I consider the evidence demonstrates that it is most likely that the flat entrance doors in Grenfell Tower failed to control the spread of fire and smoke to the lobby by:
- a) Failure to prevent the spread of smoke and flame by leakage through gaps between the door leaf and door frame. This could occur early in the

development of fire within the flat but also early in the smoke spread development from the external wall fire, prior to any flat fire.

- b) Failure of the fire door to resist the spread of fire and smoke from a flashover fire within an apartment due to the presence of multiple untested components within the doors – all 106 doors. (Note retrospective testing by BRE Global, which included untested components such as the glazing, has demonstrated that these reduce the fire resistance of the door to half of that required for compliance with ADB 2010).
- c) Failure of the fire door to resist the spread of fire and smoke from a flashover fire within the apartment due to the presence of glazing in the fire door which would be expected to fail early in the development of a fire within the flat. A total of 48 doors were specified with glazing by Manse Masterdor out of 106 doors; although the BRE have advised me that they observed 29 doors with glazing and it was unknown whether a further 29 doors had glazing or not.
- d) Failure of an unknown number of doors to self-close after an occupant escape. Fire and smoke spread to the lobby would then be immediate from the flat to the lobby. In Section 14 and Section 20, I show how many occupants left early, and their location. Any failure of those fire doors at that time, would have had serious consequential effects on the lobbies.

2.21.27 The fire doors also failed in a second way; to resist the spread of fire and smoke from the lobby – given that fire doors are required to perform in both directions. This became increasingly important, when occupants stayed put in their flats, or travelled to a neighbour's flat and stayed there (See section 14.6).

2.21.28 Whilst it is noted that the fire performance of the flat entrance doors FD30S is not intended to provide indefinite and therefore complete protection to the lobbies (ADB 2013 B1.viii), they are intended to provide protection from flames, smoke and gases (ADB 2013 B1.ix) i.e. growing fires and flashover fires within the flats.

2.21.29 The non-compliances I have found on site, relative to the test evidence provided, together with the retrospective testing of the flat front entrance doors by BRE Global, means I must conclude that those doors could not function as they were required to do in accordance with Approved Document B 2010 (the version relevant at the time of the fire door works).

2.21.30 Further, I consider the evidence of sufficient quality to allow me to conclude that the fire doors and their lack of performance, contributed significantly to the spread of smoke, and fire, to the lobbies.

2.21.31 This failure would have materially affected the ability and/or willingness of occupants to escape independently through this space to the stair, due to (a) sensory irritants from the smoke which would have caused immediate effects for anyone entering a smoke filled lobby; and (b) with time, when substantial heat was able to enter the lobby, temperatures over 121°C would have caused

immediate pain to exposed skin, whereas temperatures below this would have caused hyperthermia over a period of exposure.

2.21.32 Poor visibility due to the presence of thick black smoke, which obscured the stair door several meters from the flat entrance doors, may have also prevented occupants from attempting to escape through the lobbies to the stair.

2.21.33 The failure of the flat entrance fire doors to control the spread of fire and smoke from flats to the lobbies also materially affected the operations of LFB:

- i. As I have explained in Section 19.4 this meant these lobbies could not be used as a safe air environment for the LFB Bridgehead and so forced the Bridgehead to remain at or below Level 4 until 13:25. This greatly reduced the time available using breathing apparatus, and so the time available for rescue on upper floors, and particularly above Level 15.
- ii. Above the Bridgehead it affected ability of LFB to conduct search and rescue operations in the poor visibility of the lobbies. It also materially affected the LFB's ability to locate and operate the fire main which they could have used to cool the lobbies
- iii. As the rescue needs increased, with for example the peak of FSG calls under way between 03:00 and 03:15 (MET0004695) when there were 27 active calls, the fire fighter numbers beyond the bridgehead had to drop to 13 at 03:00 (LFB00023326). This had serious consequences for any potential rescues during this time.

2.21.34 **Lobby enclosure - protected shafts**

2.21.35 *Refuse chute* - The fire performance doors to the refuse chute is unknown, however during my site inspection, I have found no evidence that fire and smoke either entered or spread via the refuse chute. Therefore, I have not investigated this further.

2.21.35.1 *Smoke ventilation shafts* - The North and South ventilation shafts for the smoke control system penetrated every lobby of Grenfell Tower. The AOVs created an opening between the lobby on the shafts on every level of Grenfell Tower. I have concluded that the shafts and ductwork for the smoke control system constituted a "*protected shaft*" as defined by ADB 2013. Therefore, in accordance with Section 8.37 of ADB 2013, they were required to meet the compartmentation requirements of the lowest rated element of compartmentation (i.e. floor or wall) that the system penetrated.

2.21.35.2 The system penetrated the enclosure to the lobby at each level - where the dampers were provided. The shafts also penetrated each floor of the building. Therefore, in accordance with ADB 2013, the shafts and ductwork would need to achieve a 2 hour fire resistance rating for Integrity and Insulation, each side separately.

2.21.35.3 The original design of Grenfell Tower was required to comply with Section 20 of the London Building Acts. The guidance for Section 20 that was relevant at the time of construction (please refer to Appendix H) identifies that the wall between the lobby and the flats at each level would also need to achieve a 2 hour rating. I have seen no explanation in PSB's Technical Submission as to what fire resistance performance was to be achieved by their system design.

2.21.35.4 There is substantial evidence of a number of non-compliances with the system as installed in the tower, including:

- a) The existing builders work shafts do not appear to have been checked for leakage in accordance with Section 8.2.4 of the SCA guidance, or treated in accordance with the guidance in Section 11.8.2.8 of BS EN 12101-6 – and have no stated fire resistance performance in PSB's design documentation. They are marked with the required 2 hour rating in the Studio E drawings (SEA00003112).
- b) Section 10.15 of ADB 2013 states that the requirement for fire and smoke dampers to a *Protected Shaft* is 60 minute rating for Integrity and Smoke leakage. Specifically, this is an ES60 rating, as classified using BS EN 13501-3, based on testing using BS EN 1366-2.
- c) However, because the dampers are in a powered pressure differential system, they are required to meet the standards required for "*smoke control dampers*" and this ES60 rating must be achieved in accordance with the classification in BS EN 13501-4 and therefore based on testing to the higher standard of BS EN 1366-10.
- d) The dampers installed in the north and south shafts were Gilbert Series 54 "*Smoke evacuation dampers*";
 - i. The literature submitted to the Inquiry by PSB (PSB00000201) states that this product was "*fully tested to the requirements of EN1366 pt 2 for 1 hour.*" This is dated October 2011. However, no formal classification is provided in accordance with BS EN 13501-3 based on testing against BS EN 1366-2.
 - ii. I have also seen additional test evidence from Gilberts. WF Test Report No. 309850 (dated 06/10/2011) is a test of a damper sponsored by Gilberts to BS EN 1366-2:1999. The report specifically states: "*At request of the test sponsor the damper was in closed position at the commencement of fire test (Clause 10.4), and therefore the test was not conducted fully in accordance with the standard.*" The PSB literature (PSB00000201) was therefore factually incorrect at the time of issue as the damper had not been "*fully tested to the requirements of EN1366 pt 2*".
 - iii. BS EN 1366-2 is the test standard for fire dampers in a natural ventilation system – i.e. testing that the damper functions when smoke is moving under buoyancy only. In a smoke control

system, the fans are constantly running extracting air, therefore applying a higher pressure on the damper and a higher test standard is required.

- e) The Gilberts literature dated October 2011 implied that the dampers were fully compliant with BS EN 1366-2 for fire dampers. However, the formal certification of the damper fire resistance (both E and S ratings), appears to have been rescinded by the manufacturer in April 2017. It is possible that this was because the test report dated October 2011, on which the earlier literature was based, did not in fact demonstrate a test to the full requirements of the test standard.
- f) Therefore, the dampers that were installed did not have the relevant test evidence required to demonstrate performance to either of ADB 2013 or BS EN 12101-6. Specifically, they did not have the performance ES60 when classified against either BS EN 13501 Part 3 for fire dampers or Part 4 for smoke control dampers.
- g) PSB's Technical Submission does not in fact specify any fire integrity rating or smoke leakage requirement for the AOV dampers in order to comply with the requirements of ADB 2013 or BS EN 12101-6. Further, PSB's design schematic (p1238 of RYD00000577) does not specify a fire integrity or smoke leakage performance requirement for the AOV dampers, but states that the design, supply and installation of any dampers is outside their scope of work.

2.21.36 Therefore, the lower standard of AOVs may have allowed more smoke to leak from one lobby to another through these shafts. This could have contributed to the internal spread of smoke in Grenfell Tower. If the AOVs did allow more smoke to leak into other lobbies, this would be a critical failure as the ventilation shafts connect every lobby in Grenfell Tower.

2.21.37 *Lift shaft* - I have found no evidence fire resisting doors were specified for the lift doors by any party during the 2005 or 2012-2016 works, as required for a protected shaft.

2.21.38 Further, a Class B lobby smoke control system sets pressure differential requirement to keep the lift shaft clear of smoke, and to prevent the pressure within the stair from driving smoke into the lift shaft or from the lift shaft into the stair. This should be achieved by providing separate pressurization of the firefighting lift shaft, lobby and stair. The fan/motor units supplying air to the firefighting lift shaft should be within its associated stairwell, but with separate supply ductwork.

2.21.39 There are additional airflow criteria for the lift with the requirement to assume the doors to the firefighting lift shaft and the lobby are open on the adjacent storey.

2.21.40 I have no evidence available to me at this stage which shows that the lift shaft was considered as part of the lobby smoke control system regarding either pressure or airflow limits. I will investigate this further in Phase 2.

2.21.41 Travel distance within the lobbies

2.21.42 Travel distances within protected horizontal escape routes are required to be limited because the enclosing structure does not provide protection indefinitely (ADB 2013 B1.viii).

2.21.43 I have shown in Section 15 travel distance through the lobby by occupants of Flat 5 or Flat 6 on Levels 4 – 23 exceeded the maximum distance recommended under the current statutory guidance – however it was compliant with the design guidance at the time of the building’s construction.

2.21.44 During the time that all lobbies, except Level 4, remained free of hot smoke and gas, which was only up to approximately 01:18 (Section 14), the increased travel distance of 3m would have little effect on the ability of occupants to make their escape.

2.21.45 After this time and progressively through the night the lobbies became filled with smoke and heat. An increased travel distance of even just 3m has the effect of prolonging the duration of exposure to heat, toxic products and irritants, reducing the visibility of the stair exit door and increasing the difficulty in way-finding.

2.21.46 However, the effect of an increased travel distance within the lobby appears, at this stage, not to have had a dominating impact on the failure of the lobbies in providing a safe means of escape for the fire that occurred at Grenfell Tower. The presence of smoke and heat and the poor visibility are likely to have been the primary deterrents for residents.

2.21.47 I point out the large loss of life in Flat 1 on Level 23, where 7 people died, the last FSG call ended there at 02:25. This flat entrance door was only 5.5m from the stair door.

2.21.48 Provisions for persons requiring assistance to escape

2.21.49 Levels 3 – 23 of Grenfell Tower, which were residential only, were not required by ADB 2013 to be provided with provisions for occupants that require assistance to escape (i.e. refuges or emergency voice communication). However, the introductory text of ADB 2013 does acknowledge that in some circumstances a lift may be provided as part of a management plan for evacuating people and that a firefighting lift may be used for this purpose.

2.21.50 The 2016 Fire Risk Assessment for Grenfell Tower (LFB00000066) describes the potential use of the lobby lifts as a means of evacuation of persons requiring assistance by the fire and rescue services. As I have explained in Section 18, BS9991 which also provides guidance on this topic and explicitly states that evacuation should not be reliant on the intervention of the fire and rescue service.

2.21.51 I explain in Appendix L that these lifts were not firefighting lifts and it should be noted that rescue using a lobby lift would only be safe where it was designed as a firefighting lift. The lifts in Grenfell Tower do not appear to

have been designed as firefighting lifts but instead appear to be what is termed *fire lifts* (see below), which have a lower standard of performance. This meant that for people who could not use the stairs, there was no way to exit, unless rescue direct from a flat could occur. I have explained the serious impact the conditions on the lobbies and stairs had on rescue potential above.

2.21.52 The currently available evidence indicates a concerning lack of provisions for persons who require assistance, which requires further investigation. However, for any persons requiring assistance to escape, the deteriorating conditions within the lobbies would have prevented their use as a refuge as part of any escape plan. Refuges are used in other building types (for example offices), to wait for the lift or wait for rescue down the stairs.

2.21.53 As I have described in Sections 15 and 18, any persons requiring assistance from the fire fighters for evacuation using the lift (assuming it had been operable and was a full firefighting lift), may have been required to wait in the lobby.

2.21.54 However, the conditions within the lobbies became untenable and therefore this method of refuge was not possible. In this respect the lobby failed to provide a means of escape for persons requiring assistance to evacuate.

2.21.55 Impact of external fire-fighting on lobby protection

2.21.56 As I have explained in Section 17 the LFB was able to undertake external firefighting, using improvised locations around the Grenfell Tower, despite the lack of access facilities.

2.21.57 Current evidence indicates that the external firefighting the LFB were able to improvise may have prevented or delayed the ignition of internal flat fires on Level 9 and below on the East and South elevations of Grenfell Tower.

2.21.58 Therefore, it is possible that external firefighting contributed to relatively better conditions in the stair and lobbies on Level 9 and below, once consistent water application was achieved on those elevations of the Tower. There is an exception on the East elevation, where external water was applied up to Level 18. However, this position had to be abandoned by 02:18 due to falling debris.

2.21.59 I also note that some of the latest residents to evacuate from Grenfell Tower came from flats with external walls on the south and east elevations with the highest water application. Specifically: three people in Level 11 Flat 82 at 04:47; and one person from Level 10 Flat 72 at 06:05.

2.21.60 It is likely therefore, that the application of fire fighting water to the external walls of these flats slowed the rate of external fire spread and therefore slowed down the spread of fire into these flats, and helped mitigate the risk to life in those locations.

2.22 Failure of the protected stair

2.22.1 In this section I summarise my conclusions about the performance of the stair on the night of the fire. Where I have been able to, I also express my opinions on compliance of the active and passive measures present within the stair with the relevant legislation and guidance.

2.22.2 With regard to the protected stair in Grenfell Tower, it is useful to note its function as described in BS9991: 2015:

“Whilst a simultaneous evacuation is normally unnecessary (see A.1 regarding stay put strategy), there will be some occasions where operational conditions are such that the fire and rescue service decide to evacuate the building. In these situations, the occupants of the building will need to use the common stair, sometimes whilst firefighting is in progress. As such, the measures in this British Standard for the protection of common stair are designed to ensure that they are available for use over an extended period.”

2.22.3 Stair Doors

2.22.3.1 Since the publication of my preliminary Phase 1 report I have conducted an investigation of historic timber door construction to identify: the likely date of construction of the Grenfell Tower stair doors, their fire performance (Appendix M) and whether they were compliant with the relevant guidance.

2.22.3.2 From these investigations I am satisfied that the stair door was constructed as a No. 3 Class A door from Table G of Schedule VI of the *London Building Constructional Amending Bylaws*.

2.22.3.3 This is based on the internal stile and rail with plasterboard infill panel construction of the door and the presence of a 12mm rebate in the door frame, which I find to be consistent with the specification for a No. 3 Class A door.

2.22.3.4 These further investigations, together with RBKC’s statement (by letter to the inquiry dated 27th September 2018 (RBK00029044)), that no replacement or changes were made to the Level 4 to 23 stairwell doors during the 2012-2016 refurbishment, lead me to conclude that the stair doors in Grenfell Tower were probably the original stair doors from the time of construction. This conclusion is supported by the physical evidence from site which I have set out in detail in Appendix M, and I summarise below.

2.22.4 A Class A door was the standard of door required by the *London Building Constructional Amending Bylaws* and the GLC Section 20 Code of Practice 1970 both of which were applicable at the time of construction.

2.22.5 However, a No. 3 Class A door with 12mm rebate would not satisfy CP3 part 4 (1971) which was used for the means of escape design, including the lobby smoke control provision, at Grenfell Tower. CP3 part 4 (1971) relied upon the provision of a Type 2 stair door (with a 25mm rebate, 30 minutes fire resistance), a Type 3 flat entrance door (with a 12mm rebate, 20 minutes fire resistance) and a ventilated lobby, to provide protection to the single staircase.

- 2.22.6** My investigations have presented evidence that a No. 3 Class A door would achieve a fire resistance period as low as 12 minutes integrity; increasing to 20 minutes integrity where constructed with an intumescent strip at the edge of the door leaf.
- 2.22.7** I do not know why the lower standard Class A. No.3 doors were deemed acceptable by the approving authorities at the time of construction in the 1970s. On this basis, my opinion is that none of the stair doors from Level 4 upwards complied with the design guidance used for the original design of the building (CP3 1971).
- 2.22.8** I have no evidence at this stage that the stair doors were considered during the flat entrance door replacement works either.
- 2.22.9** This is important because the Level 6 stair door was fire tested to BS 476-22 by BRE as part of the MPS investigation (MET00021780). The stair door was found to achieve 16 minutes integrity and 3 minutes insulation. This is a lower standard than the 60 minutes integrity to comply with current guidance in ADB 2013.
- 2.22.10** ADB 2013 also requires stair doors to achieve cold smoke leakage performance requirements. This performance is required where stairs and their lobbies have not been designed to the pressurisation requirements of BS EN 12101-6. As I explain in Appendix J this was not provided for at Grenfell Tower, therefore the smoke leakage performance applied, and I have no evidence that this was considered at Grenfell Tower during the primary refurbishment, nor the flat entrance door replacement works in 2011.
- 2.22.11** I observed no fire damage in the stairs consistent with the total failure of a stair door, allowing fire spread onto the stairs.
- 2.22.12** I did observe patterns of damage within the lobby, which indicate intense fire and smoke venting from the flats into the lobbies. The corridor arrangement on both sides of the lobbies would have channelled the vented fire and smoke, towards the centre of the lobby and directly impacting the stair doors. This direct heating may have caused integrity failures in the stair door, allowing smoke spread to the stair.
- 2.22.13** Under these conditions, the non-compliances I have identified would have contributed to the failure to prevent the spread of smoke to the stair.
- 2.22.14** Additionally, I have identified that firefighting operations in response to the multi-storey fire may have contributed to the failure of the stair fire doors to prevent fire and smoke spread. In Section 14.4 I found evidence from witness statements that stair doors were held ajar either because fire fighters were holding open doors or because there were obstacles such as hoses on Level 3 at 01:12, Level 5 and 6 at 01:30, Level 4 and 5 at 01:45, Level 10 or 11 at 02:10 and Level 9 at 02:20.
- 2.22.15** During my site inspection I found the plastic stair lights on Level 13, 13.5, 14, and 14.5 stair landings have been fully destroyed whereas the plastic stair

lights on Levels 15, 15.5, and 16 stair landings are deformed/partially melted. I have carried out extensive analysis to try and conclude how this happened. In summary I can conclude the following:

- a) The Levels 13, 14, and 16 lobbies are severely damaged and the stair doors on these levels are gone (Note in MPS photographs METS00016987, after the fire, the Level 16 door is visible where it is badly damaged and located on the floor of the lobby).
- b) The stair door which separates the lobbies from the stair was missing or fire damaged on Levels 10 – 23, with the exception of Levels 11, 12, 15 and 17. Therefore, the pattern of missing stair doors after the fire does not correlate with the damage within the stair on Levels 13 -16.
- c) The Level 15 stair door is intact and the lobby damage is less severe than Levels 13, 14, and 16 (in particular, the riser partitions and ceiling are in better condition on Level 16)
- d) Firefighters working somewhere between Level 10 to Level 14 (Desforges MET00008013) describe extreme heat within the lobby whilst conducting a search and rescue operation. The witness statement describes the stair door being held open during this operation. This occurred around 02:10.
- e) The witness evidence of Rosemary Oyewale (IWS00000852) indicates there was much fire-fighter activity around Level 14 from around 02:00 onwards. This activity will have required opening and closing of stair doors.
- f) I have no evidence of the operation of smoke control system which could connect it with the plastic light damage at this time. However, I am investigating the performance of the smoke control system with regard to maintaining compartmentation between the lobbies of Grenfell Tower.

2.22.16 The strongest evidence of the cause of the plastic light damage is smoke and heat entering the stair from open doors to the lobby during the fire event. From the physical damage observed during post-fire site inspections it could have occurred due to the stair doors being held open on each level, although it appears it may have been as a result of one or both of the Level 13 and 14 doors being held open.

2.22.17 Therefore, the stair doors may have failed to prevent the spread of smoke to the protected single stair due to:

- (a) Non-compliances in the construction of the door against current statutory guidance for 60 minutes integrity fire resistance and cold smoke leakage.
- (b) Whilst the LGA guide permits 30 minutes integrity fire resistance, from my survey the performance may actually have been as low as 20 minutes integrity fire resistance.
- (c) Further evidence is required regarding the cold smoke leakage performance potential from the stair doors, about which I have no information.

- (d) Doors being held open by the presence of firefighting hoses and in one reported case a fatality. Further forensic investigation is under way to determine the exact number and location of hoses and how long they were in place.
- (e) I was not able to determine whether any stair door self-closers failed to operate, however, I did not find any evidence of this in fire fighter witness statements. Evidence from the 2016 risk assessment described two stair doors as failing to self-close fully and resident evidence from prior to the fire refers to a faulty stair door closer on Level 15 (IWS00000852). I currently have no evidence these defects were dealt with.

2.22.18 Stair doors are required to perform each side separately, and as there was no fire spread in the stair I do not consider these doors to have been impacted by the multi-storey fire condition, and their statutory performance remained relevant throughout the fire.

2.22.19 Services within the stairway

2.22.20 During my site inspection, I observed heating system pipes and gas pipes within the single protected stair of Grenfell Tower.

2.22.21 The presence of heating pipes in the stair is non-compliant with the requirements of ADB 2013 (Section 16.7).

2.22.22 I observed service penetrations included a lateral gas pipe penetration on 13 floors (Levels 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 16, 17 and 21) to the riser gas pipe within the stair. These pipe penetrations did not appear to be fire stopped (Section 16.7).

2.22.23 Gas pipes are only permitted in the protected stairway where the gas services comply with the relevant legislation. The gas services do not appear to have been installed at the time of the fire in accordance with the relevant legislation (Section 16.7, Appendix K). The construction works related to these services was ongoing at the time of the fire. A gas expert has been appointed by the Public Inquiry and is currently investigating the compliance of this system.

2.22.24 As I have explained above, although I have identified non-compliances related to these gas services from the perspective of the Building Regulations, I did not observe evidence of fire spread to the stair by this penetration. Therefore, it does not appear that this non-compliance contributed to the spread of fire to the protected stair.

2.22.25 I also observed equipment associated with the smoke ventilation system which penetrated the wall separating lobby riser cupboard from the stair. This was a small diameter plastic tube for sampling air pressure in the stair and lobby. I observed the plastic material of this equipment to have melted and deformed on Level 22 of Grenfell Tower. Due to the small diameter of the equipment in question, I do not currently believe these penetrations provided a significant route for spread of fire and smoke between the lobby and the stair.

2.22.26 Stair Width

- 2.22.27** As I have explained in Section 15 and 16, the width of the single stair in Grenfell Tower was 1,040mm. This was compliant with the requirements of design guidance applicable at the time of construction, CP3. However, the stair width was 60mm less than required by current statutory guidance in ADB 2013.
- 2.22.28** In Section 16.5, I found that a stair of this width and height, is deemed to provide escape capacity for $[150 + (22 \times 40)] = 1,030$ people in accordance with Table A7 of ADB 2013. This is significantly higher than the 293 residents believed to be in the building at the start of the fire. As I have identified in Section 14 of my report, there were a maximum of 9 firefighters deployed inside the building beyond the Bridgehead between approximately 00:55 and 01:40, i.e. the point beyond which conditions in the stair deteriorated significantly. These firefighters were deployed in teams of between 2 or 3 and spent part of their time in the lobbies of specific floors. Therefore, the teams were not within the stair for the full time of their deployment.
- 2.22.29** Between 00:55 and 01:38, 110 people evacuated the Tower. This was the maximum flow rate at any time during the fire.
- 2.22.30** I am not aware of evidence from LFB that those 110 people caused an obstruction on the stairs. This left 184 residents remaining in the Tower.
- 2.22.31** In Section 13.5 of my report, my analysis of the LFB BA telemetry data (LFB00023326) shows that the maximum number of fire fighters in the building at any one time was 28 fire fighters at 02:15.
- 2.22.32** At 02:15 125 residents were remaining in the tower. This is still significantly lower than the capacity of the stairs for simultaneous evacuation i.e. of 1030 persons.
- 2.22.33** AT 02:35 117 residents were remaining in the tower.
- 2.22.34** Therefore, although non-compliant with ADB 2013, it is my opinion that the stair had sufficient capacity for simultaneous evacuation (all out) of the building.
- 2.22.35** In his oral evidence on 26th September AC Roe (Transcript p36) addressed the capacity of the stair to accommodate evacuating residents and fire fighters.
- 2.22.36** However, although the width of the single protected stair was non-compliant with the current statutory guidance, increasing the width by 60mm to meet the current guidance would not have mitigated the significant demands placed on the single protected stair whilst visibility reduced to zero by thick black smoke and heat increased. These demands were:
- a) the only route of escape for all occupants;

- b) the only access route for fire fighters ascending for rescue or conduct firefighting;
- c) the only route to run water up the building in hoses when the fire main had failed;
- d) the only route to carry down rescued residents; and
- e) the only route to carry up and down equipment from the Bridgehead.

2.22.37 Despite the Grenfell Tower stair being perceived to be narrow I have so far seen no evidence that the stairs actually became substantially blocked at any stage such that its width in and of itself significantly impacted on escape by the residents or access by fire fighters.

2.23 Failure of the Firefighting facilities

2.23.1 Firefighting lifts

2.23.2 Based on the documentation assessed (Appendix L) the lifts within Grenfell Tower were not designed in accordance with the requirements for a fire-fighting lift as described in ADB 2013 (the most recent refurbishment works to the lifts were conducted in 2012-2016).

2.23.3 In my preliminary Phase 1 report I concluded that the lifts did appear to have been provided with the features consistent with a *fire lift* as described in CP3 (the original design guidance available at the time of construction).

2.23.4 This is a lower standard of performance which lacks a secondary power supply, water ingress protection or FD60 performance for the lift landing doors. It does provide a fireman's switch, which automatically grounds the lift and stops it from being called to other floors by building occupants.

2.23.5 This lower standard of fire lift is not typically used by fire fighters to transport anything other than equipment due to safety concerns during a fire.

2.23.6 On the 14 June 2017, fire fighter contemporaneous notes (MET00005384) describe the failure of the Ground Level fireman's switch to recall the lift or alter its control to firefighting mode during the initial response to the flat 16 fire on Level 4.

2.23.7 Further evidence has now been provided through CCTV footage and oral evidence from Firefighters Secrett, Badillo and Brown (Appendix L). This confirms that Firefighter Secrett attempted to use his drop key to operate the ground floor fire control switch, but the switch failed to engage.

2.23.8 CCTV evidence from the lobby confirms the lifts continued to operate as normal lifts, that is, not under firefighter control. Specifically, residents were able to continue to call the lifts using the landing controls with the effect that residents used the lift during the fire, and firefighters using the lift were called to floors they had not selected.

- 2.23.9** The significant findings from the 2016 risk assessment (TMO10017691) note that the fireman's switch was at that time located at Level 2 and was required to be moved to ground. I observed a switch at Ground Level and one at Level 2.
- 2.23.10** Further evidence has now been provided on these switches from a site investigation by WSP on behalf of MPS. This investigation has provided evidence that the Level 2 fire control switch was not connected and so could not be used to control the lifts.
- 2.23.11** The switch at Ground Level was connected, but the mechanical mechanism was seized and could not be operated by WSP. It could not be used to control the lifts. The current state of the evidence therefore indicates that neither switch could provide the fire service with fire control of either lift.
- 2.23.12** Further investigation is required in relation to the Ground Level fire control switch to establish if the switch, irrespective of the condition of the mechanism, was interfaced with one or both of the lifts and what control operation for the lift it would have provided.
- 2.23.13** This is necessary in order to confirm whether either of the lifts met the lower fire lift standard.
- 2.23.14** Whilst the lack of a fire fighting lift could have delayed the initial LFB response, the oral evidence from Firefighter Batterbee (28th June Day 12 at p41) confirms that the fire service did use the lift in normal operation to facilitate equipment transport to the Level 2 bridgehead. In those circumstances, it appears that this non-compliance did not cause a delay to the initial fire fighting response.
- 2.23.15** However, all other operations by the LFB within the 23 storeys were required to be by means of walking up and down the stair only (including carrying their equipment). This would have increased the time required by the firefighters wearing breathing apparatus to reach the upper levels and reduce the time available to them to undertake rescue operations. This was exacerbated by the very low position of the Bridgehead.
- 2.23.16** Failure of the fire control switch at ground floor, meant that the lifts continued to function as normal in the early hours of the fire. Had the fire control switch been operable, LFB could have used the fire control switch to isolate the lifts and so prevent residents from using the lifts during the fire.
- 2.23.17** This would have removed an unnecessary risk to residents. I note that Nadia Jafari (oral evidence Day 54 8th October 2018 at p45-57) lost her father during their evacuation from Level 11 to ground while using the lift.
- 2.23.18** This is in addition to the failure to provide an available form of transport for rescued occupants from the Bridgehead back down to ground during the night, and particularly as needed by mobility impaired persons.

2.23.19 Failure of the Fire main

- 2.23.20** A dry fire main was provided at Grenfell Tower instead of a wet fire main. This was non-compliant with the design guidance in force at the time of original construction, and is also non-compliant with current standards.
- 2.23.21** The fire main was located within the lobby and not within the stair. This was compliant with the design guidance available at the time of construction only.
- 2.23.22** There were no difficulties associated with the dry fire main position in the lobby during the LFB response to the initial fire in Flat 16, Level 04.
- 2.23.23** However, following the ignition of multiple internal flat fires by the external wall construction fire (which required the LFB to operate multiple hoses on multiple levels), the operation of the dry fire main failed in three ways, according to fire fighter evidence:
- a) The LFB was unable to get adequate water for firefighting from the dry main on the upper levels due to the lower capacity of the dry main system compared to a wet main system. This failure is relevant to the non-compliant installation of a dry fire main instead of a wet fire main.
 - b) The requirement for the LFB to connect multiple hoses to fight the multiple internal fires meant the demand for water outstripped the capacity of the system. However, this failure is not relevant to the non-compliant installation of a dry fire main. Wet fire mains are also only designed to supply up to 2 hoses operating simultaneously.
 - c) I have explained above that the location of the main directly outside Flat '3's posed serious problems for the fire fighters, once conditions deteriorated within the lobbies.
- 2.23.24** In a wet riser, the system would already have been charged with a pump connected when LFB arrived. There would have been no operations required by LFB to find external hydrants, connect to their pumping appliance and connect to the riser inlet. Therefore, the provision of a dry main would have contributed to increasing the time required by the LFB to get water to the initial fire event in Flat 16.
- 2.23.25** Therefore, a wet fire main could have enabled a faster initial response time to the fire in Flat 16 which might have increased the chances of extinguishing the fire before it spread externally. However, it cannot be asserted it would have absolutely achieved this.
- 2.23.26** A wet fire main, could have enabled greater water pressure for fire-fighting on the upper floors of Grenfell Tower, which may have allowed LFB to use water to cool lobbies and stair and therefore provide more assistance to people trying to escape.
- 2.23.27** The Inquiry has appointed an Expert to investigate this in more detail.

2.23.28 Failure of the lobby smoke control system

2.23.29 Overall compliance status

2.23.30 As I explain in Appendix J the purpose of lobby smoke ventilation under the statutory guidance is:

“There should therefore be some means of ventilating the common corridors/lobbies to control smoke and so protect the common stairs. This offers additional protection to that provided by the fire doors to the stair. (The ventilation also affords some protection to the corridors/lobbies).”

2.23.31 Therefore, the purpose of the smoke ventilation system is to control the amount of smoke entering the lobby and therefore reduce the risk of smoke spread from the lobby to the protected stair.

2.23.32 I have concluded that the original smoke control system was designed as a corridor smoke dispersal system as defined in Figure 16b of CP3 1971, but was not compliant with the recommended provisions of that Code, as set out in Section J4.2.

2.23.33 I have concluded that the mechanical smoke control system designed and installed in the 2012 – 2016 refurbishment was intended to provide an “average open door velocity” between the lobby and the stair, and that this velocity was intended to comply with the airflow performance criterion of a Class B (fire fighting) pressure differential system as defined in BSEN 12101-6:2005.

2.23.34 As I explain in Section J5.2.16 and Table J.6, a Class B pressure differential system has substantially more performance requirements than this single open door velocity performance. I have found no evidence that any of those other performance requirements were designed for.

2.23.35 I have concluded that the design of the lobby smoke control system was substantially non-compliant with the performance requirements of the relevant British Standard - BS EN 12101-6:2005 *Smoke and heat control systems —Part 6: Specification for pressure differential systems — Kits* - and consequently it did not meet the guidance within ADB 2013, as set out in Section J5 of this Appendix.

2.23.36 In addition, I have now considered the commissioning documentation which has been provided to the Inquiry. My investigation has shown that the commissioning of the system omitted a large number of the performance requirements of BS EN 12101-6:2005. The commissioning of the system also omitted a substantial proportion of the provisions made within the Smoke Control Association (SCA) Guidance on Smoke Control to Common Escape routes in apartment Buildings (Flats and Maisonettes) Rev 2: October 2015.

2.23.37 Commissioning is required to demonstrate compliance with Building Regulation 7. Without commissioning there can be no evidence that an active

building system can “adequately perform the functions for which they are designed”.

- 2.23.38** Therefore, I currently consider the evidence of commissioning to be substantially non-compliant.
- 2.23.39** *Performance of the system the night of the fire*
- 2.23.40** Regarding its required operational performance, BS EN 12101-6:2005 states “A Class B pressure differential system can be used to minimise the potential for serious contamination of firefighting shafts by smoke during means of escape and fire service operations. During firefighting operations, it will be necessary to open the door between the firefighting lobby and the accommodation to deal with a potentially fully developed fire.”
- 2.23.41** To understand the performance of the system on the night, I want to make clear that this requires consideration of a series of points.
- a) The performance of the system to the standard described in BS EN 12101-6:2005 was not possible as that is not what was designed or commissioned;
 - b) An alternative performance condition has not been clearly set out by the design team and so that performance cannot currently be assessed by me;
 - c) The evidence I do have, shows a substantial number of the performance requirements are omitted from the design features, and therefore I do not currently understand how the system as designed could ever achieve the performance required by BSEN 12101-6: 2005. That performance requirement is to minimise the potential for serious contamination of firefighting shafts by smoke during means of escape and fire service operations;
 - d) I understand that the design team considered the system as designed as being “no worse” than the existing system in Grenfell Tower. I currently have no evidence as to how they established and proved this to be the case.
- 2.23.42** There is an increasing amount of evidence from the residents about the way the system operated on the night. I will need to review this very carefully when their evidence is completed. This includes evidence of noise in the lobbies at Level 23 and noise in the north and south shafts on other floors.
- 2.23.43** The oral evidence of Farhad Neda (Transcript 18th October, p27) about smoke leaking into the lobby of Level 23 via the smoke shaft vents, on the north and south side, is a critical piece of evidence at this stage. This is because it could indicate a significant failure of the smoke control system to prevent contamination of compartments away from the fire compartment (in breach of Section 11.8.2.10 of BS EN 12101-6, as discussed further below).
- 2.23.44** This evidence may also indicate that there was a failure to comply with the compartmentation rules for protected shafts in Section 8 of ADB 2013. The

presence of non-compliant smoke control dampers (which I have explained above) is of concern as it may explain this witness evidence.

2.23.45 *Single floor operation*

2.23.46 The smoke control system was intended to operate on one floor only, as per the requirements in the Statutory Guidance, ADB 2013. The system therefore could not operate on multiple lobbies simultaneously, and so could not prevent smoke entering the stair in circumstances where there was smoke on multiple floors. This is consistent with the Statutory Guidance for smoke control systems which does not require operation of any smoke control system on multiple floors.

2.23.47 In Section 14 of my Expert Report I provided the evidence currently available about the operation of the smoke control system on Level 4 in the early stages of the fire. This is relevant only in the early stages of the fire, when an internal compartment fire was located on Level 4 only, and therefore when the lobby smoke control system should have been operating within its required design parameters.

2.23.48 It is to be expected that the smoke control system would have operated on the fire floor (i.e. floor 4) had it been functioning correctly. In that regard it is now clear that the autodialler had sent a signal to Tunstall by 00:55, and there is no evidence of smoke at that time on any other floor other than Floor 4. This aligns with the evidence of the residents in Flat 16 who observed smoke by their flat entrance door, and opened that door onto the lobby. A smoke detector was present in the lobby outside Flat 16 and near the north builders' work shafts.

2.23.49 Residents on Level 4 observed smoke on the lobby. Additionally, Mohammed Ahmed, a resident of Flat 102 on the 13th floor escaped from the building at 01:21 (MET00016072); as he escaped past Level 4 he reports seeing three firemen at the stair door and thick black smoke coming from the hallway into the stairs.

2.23.50 This does not currently appear to demonstrate *"A Class B pressure differential system can be used to minimise the potential for serious contamination of firefighting shafts by smoke during means of escape and fire service operations. During firefighting operations, it will be necessary to open the door between the firefighting lobby and the accommodation to deal with a potentially fully developed fire."*

2.23.51 I intend to carry on my investigations into the smoke control system and how it performed on the night during the course of my Phase 2 work.

2.23.52 At this stage, I am not in a position to express any opinions on the operation of the system on the night and what impact that had on the spread of fire and smoke. I will complete this work when the resident evidence is completed. I have explained all the work that is in progress on this topic at the end of Appendix J of my expert report.

- 2.23.53** I will then combine all of the evidence regarding the system's operation on the 14th June 2017 in order to investigate:
- a) Whether the system operated to control the flow of smoke from the Level 4 lobby to the single stair prior to the multi-floor internal fire filling multiple lobbies with smoke; and
 - b) Whether the construction of the smoke ventilation system provided a route for smoke spread between lobbies in Grenfell Tower.
- 2.23.54** **Fire fighter control of the lobby smoke control system**
- 2.23.55** I have explained that the smoke control system was provided with an override control for fire fighters. This was by means of a touch screen HMI control panel at Ground Level entrance lobby and key switches in each of the lobbies served by the system.
- 2.23.56** From the HMI panel in the ground floor lobby the status of the system could be checked, the system shut down and/or the floor on which the system was operating could be controlled.
- 2.23.57** There is evidence that fire fighters interacted with the HMI panel as follows:
- a. There is CCTV evidence of fire fighters opening the HMI panel enclosure and interacting with it (INQ00000343) this was first at 01:35.
 - b. There has been oral evidence from fire fighters indicating that WM Dowden (Transcript 26th June, p136) attempted to use the override (yellow) key switch on the Ground floor at 02:01.
 - c. There is oral evidence from fire fighters (Transcript of Egan, 4th July, p2) and photographic evidence (MET00018915) indicating that the override switch was turned from "Auto" to "on".
- 2.23.58** Switching the panel to "On" permits manual control operations to be undertaken, and may lead to the system being shut down, either intentionally or accidentally by operation of the reset and/or shutdown commands.
- 2.23.59** There is no specific evidence that the system was shut down intentionally, at this stage.
- 2.23.59.1** The smoke control system could also be operated using a (yellow) key switch control provided in each lobby. Once the HMI panel was switched from Auto to On, activation of this key switch control in a lobby, would instruct the system to operate on that floor. Therefore, it is possible from these interactions that the floor of operation was changed by the LFB.
- 2.23.60** At this stage, I have seen no evidence which would suggest that any of the lobby key switches were successfully operated during the fire.
- 2.23.61** I note that the BRE inspection for the MPS, identified that the AOVs on Level 11 and Level 18 were open. This could have been instructed intentionally or accidentally by fire fighters operating the touch screen on the HMI panel,

while the key in the panel was switched to “On”. Or by the (yellow) key switch control provided in each lobby, when the key in the HMI panel was switched to “On”.

2.23.62 Conflicting evidence regarding the interfaces with the lobby smoke control panel

2.23.63 The absence of a detection and common alarm system within the protected lobby was compliant with the current statutory guidance and the design guidance available at the time of construction.

2.23.64 A detection system was present in the lobbies, which should have been interfaced with the smoke ventilation system (see Section 19.6 below).

2.23.65 Further evidence has been provided that the smoke panel in Grenfell Tower operated at 00:55 (THL00000003) and triggered autodial equipment which notified Tunstall of the activation. The specific location of the device that caused this activation is not specified in the evidence.

2.23.66 The time of activation was within 1 minute of Mr Kebede’s 999 emergency call, at 00:54 (LFB00004695), in which he states he is outside his flat and therefore is shortly after the outbreak of fire in Flat 16.

2.23.67 In my opinion, it is likely that a Level 4 lobby detector activated the smoke panel, for the following reasons:

- a) At 00:55 as the fire was still contained within Flat 16 (Section 5 and 6) and there is no evidence it had spread to any other flats (Section 12); and
- b) From my site investigation the only route I have found for smoke to spread from a flat kitchen to the lobby is through the flat entrance door.

2.23.68 I have not found any evidence that the fire lifts were intended to be interfaced with the lobby smoke detection system at this time. CS Stokes in the 2016 fire risk assessment (TMO10017691) states that the lift would not be interfaced with the detection system.

2.23.69 However, this evidence conflicts with the findings of the WSP lift inspection report (MET00019973).

2.23.70 It also conflicts with the resident evidence regarding the failure of the lifts at the times before the fire, when the lobby ventilation system appeared to be on. It is important to investigate if this lift failure used to occur during smoke control mode or environmental mode, and how either activity caused lift failure.

2.23.71 I would recommend that a specialist lift expert, instructed by the Inquiry at Phase 2 of its work, should investigate this.

2.24 The remaining non-compliant active and passive fire protection measures

- 2.24.1** In Section 15 and 16 of my report and throughout their associated Appendices, I provide my preliminary opinion on the compliance status of the active and passive fire protection measures installed in Grenfell Tower on the night of the fire.
- 2.24.2** I have not identified them all here in my Conclusions, as I consider those referenced above only, at this stage, to have been relevant to the events in Grenfell Tower.
- 2.24.3** This was an internal fire, for which current statutory design guidance provides fire safety guidance. It then became a major fire, of a scale that falls outside the remit of current statutory design guidance.
- 2.24.4** However, the number of non-compliances signify a culture of non-compliance at Grenfell Tower. I am particularly concerned about the maintenance regime of the active and passive fire protection measures. I note that multiple automatic systems such as the control of the fire lift and the smoke ventilation system, appear not to have operated as required.
- 2.24.5** I will address question of whether there was a culture of non-compliance at Grenfell Tower in my Phase 2 report.
- 2.24.6** I am aware that alternative methods to comply are permitted under Section 0.21 of the Approved Document B 2013. I will investigate what, if any, alternative compliance approaches were proposed by any stakeholder, to deal with the non-compliances (as I have currently defined them).
- 2.24.7** I intend to explain the significance of all the non-compliances I have found, with regard to the concept of Material Alteration, under Regulation 3 of the Building Regulations. Therefore, I will investigate if some, or all of the non-compliances, were such that overall they resulted in the building being less satisfactory than it was before the refurbishment work was carried out in 2012-2016.
- 2.24.8** I will investigate whether the non-compliances as I have found them directly contributed to the spread of fire and smoke in my Phase 2 report. I have provided preliminary opinion here only in my Phase 1 report.

2.25 The consequences of failure

- 2.25.1 Location of the deceased**
- 2.25.2** As a result of the fire, seventy-one people lost their lives. In addition, there were other consequences, including the physical injury experienced by survivors, the trauma experienced by the survivors and bereaved, as well as the loss of one hundred and twenty-nine homes.
- 2.25.3** From my analysis to date, I have been able to conclude the following.

- 2.25.4** No one died from any of the Flats on Levels 10 and below.
- 2.25.5** The fatalities in Grenfell Tower comprise people who were originally located on Levels 11 and 14 – 23 when the fire started on 14th June 2017. On Levels 11, 14 and 17 -23, a proportion of the fatalities from these floors were not recovered within the flat I believe they were in when the fire broke out.
- 2.25.6** On Levels 15 and 16 all fatalities found in the flats on these levels also resided there. No fatalities from any other location were recovered on these floors.
- 2.25.7** There are two distinctions in location of the deceased who were resident on Level 18 and above (a total of 54 persons), compared with Level 17 and below (a total of 16 persons).
- 2.25.8** On Levels 11 – 17, thirteen people were unable or unwilling to leave their flats; they were recovered in the same flat it is believed they were resident in. Three of these residents were recovered outside Grenfell Tower.
- 2.25.9** On Level 18 and above, a total of 47 fatalities were recovered:
- a) 24 persons were found at Level 23, [9 from Level 23];
 - b) 11 persons were found on Level 22, [all from Level 22];
 - c) 6 persons on Level 21, [all from Level 21];
 - d) 2 persons on Level 20, [stayed in own flat];
 - e) 3 persons in the stair on Level 19; and
 - f) 1 person in the stair in Level 18 [from Level 22].
- 2.25.10** The remaining 7 fatalities of residents from Level 18-23 were recovered from floors 13, 9 or outside Grenfell Tower.
- 2.25.11** A high number of people residing on Levels 18 – 22 moved upwards to Level 23 (a total of 15 persons). On Level 23, 13 of those people were recovered within the flats and 2 persons from the lobby [both from Level 19]. This is in addition to the 9 people recovered from Level 23 who were also resident there.
- 2.25.12** I currently consider that the persons who moved from Levels 18 - 21 to Level 23, had departed from flats on the East side of the building: Flats 1 - 2 and 6, or Flat 5 which is on the North West corner of the building. Fire spread to these locations occurred early from 01:29 – 02:22 (Section 12).
- 2.25.13** Therefore, it appears the initial external fire spread from Flat 16 upwards (the Flat 6 on the East elevation on every floor above Level 4) and the subsequent spread on the North and East elevations (Flats 5, Flat 2 and 1), caused people to leave their flats.
- 2.25.14** This also coincides with the time, currently recorded, at which the stair and lobbies became filled with thick hot smoke (Section 14).

- 2.25.15** The resident witness evidence I present in Section 14.5 provides evidence as to why people perceived they were unable to escape down through the stairs between 01:20 to 01:49 and these people therefore moved up to the top floor of the building to Level 23.
- 2.25.16** The engulfing of Level 23 by the external fire occurred between 01:26 when it first reached Flat 6 on the East elevation and 03:43 when it finally reached Flat 3 on the South West corner. As this occurred, fire began to spread from the exterior to the interior of the flats. Therefore, for the persons already residing in the flats in Level 23 (9 persons) and those who I have described moving there (a further 15 persons) these flats progressively failed as a place of relative safety.
- 2.25.17** On Level 23 no persons were recovered from Flat 6 on the North East corner of the building. The fire first spread to Level 23 at this point around 01:26 (Section 12). The persons within this flat moved to Flat 3, which was diagonally opposite Flat 6 across the central Lobby.
- 2.25.18** Seven persons were recovered from Flat 1 at Level 23, including 6 persons from lower floors. Flat 1 is located on the East façade of the building. Fire had spread to the external wall of Flat 1 on Level 23 by 01:52.
- 2.25.19** Four persons were recovered from Flat 2 including two persons from lower levels. Four persons were recovered from Flat 5, all of whom were from lower levels of the building. Flat 5 is located on the North West corner of the building. The external fire had spread to Flat 2 and Flat 5 on Level 23 by 02:10.
- 2.25.20** Six persons were recovered from Flat 3 which is located on the South and West corner of the building. One person, the flat resident, was recovered from Flat 4, located on the West elevation of the building. This corner was the last to which the external fire spread; this occurred between 03:20 and 03:42.
- 2.25.21** Seven people attempting to escape down from Levels 18 – 22 were recovered as fatalities within the stair and lobbies. Two further residents of Level 19 were recovered as fatalities in the Lobby of Level 23 and therefore appear to have moved up.
- 2.25.22** Whereas from Levels 11 -17, one person from Level 17 was recovered as a fatality after attempting to escape from their flat out of the thirteen fatalities recovered on these floors. They were recovered in the lobby of Level 17.
- 2.25.23** On every level of Grenfell Tower people escaped away from Flat 6, which was directly above the Flat 16 on Level 4, the location of the initial fire event. The majority of the residents in Flat 6 on every floor evacuated the building before 01:32. Two people evacuated at 03:52, however, I believe they most likely moved to another part of the building before finally evacuating at this late time. There were a total of 11 fatalities of people residing in Flat 6. Eight of those fatalities were recovered at Level 23, including 6 from Levels 19, 20 and 22.

- 2.25.24** In addition to the vertical movement of people, people on Levels 14, 22 and 23 moved from their flat to another flat on the same floor. This was either by their own decision (Level 22 and Level 23) or because they were moved by LFB (Level 14). In all cases people moved from the North and East side of Grenfell Tower (Flat 6, 5 or 1) to Flat 3, which was diagonally opposite, on the South and West elevations. The position of Flat 3 also meant it was the last flat on every level the external fire spread to (as I have shown in Section 12).
- 2.25.25** **Impact of the fire and smoke conditions on the residents**
- 2.25.26** The poor visibility present in the lobbies and stair reduced the speed at which people could travel, therefore increasing the time required to make an escape and increasing the duration of exposure to the products of fire (smoke and heat). This is in addition to the way-finding difficulties presented by reductions in visibility. These factors on their own, or in combination, appear to have discouraged residents from evacuating independently.
- 2.25.27** The effect of heat - where temperatures exceeded 150°C - can be tolerated for only very short periods of time. They would cause immediate pain to any exposed skin.
- 2.25.28** Also the impact of toxicity from the smoke which filled the lobbies and stair, was a significant issue during the fire. Smoke contains a number of toxic asphyxiate gases in potentially lethal concentrations and smoke also contains sensory irritants. The asphyxiate gases could cause a slowing of escape by reduced awareness or could cause incapacitation or death. The sensory irritants, which cause symptoms to humans on exposure, could slow evacuation by impairing vision, causing a burning pain or reducing breathing rates, as well as pulmonary oedema (a build-up of fluid in the lungs).
- 2.25.29** The combination of poor visibility and sensory irritants when residents opened their flat entrance doors to try to enter lobbies, would have been a significant deterrent to escape. This is particularly the case when the guidance being issued to the 999 callers was to Stay Put - the lobby conditions would have emphasised to some that this was indeed the safer option.
- 2.25.30** Once the Stay Put guidance changed, the conditions at the time, with poor visibility and sensory irritants, was a substantial deterrent for the remaining residents, especially when no form of assistance was available to guide them through the lobbies, or to guide them down through the stairs.
- 2.25.31** I want to acknowledge as a consequence, the horrific experiences of the deceased, survivors and the bereaved, as the evidence graphically illustrates.
- 2.25.32** **Impact of the fire and smoke conditions on the fire fighters**
- 2.25.33** For the internal fire-fighting operations, the firefighting stair and lifts are required to provide a safe air environment in order to reach the Bridgehead, which is typically located in the lobby two floors below the fire floor.

- 2.25.34** The lobbies below the fire floor should provide a safe air environment to act as the Bridgehead.
- 2.25.35** The stair above the Bridgehead, is only to be accessed by crew in breathing apparatus.
- 2.25.36** Once the Bridgehead has been secured, firefighting and rescue activities can commence. These tactics have the following stated benefits in fighting fires in high rise buildings:
- (a) Minimises use of breathing apparatus air supply to access the fire sector; and
 - (b) Reduces difficulty in manoeuvring charged hoses around corners in stairs by minimising the number of stair flights being traversed.
- 2.25.37** Therefore, for firefighting, the fact that smoke and heat was able to enter the lobbies, as far down as Level 4, and for some hours forced the LFB to set up the Bridgehead at Ground Level, is relevant to the failure of the stairs and lobbies, as a safe air working environment for a Bridgehead.
- 2.25.38** This location also extended the time required for the fire service to reach the upper levels of Grenfell Tower throughout the fire with breathing apparatus, thus reducing the time available for fire-fighting and search and rescue, on all levels.
- 2.25.39** Fire and Rescue Authorities must also have effective arrangements in place to handle fire survival guidance calls from residents and others when they believe they are unable to leave the building due to disability, poor mobility, illness or the effects of fire and smoke. The Bridgehead location and lobby sector location forms an important role for this activity, as it is in these locations that all such advice and resulting actions are co-ordinated.
- 2.25.40** The scale of fire survival guidance calls at Grenfell Tower (recorded at a total of 154) rendered this process exceptionally complex.
- 2.25.41** I consider the multiple internal fires, and the extensive smoke spread throughout the Tower, to have caused a total failure of Defend in Place firefighting; one of the core fire protection measures to support the Stay Put strategy. It was not possible for LFB to suppress all the products of combustion from the external rainscreen system fire.
- 2.25.42** Above the location of the Bridgehead, how smoke and heat was able to enter the lobbies on multiple floors as well as the stair, is also relevant to the failure to provide a safe place of work for the fire and rescue service to undertake search and rescue operations on those upper levels. It also severely limits the potential to undertake firefighting on those levels.
- 2.25.43** The reduction in visibility caused by smoke would have limited the ability of LFB to find the fire main within the lobbies, as well as limit the ability to access flats easily. As LFB became so reliant on breathing apparatus (again

due to the presence of smoke so extensively throughout the single protected stair), any additional time lost on tasks was time lost for rescue.

- 2.25.44** The reduction in visibility would also have slowed the speed at which the LFB could ascend the stair. From the fire service witness statements reviewed (see Section 14) poor visibility also appears to have caused confusion and specific issues regarding orientation within the Grenfell Tower. This would have affected the ability to conduct time effective search and rescue operations, as well as impacting on LFB's ability to communicate rescue needs and conditions accurately to the Bridgehead.
- 2.25.45** The heat experienced within the stair and some of the lobbies, prevented the LFB from reaching the fire main to undertake firefighting. It would also have added to the physical stress experienced by having to ascend up to 18 storeys above the Bridgehead in breathing apparatus.
- 2.25.46** Although the toxicity of smoke should not have affected the fire fighters directly, due to their breathing apparatus, it would have limited their time available for rescue due to their high reliance on breathing apparatus, which has a fixed quantity of available air.
- 2.25.47** This therefore impacted their available time for rescue in another way - with respect to their safe exit time from the building when assisting or carrying rescued residents. The toxic smoke increased the need for the LFB personnel to physically support and even carry down residents given the toxic smoke which impaired residents' movement in the stairs.
- 2.25.48** **Risk category - intolerable**
- 2.25.49** The ultimate consequence was a disproportionately high loss of life. This was a small kitchen fire escalating to an almost all-building fire, compromising the fundamental basis of the Stay Put strategy.
- 2.25.50** The building envelope created an intolerable risk on the night of the fire, resulting in extreme harm ¹. It did not adequately resist the spread of fire over the walls having regard to the height, and use of the building. The active and passive fire protection measures within the Tower were then required to mitigate an extraordinary event, and as a result, the consequences were catastrophic.

¹ PAS 79:2012 Fire risk assessment – Guidance and a recommended methodology

Next Steps

2.26 Phase 2 report

2.26.1 This report contains my preliminary conclusions on the matters raised in my Phase 1 instructions (see Section 1). In Phase 2, I am instructed to provide a report on:

- (a) The design and construction of Grenfell Tower and the decisions relating to its modification, refurbishment and management (so far as is relevant to the events on the night of 14 June 2017);
- (b) Whether such regulations, legislation, guidance and industry practice were complied with in the case of Grenfell Tower and the fire safety measures adopted in relation to fire; and
- (c) Final conclusions on the active and passive fire protection measures within Grenfell Tower on 14th June 2017 and the extent to which they: (i) failed to control the spread of fire and smoke and (ii) contributed to the speed at which the fire spread.
- (d) Recommendations about what, if any changes could be made to the regulatory regime and industry practice to prevent a similar incident from happening in the future.

2.26.2 Prior to preparing my Phase 2 Report, I would like to highlight a number of particularly concerning matters which arise as a result of my Phase 1 work.

2.27 Persons requiring assistance during evacuation.

2.27.1 There is increasing evidence from the residents regarding mobility issues in various forms, and the impact this played in reducing the ability to self-evacuate during the Grenfell fire. Rescue cannot be guaranteed, particularly in the current regime where it remains entirely unclear if the fire and rescue authority are even made aware of any special needs of occupants in existing residential buildings.

2.27.2 Section 2 *Means of escape from flats* in ADB 2013 makes no provision for occupants that require assistance to escape.

2.27.3 However, the functional requirement for means of escape is clear. It requires:

“...appropriate means of escape in case of fire from the building to a place of safety outside the building...”.

In addition, Section Bi.v states:

“Note: Some people, for example those who use wheelchairs, may not be able to use stairways without assistance. For them evacuation involving the use of refuges on escape routes and either assistance down (or up) stairways or the use of suitable lifts will be necessary.”

2.27.4 There is evidence of the lack of assistance for such persons in Grenfell Tower.

2.27.5 In the next stage of my work, I intend to explore the provisions made by the relevant parties at Grenfell Tower, for occupants that required assistance to escape at Grenfell Tower.

2.27.6 I also intend to explore how this information was communicated to relevant residents and the fire service before the night of the fire.

2.27.7 It is also important that the Inquiry investigates how many residents in Grenfell Tower required assistance to evacuate, whether they were known to LFB and the steps taken to rescue them.

2.27.8 In my opinion, the lack of guidance for buildings containing flats in ADB 2013 should attract immediate attention.

2.27.9 I note that in the LGA Guide, Section 79.9 which deals with preparing for emergencies, it advises:

“In ‘general needs’ blocks of flats, it can equally be expected that a resident’s physical and mental ability will vary. It is usually unrealistic to expect landlords and other responsible persons to plan for this or to have in place special arrangements, such as ‘personal emergency evacuation plans’. Such plans rely on the presence of staff or others available to assist the person to escape in a fire.”

2.27.10 Further it provides in 79.10 to 79.11:

“Even in sheltered housing schemes, there will be reliance ultimately on rescue by the fire and rescue service in the event that residents cannot escape by themselves. However, in sheltered housing schemes, it is commonplace to hold information relating to any resident with particular mobility or other issues affecting their ability to escape. This can be made available to the fire and rescue service on arrival at the premises (e.g. by keeping it in a ‘premises information box’, which can only be unlocked by the fire and rescue service, at the main entrance).

It is not realistic to expect such an approach to be adopted where there are disabled people and others requiring assistance in a ‘general needs’ block. Any attempts to keep information of this kind must be updated regularly as inaccurate information could potentially be more harmful than no information.”

2.27.11 I consider that the lack of provision for persons requiring assistance in a high rise residential building is unacceptable, and results in a substantial breach of the functional requirement for means of escape under the Building Regulations. In my view, the LGA guidance should be updated to adequately deal with persons requiring assistance from “general needs” blocks.

- 2.27.12** It is also my opinion that a failure to provide adequate means of escape for persons requiring assistance also causes a breach under the RR(FS)O 2005, which I will address in my Phase 2 report.

2.28 Mitigating the life safety risk posed by rainscreen cladding systems formed with polymeric materials

- 2.28.1** In my opinion, it is not acceptable to expect the fire and rescue services to mitigate the risk posed by combustible external wall construction in high rise residential buildings, as there are so many reasons why that is not feasible - as I have explained throughout my report, but particularly in Section 17.
- 2.28.2** Therefore, where there are other buildings of similar construction to Grenfell Tower, I would urge relevant parties to communicate with one another now and consider whether Stay Put, coupled with a defend in place internal fire fighting strategy, remains viable.
- 2.28.3** Such an exercise should incorporate specific consideration of (a) evacuation of those who require assistance to evacuate (see Section 18); (b) communication methods with residents of high rise buildings in the event of fire (See Section 18); and (c) availability of facilities for fighting external multi storey fires in these buildings (see Section 17), especially firefighting strategies for when internal compartmentation is overcome by an external fire. There should be a bespoke set of provisions and access needs for external firefighting in those circumstances.
- 2.28.4** There is also, in my view, an urgent need to consider how to communicate with residents in a high rise residential building, in the event of fire. This includes robust and resilient processes for confirming location, rescue needs, self-evacuation abilities, localised and overall fire conditions, and providing tailored advice regarding conditions in the stairs and lobbies. (See Section 14 of my report).
- 2.28.5** For residential buildings with a Stay Put strategy, I remain concerned that some materials of limited combustibility (Class A2) may not be adequate for the external surface of a rainscreen cladding system, in a high rise residential building.
- 2.28.6** In my opinion, full scale testing of rainscreen cladding systems ought to be carried out, but must now include window openings and other relevant fixtures and fittings, rather than the current arrangements in BS8414 Parts 1 and 2. Until these matters are resolved I recommend an immediate moratorium on the use of any new test data based on BS8414, whilst a robust test method is urgently established.
- 2.28.7** A more robust testing framework, reflecting real building design and construction detailing, would also assist in establishing whether materials of “limited combustibility” (Class A2) are suitable. This would also allow a more credible view on the fire performance of individual materials when used in typical construction forms, in general.

- 2.28.8** Until this change in the BS8414 testing methods are implemented, I recommend the higher performance requirement of Class A1 for external surfaces. Please refer to Section 2.31 below for further information.
- 2.28.9** The absence of a body of relevant fire test evidence for rainscreen cladding systems, and the components of rainscreen cladding systems, including insulation and cavity barriers, based on the current submissions to the Public Inquiry, shows a serious failing in the current testing and classification regime. A body of publicly available and relevant fire test evidence is urgently required to support common construction forms.
- 2.28.10** My review of the BBA certificate for Reynobond Architectural Wall Panels, and the relevant fire test data upon which it relies, has shown what I consider to be a startling series of omissions in the communication of tested fire performances over the 9 years this certificate was in circulation; as well as the considerable limits of applicability of the reported data. These tested fire performances are highly pertinent to designers when selecting materials and assemblies for use in buildings.
- 2.28.11** I recommend that certificates should no longer be published without all test data – pass or fail – relevant to it.
- 2.28.12** Further, I recommend that the first page and title of the 2017 2nd issue amended BBA certificate 08/4510, which is the currently available version for Reynobond architecture wall panels, be immediately changed to state that the certificate is only valid for Reynobond 55 FR panels with a fire retardant core, in a riveted form, and when installed within the field of application stated in the BS EN 13501-1 classification report RA06-0372 (BBA00000054).
- 2.28.13** The evidence provided to the Inquiry by Celotex also raises concerns about the variability in reaction to fire test results for the different compositions of insulation material – for example Line 1 and Line 2 material composition which are sold under the same product name (RS5000 or FR5000). As does the evidence submitted by Arconic regarding the varying fire performance of different core colours (black or translucent) where both types are sold under the same name Reynobond Architectural Wall Panels. These variations are typically not communicated in relevant fire certificates for products, yet appear to be capable of substantially altering material performance in fire. Again I recommend that product certificates or supporting fire test reports or classification reports, should no longer be published without all relevant material composition data to support the certificated fire performance.
- 2.28.14** Finally, I find it another serious concern that the BS 8414-2 test report and associated BR135 classification report, for RS5000 insulated system with a ventilated Eternit rainscreen failed to accurately describe the specific construction and materials installed in the test sample. Such omissions make it impossible for a designer or contractor to provide a design or construction which is compliant with relevant test evidence, whilst using those products.

- 2.28.15** I therefore recommend that assembly construction for the purpose of testing, becomes the responsibility of the test house to inspect and verify, not the current status quo where this assurance is not provided. It should be the responsibility of the test house to reject assemblies that cannot be produced in real construction projects. Alternatively, an independent 3rd party, should be employed to provide this level of transparency and assurance. This information must be provided with any certificate which references this assembly or the individual products used in the assembly.

2.29 Fire Doors

- 2.29.1** On the 15th March 2018, the Government issued a press release on the topic of non-compliant fire doors, it states:

“Independent experts have advised that the risks to public safety remain low, and that evidence from investigations to date does not change this assessment”.

It further advises:

“The risk to public safety remains low and there is currently nothing to suggest this is a widespread issue”.

- 2.29.2** I note the current Masterdor Suredor website states that its doors are:

“Specially designed for social housing specification projects, Masterdor Suredor is a thermally efficient high performance GRP door range that replicates the styling of traditional timber doors providing a cost effective tried and tested solution for your project.”

- 2.29.3** BS9991 2015 advises:

“Fire doors: Doors in fire-separating elements are one of the most important features of a fire protection strategy, and it is important to select a fire door that is suitable for its intended purpose. They should normally be self-closing ...”

- 2.29.4** Fire doors which contain glazing pose a serious failure risk unless expressly constructed and tested to prove their viability. Fire doors containing multiple additional fixtures and fittings, unless expressly constructed and fire tested to prove their viability, also pose a serious risk of failure.

- 2.29.5** It is particularly the case that in single stair high-rise residential buildings such failures cannot be tolerated, due to the Stay Put strategy.

- 2.29.6** In my professional opinion, fire doors that do not provide the necessary fire and smoke leakage performance do pose a risk to life, and should be replaced in existing buildings.

- 2.29.7** Based on my review of historic fire doors, which I present in Appendix M (in the context of the stair doors at Grenfell Tower), I also recommend a change in the advice provided by the LGA Guide Fire Safety in Purpose Built Blocks

of Flats, regarding the upgrading of existing fire doors (on stairs or flat entrances). There is a substantial body of evidence regarding the lower performance of fire doors from the 60s and 70s, which even when provided with intumescent strips and smoke seals along the edges, and fitting a protected letter box ('upgraded FD30S' door), cannot provide even 20 minutes fire resistance. Nor is it safe to conclude that such doors "satisfied the standard applicable to fire-resisting doors at the time of construction of the building or manufacture of the door ('notional FD30' door)". These are the two approaches set out in the LGA guidance in lieu of replacing a fire door with a new fire door, and I disagree with both.

2.30 Industry awareness of fire performance – relevant test evidence

- 2.30.1** I have found no evidence so far that there was any understanding by any member of the design team or construction team, nor by the approving authority, that the rainscreen cladding system was either combustible or in breach of the Building Regulations.
- 2.30.2** I have provided my definition of relevant test evidence in Section 3 of my report.
- 2.30.3** I have reviewed all of the fire test evidence provided to the Public Inquiry at this stage, and in general found it not to be relevant test evidence for Grenfell Tower. None of it demonstrates that the relevant material or product at Grenfell Tower is in accordance with a specification or design which has been shown by test to be capable of meeting the required performance. This remains the case having reviewed even more information provided to me since April 2017.
- 2.30.4** This is particularly with respect to the rainscreen cladding system, various insulation products, and for the cavity barriers, as installed at Grenfell Tower but also regarding the fire doors. Please refer to Appendix E.
- 2.30.5** I consider the absence of relevant test evidence to be non-compliant with the provisions made in Appendix A of the ADB 2013 for reaction to fire tests.
- 2.30.6** Regarding the tests referenced specifically in Section 12.5 of the ADB 2013 by means of BRE Report *Fire performance of external thermal insulation for walls of multi storey buildings (BR 135) for cladding systems using full scale test data* from BS 8414-1:2002 or BS 8414-2:2005, it states:
- "The classification applies only to the system as tested and detailed in the classification report. The classification report can only cover the details of the system as tested."*
- 2.30.7** Additionally, as per Appendix B of ADB 2013, any test evidence used to substantiate the fire resistance rating of a door should, as stated in Appendix B of ADB 2013, *"be carefully checked to ensure that it adequately*

demonstrates compliance and is applicable to the adequately complete installed assembly”.

- 2.30.8** Further ADB 2013 states “*Small differences in detail (such as glazing apertures, intumescent strips, door frames and ironmongery etc) may significantly affect the rating.*”
- 2.30.9** I have found no relevant test evidence has been provided at this stage, for the rainscreen system, nor its component parts.
- 2.30.10** I have found that the flat entrance fire doors which were installed, were not in compliant with the relevant test evidence provided.
- 2.30.11** I have found no evidence that this was understood by relevant professionals, prior to handover of the fire safety system, nor was it understood by the fire safety management regime.
- 2.30.12** In my view it is essential that there is renewed and proper understanding of relevant test evidence, and how it relates to performance, as already emphasised in ADB 2013.
- 2.30.13** This is a critical change which is needed throughout the design and construction industry.
- 2.30.14** As to the new dampers installed as part of the smoke control system, the literature submitted to the Inquiry (PSB00000201) states that this product was “*fully tested to the requirements of EN1366 pt 2 for 1 hour.*” This literature is dated October 2011. However, no formal classification is provided in accordance with BS EN 13501-3 based on testing against BS EN 1366-2.
- 2.30.15** This “1 hour” performance statement appears to have been rescinded by the manufacturer in April 2017. It is possible that this was because the relevant fire test report dated October 2011, did not in fact demonstrate that a test to the full requirements of the test standard had been carried out (please refer to Appendix J of my report).
- 2.30.16** This only serves to emphasise even more the urgent regime change needed regarding the process of carrying out fire tests, including the need to (a) communicate their results with transparency; and (b) communicate how those results apply with transparency. In my opinion, there is an urgent need for a more formal intervention to change the current status quo.

2.31 The issue of “*Filler material*” and its application to products used as External Surfaces

- 2.31.1** The external surface, the insulation and the cavity barriers, are addressed in turn in Section 12 of ADB 2013 (12.6, 12.7, and 12.8), and together form the External Wall construction. I have always considered those three elements in turn, as the external wall construction in my professional experience also.

- 2.31.2** The introduction of ACP rainscreen cladding panels into the construction industry market, created the industry wide use of *composite external surfaces*. This required and still requires attention.
- 2.31.3** The suite of National and European reaction to fire tests is complex and confusing, as I have illustrated in my Appendix F. No guidance is provided on which regime takes precedence when differing classifications are obtained for the same material or product. This has become a critical problem.
- 2.31.4** The test standards BS 467-6 and BS 476-7 would not expose the core of composite materials directly to heat. Its exposure is indirect by heat transfer through the outer aluminium layer.
- 2.31.5** The national Test Standards BS 476 – 4 and BS 476 – 11, both expose the core of composite material directly to heat, as the full depth of the composite material is placed inside a furnace and heated from all sides.
- 2.31.6** The European test standards BS EN ISO 1182, BS EN 1716, and BS EN ISO 11925-2 all expose the core directly to heat. In BS EN ISO 1182 the full depth of the composite material is placed inside a furnace and heated from all sides. In BS EN 1716 the core is ground to a powder then ignited. In BS EN ISO 11925-2 a gas flame is impinged directly onto the exposed edge of the sample if the edge is exposed in end use (as occurs in ACM panels).
- 2.31.7** The European test standard BS EN 13823 does not directly expose the core of ACM panels to heat. However, it cannot be used in isolation to demonstrate Class A2, B or C and must always be used in conjunction with a European test that exposes the core directly.
- 2.31.8** This difference is critical in products where the combustible core of the product is exposed in practice, and also by very means of its thickness within a composite, particularly in ACM material used in panel forms, which are approximately 3-4mm in thickness. It is very difficult to demonstrate that the core in such a slender composite would not be exposed to heat in practice – either via an exposed edge or via conduction through the aluminium sheet.
- 2.31.9** Therefore, as I have explained in Appendix F, there are two aspects of ADB 2013 that, in my opinion, require urgent review and change.
- 2.31.10** The first is that the absence of definitions of “external surface” and “filler” as they apply to the rainscreen cladding outer layer when formed using ACP with a combustible core.
- 2.31.11** And the second point relates to Diagram 40 in Approved Document B which contains contradictory requirements. A material can fail to meet all applicable European performance requirements (Class B; Class A2; or Class A1) as is allowed by means of Diagram 40 and Section 13a of the ADB, but nonetheless can be compliant with the National Class 0 (when classified by means of a Class 1 material which has a fire propagation index (I) of not more than 12 and sub-index (i1) less than 6), defined by testing to British standards (Clause 13b of Appendix B of ADB 2013).

- 2.31.12** I consider that urgent changes to Section 12 of ADB 2013 are required and specifically with reference to Diagram 40.
- 2.31.13** First, I suggest that all parts of the surface for high rise residential buildings should be European performance classification A1. The rules currently split a high rise building into two parts, above and below 18m, and allows two different performances on each.
- 2.31.14** Therefore, my second recommendation is that this 18m based split should be removed from the statutory guidance.
- 2.31.15** Thirdly, consideration should be given to expanding this new performance requirement of Class A1, to include all hospitals where there are exceptionally complex evacuation needs, and for any other assembly building with either Stay Put evacuation requirements, or complex phased evacuation requirements, regardless of height.
- 2.31.16** Regarding my selection of Class A1, please note an A1 classification is the only reaction to fire classification that requires a material to have been tested to BS EN ISO 1182 “*reaction to fire tests – non-combustibility test*” (with no alternative test method allowed). In that test, one part of achieving the classification A1 is that sustained flaming must not be observed (categorised in the test standard as flaming for 0 seconds).
- 2.31.17** Sustained flaming is defined in Section 3.8 of BS EN ISO 1182 as the “*persistence of flame at any part of the visible part of the specimen lasting 5 seconds or longer*”.
- 2.31.18** Every layer of a composite panel must be tested separately in this test standard.
- 2.31.19** In the event evidence becomes available (See Section 2.28.7 above) that an A2 standard external surface can adequately resist the spread of fire and smoke, in representative external wall systems, then this lower standard should be considered within the statutory guidance documents.
- 2.31.20** A material is not required to be tested to BS EN ISO 1182 in order to obtain an A2 classification. Even if a material is classified to A2 relying on this test standard, sustained flaming is allowed during the test for up to 20 seconds. Test samples in this particular test are approx. diameter 45mm and height 50mm. Hence flaming for 20 seconds is relatively substantial. It is for this reason I am recommending Class A1 at this time.
- 2.31.21** Additionally, I recommend that the performance of National Class 0, when relying on the British Standard Tests BS 476 Part 6 and Part 7, should be removed entirely from Section 12. The testing regime which supports this classification does not require that each layer of a composite system is directly exposed to heat, only one surface.
- 2.31.22** For the European testing regime, every layer of a composite system is directly exposed to heat, and so removes any room for doubt on this subject.

- 2.31.23** It should also be made the case that it is no longer possible to equate National and European class performance – they are not derived the same way and are not comparable.
- 2.31.24** Therefore, it is my view that the currently recommended Class B performance should be removed from Section 12 for high rise residential buildings and all buildings with complex evacuation requirements – as a degree of surface flaming can occur in a material classified by test as Class B. Similarly, the allowance of Class C and Index I < 20 materials in high rise residential building, for the external surface less than 18m above Ground Level, should also be removed.
- 2.31.25** I have been unable to find any conclusive evidence that the context of “*filler material (not including gaskets, sealants and similar) etc.*” as written in Insulation Materials/Products Section 12.7, was intended to incorporate the core of an External Surface, and specifically an ACM.
- 2.31.26** I consider the evidence tends more towards the definition of filler material as it relates to Buildings, where filler is clearly defined as a joint or a surface filler (BS EN ISO 6707).
- 2.31.27** I note the use of the word “core” throughout BR 135, which does not mention the words Filler material at all. And I note throughout Appendix F in Approved Document B 2013, as it relates to another form of composite panel, it too uses the word core, and not filler material.
- 2.31.28** I am aware that there is a range of opinion, since the Grenfell Tower fire, on this issue and that some others consider that the core in an ACP is now *filler material* and therefore is dealt with by the provisions made for Insulation under Section 12.7 of the ADB 2013. I have been unable to find the technical basis for this body of opinion.
- 2.31.29** For the reasons I have set out in detail in Appendix F, I disagree with this view.
- 2.31.30** However, there is a more fundamental issue here regarding the fire performance of the core in composite external surfaces, such as those found in rainscreen cladding systems formed with ACP.
- 2.31.31** I have concluded in Appendix D of my report, that the legal requirement is to demonstrate compliance with the functional requirement of the Building Regulations 2010.
- 2.31.32** It is my opinion, having carried out this detailed review of the suite of test standards in Section F of my report, that in order to comply with the Building Regulations, I must consider the whole of the product which forms the external surface of the rain screen panel system – i.e. the two layers of aluminium and the core (typically approx. 4mm thick in total). Otherwise the performance of the core is entirely omitted when considering the construction of the external walls.

2.31.33 For the avoidance of doubt, I do not consider it possible to comply with the functional requirements of the Building Regulations B4 (1) if the relevant test evidence omits the core in an ACP, or the relevant test evidence is based on a test that does not expose the edges of the ACP to direct heat.

2.31.34 That is why I consider the urgent changes I have recommended above, to Section 12 of ADB 2013 is needed.

2.31.35 My opinion on *filler material*, has had no material impact on my compliance assessment of Grenfell Tower, because no relevant fire test evidence was provided to support the use of the products on Grenfell Tower.

2.31.36 It also appears that no such test evidence existed in the first place (please refer to my Appendix E).

2.32 Polymeric materials and toxicity

2.32.1 In all my analyses presented here, the presence of smoke delayed or prevented residents from entering the lobby outside their flat, and then from entering the single escape stair.

2.32.2 I observed the composite fire doors used at Grenfell Tower produce large quantities of smoke and other products of combustion themselves, when heated, during a recent test at the BRE on 17th March 2018.

2.32.3 These materials, along with the polymeric materials used throughout the rainscreen cladding system, the infill panels between the windows, and the insulation used around the window surrounds, require expert review. This is with regard to the process of and products of combustion of such materials, which pose a direct threat to life. These can include thermal radiation, temperature of smoke, soot (the impairment of movement), acute toxicants, irritants and asphyxiants (incapacitation), toxic gases; chronic toxicants and carcinogens (with the potential to increase the likelihood of developing cancer).

2.32.4 I therefore recommend that the Inquiry's toxicology expert, Professor Purser, considers these issues.

2.33 The gas installation at Grenfell Tower

2.33.1 A key area for further investigation is the gas installations at Grenfell Tower, both in terms of whether it complied with the relevant regulatory regime and whether it could be isolated within a reasonable time on the night of the fire. I have prepared a briefing note for the newly appointed Gas Services Expert in Appendix K of this report. In particular, it will be important for the Inquiry to investigate the role, if any, that the gas services played on the night.

2.34 Suppression systems in existing high-rise residential buildings

- 2.34.1** I am aware of a body of professional opinion that considers that a suppression system may have prevented the fire events at Grenfell Tower.
- 2.34.2** Suppression systems can be a substantial mitigation measure in many internal fire events.
- 2.34.3** Regarding the specific complex fire scenario here – i.e. an external wall fire, caused by an internal fire event breaking through the construction detailing in and around a window opening – I am of the opinion there is a useful body of research work needed here to resolve this matter.
- 2.34.4** There is the need for very specific detailing of an effective suppression system in this event, and I am not aware such a system exists in the market at this time.
- 2.34.5** In particular, a number of matters would require detailed technical investigation including: the system arrangements on and near the window, the obstructions that could prevent effective fire control, the necessary water flow and the timing of the operation of such a system in order to suppress and control a fire before ignition of the various combustible cladding materials of the type found at Grenfell. All these matters require a detailed technical understanding and require new data, to create a basis for design that can be relied upon.
- 2.34.6** I am not aware of any body of work with this focus as yet, and do recommend that it is carried out.