IN THE MATTER OF THE GRENFELL TOWER INQUIRY

BEFORE SIR MARTIN MOORE-BICK, MS THOURIA ISTEPHAN AND MR ALI AKBOR OBE

MODULE 3: BSR TEAM 2 WRITTEN OPENING SUBMISSIONS *on the* SMOKE VENTILATION SYSTEM

Introduction

1. This system has a long history dating from its initial construction of neglect and non-compliance. The original smoke ventilation system was a bespoke system,[1] not compliant with the strictures of CP3 1971.[2] The refurbishment too was also a bespoke system, an upgrade of the original system and did not meet the guidance the within ADB 2013,[3] various British Standards and either of the relevant Smoke Association Guidelines.

2. Works to the smoke ventilation system (SVS) were intended to bring it to a higher standard than was installed and to widen its service to the new areas on Tower's lower floors. The original intention was to refurbish and update the controls to provide a fully mechanical system, rather than natural ventilation with a mechanical override switch for firefighting but retaining the 'push-pull' strategy. The ventilation was to be increased through higher capacity fans. However, when PSB were instructed, they determined this was not possible, the initial plan was to update the system to as close to current regulations as possible *within* the limitations of the existing infrastructure. Regrettably, PSB did not consider structural work that would have enabled the enlarging of the SVS ductwork. As they were instructed so late it would not realistically have been possible to have considered such a significant redesign option. Had there been better construction management of the project it would have been realised that, to bring the SVS into compliance, capital works to enlarge the shafts should have been considered at a very early stage in design, not after renovation works had commenced. This fundamental design management requirement was not foreseen and PSB by virtue of their late instruction were presented with a *fait accompli*, at which point the SVS renovation was reduced to the lowest common denominator Building Regulations requirement of not

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[1] {BLAR00000025/4}, J1.1.6.
[2] {BLAR00000025/4}, J1.1.5.
[3] {BLAR00000025/4}, J1.1.6.

making the building any worse.[4] In practice it seems that whilst renovation works progressed the SVS design was overlooked, notwithstanding that it was non operational.

3. As early as December 2013 Hanson in a memo to John Allen of the Royal Borough of Kensington and Chelsea Building Control (RBKCBC) rejected the enlarging of the shafts at an early stage stating, "*it was not proposed to redesign the system to a modern standard of performance as this is likely to require larger riser shafts, the incorporation of which falls outside the intended scope of the works.*"[5] Remarkably, and without any justification Allen responded to the memo stating:

   "RBKC building control would be satisfied under the building regulations if either: -

   a. the level of extract provided by the existing powered ventilation system is maintained at the new residential levels at 'Walkway +1 level and 'the single flat at 'Walkway level'. (On the basis of no adverse affect).

   Or

   b. the ventilation extract is justified."

   RBKCBC therefore at an early stage considered and disregarded compliance at an early stage.

4. It appears Max Fordham (MF) in their RIBA stage C/D work were not asked to produce cost benefit options for this work and so it was never considered. This was a case of the Kensington and Chelsea Tenant Management Organisation (KCTMO) directing the engineering and construction professionals not being advised by them. This precise issue ought to have been considered at a preliminary design stage. The KCTMO had not understood that MF were instructed to RIBA stage D. They were not instructed to produce detailed SVS design work. The lack of understanding of the distinction between the two resulted in the SVS not being progressed when it ought to have been. That lack of progress inevitably contributed to a non-compliant system. This laconic supercilious attitude typified the TMO's approach to design and construction management decisions outside of their own expertise.

5. During the refurbishment works in 2012 - 2016, the existing pairs of smoke shafts serving the north and south sides of each lobby on Levels 4 to 23 were retained and extended for use by the refurbished smoke/environmental ventilation system. It is important to note

[4] {MAX00017304/12}.

[5] {RBK00003014/1}.

that the same mechanical infrastructure served both smoke ventilation and environmental purposes. A point which Mr. Stokes appears not to have been aware of.

2010 Grenfell Fire

6. In April 2010 there was a fire in flat 64 the smoke from which made its way up to lift lobby of the 15th floor (later 18th) effecting Flat 156, resulting in Mrs. Sayeda Ahmed inhaling smoke. DWF, solicitors for RBKC, wrote to Mrs. Ahmed's solicitors stating:

"Having obtained our client's further instructions they are prepared to concede that on the date of the fire for which we are concerned the fire detection system which was in place at Grenfell Tower was defective and they are accordingly prepared to accept responsibility for your client's claim. In the circumstances our client is prepared to concede liability to your client with a view to saving costs subject to causation being proved."[6]

7. A few days later, Janice Wray, Health & Safety Advisor at the KCTMO, admitted to the LFB as follows:

"3. ...I am advised that the incomplete sealing of a number of the vents had been identified on the most recent inspection visit. The contractors had been asked to submit a quotation for the necessary remedial works to address this problem and this was received on 20th April. I can confirm that a works order was raised the same day for the works to be progressed. Unfortunately, the contractors had some difficulty which they had not foreseen sourcing the required parts and the works were scheduled to start on site yesterday (Tuesday 4th May). As discussed, in retrospect the delay should have caused us to consider what, if any, interim measures were required until repairs were completed and the system was fully operational again. I have spoken to the TMO Senior Engineer and advised that I believe, as a minimum, we should have advised the local Area Housing Team and the local Fire Station Manager of the defect and kept them appraised of progress and completion target for remedial works etc."[7]

None of that information had been passed to Mr. Stokes, the fire risk assessor, notwithstanding that the issues were communicated wide and far[8].

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[6] {IWS00000388}, IWS of Shahid Ahmed of flat 156, Floor 18 - Refurb & Fire.

[7] {EXO00000953}, Email from Janet Wray (TMO) to LFB regarding fire at Grenfell Tower on 30 April 2012, Document Date: 05/05/2010.

[8] TMO10037439/0002

8. In many of his fire risk assessments (FRAs) Mr. Stokes noted that: *"There are automatic opening vents on each flat/lift lobby area, it is not known whether this system is serviced and maintained."*[9] He sought confirmation that maintenance was carried out… *"in accordance with manufacturer's instructions"*[10].

9. In September 2012, Bruce Sounes emailed the TMO, seeking information about the proposed upgrade:

> *"You forwarded us a specification for the upgrade to the alarm and smoke extract in July. It was prepared by Aecom and dated October 2011.*
>
> *Presumably this was the result of feedback from the London Fire Brigade? Our fire consultant (Exova) would like to know if there was anything received in writing outlining their concerns with the current system. If not, how was the specification arrived at?"*[11]

10. Wray dealt with this request internally:

> *"As per conversation just now I have attached an e-mail I sent to the LFB's Fire Safety Officer following a fire in the common parts of Grenfell Tower in April 2010. Unfortunately, as I have outlined the vents did not operate as required during this fire which led to pressure on us from the LFB. Subsequent to this correspondence Keith Fifield, our then Building Services Manager, and I met with the LFB at Grenfell Tower. However, as commonly happens none of this was put in writing by the LFB. I believe that this and further investigations undertaken by RGE, our Planned Maintenance contractor, led to Keith & his team concluding that this system needed to be replaced / refurbished. I'm afraid I was not involved in the detail of progressing this or drafting the specification."*[12]

11. This was, in every respect, typical of the TMO's approach. They seemed unwilling to deal with fire safety issues, save reluctantly and under pressure from the LFB. There was no clarity as to who was doing what or, indeed, what was being done, a theme which repeats itself in the system's design.

12. MF were also asked to look at the smoke ventilation system, on the basis of a previous specification provided by Aecom, at RIBA Stage C and D, *i.e.,* the concept design stage.

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[9] {CST00000704} *etc.*
[10] {CST00000704/4}.
[11] {TMO10037811/2}, 10/09/12.
[12] {TMO10037811/1}, 11/09/12.

The extent of the design at stage C/D is insufficient for construction purposes, but ought to be sufficient as a guide on what is achievable. However, at the conclusion of Stage D in November 2012, from the state of Exova's discussions with RBKCBC, it was still not clear what level of information or calculation was required with regards to the upgrade of the system so no further details were provided about the SVS at that stage.[13]

13. In September 2013, prior to design work starting, MF sought out test certificates for the existing system from the TMO. They immediately ran into difficulties[14]. SVSs are required to be tested regularly, the result would have indicated if the system could be retained, or if further work was necessary. This process continued for some time. Williams confirmed there was a problem obtaining information on the system from the maintenance contractor RGE, indicating the KCTMO did not even hold the data. [15]

14. PSB were contacted in November 2013 *i.e.*, after the concept stage and even then, only when it was belatedly identified than an engineered solution would be required.[16]

15. In autumn 2013 Mr. Sounes sent to RBKCBC a description of the proposed upgrade to the smoke system exhaust. He observed that: "*agreement on the smoke ventilation to the tower is the single biggest risk to the proposals, but we don't think it is reasonable to leave the existing system in place.*"[17] By January 2014, Rydon had submitted a detailed design of the SVS to RBKCBC.[18]

16. In January 2014 MF's Matt Cross-Smith chased KCTMO maintenance contractor RGE for the SVS maintenance records. They "*explained that as they did not believe that the system worked, they could not test it and therefore it had not been maintained for a considerable period of time.*"[19] The report Mr. Cross-Smith obtained from RGE contained basic errors. He received no answers to his questions. RGE had paid little attention to the upkeep of this safety critical system. It is unclear how long it had been non-operational. The system at this stage was in a state of dereliction following the combined neglect of the KCTMO and their maintenance contractor.

17. It is apparent the situation was unsatisfactory in 2014 and that the team working on the

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[13] {MAX00017304/13}.
[14] {MAX0000367} Email from Claire Williams of 16 September 2013.
[15] No relativity reference, an Email dated 1st October 2013, MCS/17, attached to Matt Cross-Smith's witness statement, {MAX00017304}.
[16] {MAX00017304/14}.
[17] {RBK00033907}, email Sounes to Allen and Hanson, 25/10/13.
[18] {RYD00031151} Minutes of Grenfell Tower Progress Meeting No 7 on 20 January 2014, section 6
[19] {MAX00017304/14}.

refurbishment was struggling to get on top of AOV issues. At a meeting with the LFB in March 2014, it was recorded:

"Visit to lobby, Floor 5

- Vents open & closed - existing situation not working.

- Matthew Ramsey very unhappy with fact dampers do not appear to be functional. Risk of 4 week enforcement notice. A demonstration would be req'd. This is urgent.

- Suggest RBKC Archives? worth trying for details of existing smoke vent system."[20]

18. The LFB followed up with a fire safety deficiency notice and schedule, which stated:

"A significant number (approx. 25%) of automatically opening vents within the common parts of the premises were found not to be in working order. No suitable system of monitoring was in evidence to identify deficiencies with the smoke ventilation system. Approximately 25% AOV ventilation units within the common residential lobbies were not held in the closed position indicating the system has not been maintained in effective working condition."[21]

19. Although the KCTMO was fully aware of the SVS defects, it is striking that no issue had been identified by Stokes or the KCTMO until the LFB raised the matter in 2014. The GTLA had repeatedly raised the issue of the SVS and the KCTMO had even consulted leaseholders on a replacement[22].

20. On 12th March 2014 Williams observed:

"*The Fire Brigade visited Grenfell Tower on 12/13 March 2014 as arranged. In attendance from LFB were Ben Lewis, Matthew Ramsey and Dan Hallissey and they made several observations in relation to the dry riser, doors open in firefighting situation, smoke vent to lobby and stair etc. Matthew Ramsey was very unhappy with the dampers not being functional and he referred to an enforcement notice. Bruce Sounes of Studio E architects attended with me. Following this site visit I wrote to Janice Wray, Carl Stokes and Bruce Sounes reporting on matters and for issues in particular relevant to the Fire Brigade concerning airflow calculations, the smoke vents to each lobby, access to finger blocks and seeking confirmation that the lifts were either fireman's or firefighting lifts.*"[23]

Clearly by this stage the KCTMO had still not realised the importance of ensuring this

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[20] {MAX00004353/7} RE: Grenfell and finger blocks - visit with fire brigade 17/03/2014.

[21] {LFB00000068}, Correspondence between LFEPA and KCTMO - fire safety deficiency notice and schedule dated 24 March. Specified lights, training & AOV faults, 24/03/2014.

[22] {RBK00003376}.

[23] {TMO00840364/32}

safety critical active fire protection system was well maintained. This is emphasised by the fact that seven months later in October of 2014 the smoke ventilation systems in the finger blocks of Testerton Walk and Barandon were nonoperational either having been isolated or having had their alarms disconnected, these systems would not work in the event of smoke entering the common parts of the building[24].

21. As late as 24th November 2014 MF, RBKC Building Control, PSB, JSW, Studio E and the KCTMO were meeting to discuss the SVS. PSB and JSW put forward a pressurised system[2526]. In his first witness statement Hugh Mahoney of PSB raised a form of pressure differential system as a possibility, where a negative pressure is maintained in lobbies through the use of extract fans, creating a pressure differential between the stair and lobby to prevent smoke entering the egress stair.

> *"The design I developed was for a depressurisation system, in other words a system which achieved smoke control using depressurisation principles achieved by mechanical extraction. Depressurisation systems are one of the most common types of smoke control system used in buildings in the UK."*[27]

22. Even at this late stage the system's design philosophy had not been decided. This design was fundamentally different to the original design offered by MF, based on pressure differentials rather than a simple smoke clearance system.[28]

Design Guidance

23. Approved Document B (AD B) 2006[29] incorporated the amendments up to and including those in 2013. Section 2 contained recommendations in relation to means of escape and Section 17 in relation to firefighting shafts.

24. AD B makes plain that the aim of smoke control measures for escape was to ventilate the smoke that passes through a flat entrance door when the occupants escape. To that end it recommended that the common lobby was ventilated "*to control smoke and so protect the common stairs*."

25. The approved document specifically provides that mechanical ventilation may be

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[24] {LFB00000893}
[25] {MAX00017304/15}.
[26] {EXO00000354}, M Smith to T Ashton Exova email asking for comments on AOV JS Wright proposal Exova 06/01/2015; see also, {JSW00003454}, Emails between PSB and JSW re plant room option 2 (both fans in the roof) 02/02/2015.
[27] {PSB00001329}, paragraph 24.
[28] {MAX00004795}
[29] {CLG00000224}

provided "to the stair and/or corridor/lobby" to protect the stairs and that guidance on the design of smoke systems "using pressure differentials "is available in BS EN 12101- 6: 2005. For firefighting shafts ADB provides that construction should be in accordance with BS5588 - 5[30]. Clause 17.14 of AD B set out that where its recommendations in relation to escape and compartmentation were adopted, the addition of a specific firefighting lobby between the common lobby and stair was not necessary. In other words, the means of escape measures would generally be adequate for firefighting access.

26. If a smoke control system conforms to AD B there is no requirement to consider objective or performance criteria as the ventilation system is deemed to comply with AD B. This was not the case at Grenfell, consequently performance criteria for the system, according to guidance should have been established.

27. Between the commencement of discussions with RBKCBC in 2012, the full plans application in 2014 and completion of works, the Smoke Control Association (SCA) guidance Revision 1[31] was revised and a second revision dated October 2015[32] was published. Mr. Hanson states in his first witness statement[33], that the system was designed in accordance with the principles of the SCA Guidance Revision 1 June 2012. The SCA guidance notes that smoke control system design is often constrained by space restrictions and building layouts. Consequently, it became necessary and common to develop engineering performance-based solutions supported either calculations or computational fluid dynamics analysis (CFD). No mathematical modelling or CFD was ever developed at Grenfell. PSB carried out shorthand calculations in lieu of any more detailed or refined analysis[34].

28. There are a number of different recognised mechanical smoke control system design options that could have been adopted by PSB and which would have been compliant with both the SCA Guidelines, widely regarded as best practice and ADB. These options were not considered by PSB. That doesn't appear to have been any formal consideration of the suitability or advantages or disadvantages of any of the recognised design bases. Dr. Lane sets out the available design options at {BLARP20000035/84}. Mr. Mahoney equates the PSB design to a 'Coltshaft mechanical shaft system'

"My design reflected a more common of mechanical extract depressurisation

[30] Superseded by BS 9999: 2008
[31] {LFB00059241}.
[32] {RBK00002932}.
[33] {RBK00033894} paragraph 52.
[34] {SEA00010379}

system. A performance based building appropriate solution widely adopted as a type of smoke control system, and which often referred to within the industry as depressurisation systems and is commonly called the Colt Shaft mechanical shaft system."

Dr. Lane rejects the suggestion that the Grenfell system could be regarded as a Colt System:

"My findings regarding the PSB system as installed in Grenfell Tower cannot be read as in any way relevant to an assessment of the effectiveness/compliance of any Colt system."[35]

The differences between the Grenfell system and a Colt system are numerous and substantial including the number of shafts, the fire rating of the shafts, extract fan specification, power supply and fire door performance[36].

The PSB design

32. The PSB proposal for the smoke control system to protect the means of escape and firefighting stair in Grenfell Tower was set out in the third revision of the PSB. Smoke Ventilation Technical Submission revision dated 12 June 2015[37]. This was the document formally responded to by the BCB and referenced by the BCB as part of its subsequent consultation with the LFB.

33. PSB proposed a mechanical extract system designed as described in clause 1.1.2 of the document to provide an average open-door velocity, across an open lobby/stairwell door of 2.0 ms^{-1}. That velocity was consistent with the recommendations of a Class B pressure differential system as defined in *BS EN 12101 Part 6: Specification for pressure differential systems*. The proposal incorporated mechanical extract from the lift lobby adjacent the stair at the storey level of the fire. The design concept was to reduce the air pressure in the lobby below the level of the fire and stair leading to the fire level, causing air to flow into the lobby. The lowering of the air pressure in adjacent areas was in stark contrast to a pressure differential system as *per* BS EN 12101-6.

34. In paragraph 37 of his second witness statement Mr. Mahoney states that a depressurisation system designed in accordance with BS EN 12101 - 6 extracts "*air direct from the fire zone.*"[38] However, the definition of depressurisation at paragraph 3.1.10 of

[35] {BLARP20000035/161}
[36] {BLARP20000035/163}.
[37] {RBK00027392}
[38] {PSB00001373/5}.

BS EN 12101-6 is "*smoke control using pressure differentials where the air pressure in the fire zone or adjacent spaces is reduced below that in the protected space.*"[39]

35. The specification makes plain that the most appropriate use of a depressurization system is likely to be in basement spaces; that there is no protection of any part of an escape route within the depressurized space itself, which may be filled with smoke or fully involved in a fire. The standard goes onto state that "*This constitutes a fundamental difference between pressurization and smoke exhaust ventilation.*"

36. Dr Lane in her SVS report concluded that the system was ultimately designed to provide an average open-door velocity and that the design did not meet the performance design criteria in BS EN 12101-6. [40]

37. Ms. Menzies is of a similar view that the design proposal did not fully comply with BS EN 12101-6 for the reasons explained by Hugh Mahoney in his second witness statement[41], namely that only one of the performance criteria of the standard was incorporated into the design proposal.

38. PSB's design proposal was performance based and only adopted the appropriate air flow criteria across the stair door[42] from the standard. It did not adopt the recommended pressure differential criteria in the various spaces, as mandated by the standard nor the recommended fan temperature which was appropriate for extracting smoke and hot gases from the fire zone; Ms. Menzies points these failures out[43] It was therefore a bespoke system based on a bespoke design narrative, incongruous to the British Standard not having incorporated large parts of the specifications contained within it. The specifications within BS EN 12101 Specifications relating to the installation, components, testing and maintenance were relevant and were similarly referenced in the Smoke Control Association guidance for 2012 and 2015.

39. No mandatory guidance existed to address the Grenfell Tower SVS design proposal for partially retained renovated legacy systems. The adoption of any particular guidance is not mandatory to achieve compliance with the Building Regulations. However, as Ms. Menzies puts, "*it should be remembered that guidance is based on the assumption that its inter-related measures are adopted and "cherry picking" from numerous of documents*

[39] BS EN 12101-6, paragraph 3.1.10
[40] Appendix J {BLAS0000031} paragraphs, Jl.1.9 to Jl.1.11.
[41] {PSB00001373}.
[42] At fire storey level.
[43] {BMER0000007/17}, paragraph 112.

is unacceptable without justification and can be inappropriate[44]*."*

40. BS 9991 and AD B both distinguished between pressure differential systems and mechanical smoke ventilation systems. Either type of system if correctly designed would have satisfied the Requirements B1 and B5.

41. The dampers serving the lobby smoke control at every level, were required to be smoke control dampers, by reference to the SCA Guide (both the 2012 and 2015 revisions) and BS EN 12101-6. In Grenfell Tower the minimum required fire resistance duration was E60S to comply with ADB 2013. PSB did not specify smoke control dampers, and instead specified a product, rather than a fire performance. This was the Gilbert Series 54 damper. Dr. Lane analysed the product literature of the Gilbert Series 54 dampers and concluded that "*they are sold as and referred to as fire dampers, but even then they had never been fully tested to the relevant standard for fire dampers (i.e. BS EN 1366-2) or formally classified as such."*[45]

42. A fire damper is the lowest possible damper standard referred to the ADB 2013 and is expressly cited as inappropriate for use on protected escape routes in paragraphs 5.48 and 10.13. Dr Lane concludes that the dampers installed across the system were non complaint with British standards[46].

SVS Controls

43. JSW submitted the SVS proposals to Building Control on 19 January 2015[47]. JSW confirmed on 24 June 2015 that Building Control had approved it.[48] Rydon subsequently requested JSW install controls to operate the AOVs.[49]

44. The faults in the design of the system also extended to the controls software and instrumentation wiring. At ground floor and level one, the software did not provide for power to the dampers, there were loose wire connections to first floor lobby damper which precluded smoke extract from the level one lobby of the south shaft,[50] there were loose wiring connections to the first-floor lobby pressure switch, the wiring connections on the PSB drawings did not match the required connections on the damper actuator

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[44] {BMER0000007/0019}, paragraph 123.
[45] {BLARP20000036/1}.
[46] {BLARP20000035/243}.
[47] {MAX000053291}, {MAX00002217}.
[48] {MAX000053291}, {MAX00002217}; The memo from Building Control approving the SVS refers to Guidance on Smoke Control to Common Escape Routes in Apartments Buildings Rev 1 June 2012.
[49] {RYD00061100}, email from Rydon to JSW, JSW are to install and supplies/controls to operate the AOVs, 09/12/2015.
[50] {MET00065879}.

sheet;[51] all of which were capable of causing compartmentation breaches.

45. Dr. Lane is particularly critical of the lack of adequate cause and effect documentation reflecting the full performance of the lobby smoke control system, the paucity of this documentation appears to have led to an inadequate set of test procedures being undertaken.[52]

Lead up to commissioning

46. By December 2015, JSW were pressing PSB to get the AOV system functional to the occupied area of Grenfell before Christmas.[53]

47. The lack of clarity persisted. In February 2016, MF communicated to Rydon that:

> *"Tony forwarded on the RAMS document* [Risk Assessment & Method Statement] *from PSB. The system description within Section 4 is not particularly clear to me. For example, there is no mention of extracting from both shafts simultaneously or of the operation of the dampers between smoke rated fans and general ventilation fans. The commissioning test also does not mention the additional dampers between fans or take into account that some of the extract dampers in the lift lobbies may already be open. Could you request that PSB revise it to more accurately reflect the system installed at Grenfell?"*[54]

48. At this point MF were made aware the system was designed to work on a single floor with an anticipation that the stair door would be fully opened on the fire floor but not for fires or doors to open on multiple floors. Design assumptions that seem artificial and unrealistic cognisant that the system HMI (Human Machine Interface) provided no indication of which floor the fire was on. It is remarkable that MF would have been in the dark on the design basis and capability of this safety critical system for so long.

Commissioning

49. According to Granville Partlow (the PSB engineer who commissioned the SVS system between February and April 2016), the system was commissioned in parts over several weeks. It is clear from his statement that there was no design basis to test. The

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[51] {BLARP20000035/326}.
[52] {BLARP20000035/409}.
[53] {PSB00000819}, email, JSW to PSB, 14/12/2015
[54] {MAX00006726}, email from Max Fordham to Rydon re: Operation of the AOV and advice to revise the RAMS by PSB UK / Witt UK Document Date: 05/02/2016; see also, {PSB00000214} PSB Smoke Ventilation Technical Submission - Lobby Smoke Control Systems at Grenfell Tower 15/03/2016.

commissioning report amounted to a very limited series of tests to ascertain the system's performance; it was not testing a design specification: It was more a case of seeing what the system could do as opposed to testing its performance against a design specification. Moreover, the PSB '*above ground commissioning report*' is woefully deficient, consisting of 5 pages; the entries have been typed in suggesting the document was completed off-site. It does not cover obvious areas normally recorded in a commissioning exercise. Mr. Partlow's statement itemises the work he asserts was carried out during commissioning. However, this was not in the large majority recorded in the report. The document misses basic matters such as damper installation, damper actuation, fan ratings, controls interlocks and the control interface to name but a few.

50. In March 2016, PSB gave a demonstration of the SVS. At that time, MF received version 6, the last PSB technical submission describing how the environmental fans were intended to operate. MF had still not received the PSB commissioning sheets or design calculations a week before the test, without which they would have been unable to review the acceptability of the design or if the system was commissioned correctly. They also sought confirmation the system was compliant with BS EN 12101: 6.[55] Ultimately MF never received a copy of PSB's design calculations or a copy of the commissioning report.

51. MF assert, notwithstanding that they never received the commissioning data and only partially witnessed the commissioning tests, that the SVS worked without any problems[56].

52. Hanson attended when the system was demonstrated in May. He asserts the demonstration "*was limited to the sequence of operation of the system from activation of a small selection of the smoke detectors in the lobbies on a few floor levels. It did not involve a witnessing of the previously commission airflow rates etc. It was a demonstration of the sequence of operation*".

53. It is not clear on the evidence served that the entirety of the system was ever tested at commissioning, although in May 2016 it was identified that no inlet air vent was incorporated into the design. This was a fundamental design omission, latterly rectified on an *ad hoc* basis, but which goes to the rigour of the design process generally.

54. Ms. Menzies is highly critical of the approach taken by RBKCBC to the commissioning of the system, pointing out that neither Mr. Hanson nor Mr. Hoban accepted the

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[55] BS EN 12101:6 Smoke and heat control systems - Part 6: Specification for pressure differential systems, Kits.

[56] {MAX00017304/0022}, paragraph 62.

commissioning certificate[57] for the renovated SVS. Neither is there any *"indication that further commissioning of the amended smoke control system was undertaken."*[58]

Neither is there any evidence that RBKCBC had required or did not require further commissioning. This *laissez faire* attitude was as Ms. Menzies puts it:

> *"a failure on the part of the BCB not to require further commissioning and not to have witnessed a further demonstration."*[59]

55. Ultimately Ms. Menzies view is that "*a Completion Certificate for the refurbishment works should not have been issued by the BCB."*[60]

56. Dr. Lane is highly critical of the commissioning work undertaken, in chapter 10 of her Smoke Control System report, "*The lobby smoke control system at Grenfell Tower*":

> *"10.11.12 PSB designed and commissioned a mechanical extract system in Grenfell Tower, with a pressure differential forming the primary design basis (25 Pa pressure difference between the stair and the lobby, when all doors were closed).*
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> *10.11.13 The SCA Guide 2015, as shown in Table 8-2, sets out fifteen tests, when one considers the combined recommended commissioning tests for a mechanical shaft system and a pressure differential system. It recommends "where applicable, the operation and function of the pressure sensors should also be checked".*
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> *10.11.14 BS EN 12101-6, also described tests where measuring pressure is as an appropriate part of the test procedure for a pressure differential system.*
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> *10.11.15 The SCA Guide refers to this standard, for pressure differential systems stating "BS EN 12101-6 provides a detailed set of test procedures which should be carried out."*
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> *10.11.16 PSB took no measurements of pressure in any lobby at Grenfell Tower."*[61]

57. Mindful that one of the design objectives was smoke control in the lobby area which itself was predicted on pressure as a controlled variable it is breathtaking that the

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[57] {BMER0000007/69}, paragraph 309.
[58] {BMER0000007/69}, paragraph 310.
[59] {BMER0000007/69}, paragraph 311.
[60] {BMER0000007/70}, paragraph 313. A point also made in Ms. Menzies earlier report, {BMER0000004}, at paragraph 530.
[61] {BLARP20000036/22}.

commissioning test did not measure pressure at all in any of the lobbies in the Tower.

58. PSB adopted a short form approach to commissioning giving short shrift to comprehensive testing. As Dr Lane describes:

> "5.3.27 *Mr Mahoney chose three specific performance criteria: a velocity of 2m/s through the open door to the stair, a differential pressure of -25Pa between the stair and the lobby and a door opening force of 25Pa between the stair and the lobby and a door opening force of less than 100N."*
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> "5.3.28 *I am not aware of any documents which suggest that the selection of these criteria were based on a proposed performance for a means of escape including visibility, temperature, thermal radiation, and toxicity, as would be recommended by either version of the SCA Guide."* [62]

59. It is of great concern that commissioning did not adopt the comprehensive fifteen tests recommended by the SCA Guide 2015. Instead PSB were satisfied with three performance criteria. This is all the more concerning when one considers that Mr. Mahoney had not analysed the performance of the original system as described in CP3 1971 and the original system did not have any performance records that the designer could use to ensure that the renovation was performing to at least the same standard, as required by RBKC BC and the Building Regulations. Cognisant of the dearth of historical system data and the safety critical nature of the SVS a more robust approach was warranted.

60. Notwithstanding that only three performance parameters were chosen these parameters were not sufficiently tested. PSB calculated an extract rate to achieve a single stair door open flow rate of $2.0ms^{-1}$. PSB measured a single stair door open flow rate, at every floor, and provided a record of it. The measurements exceeded $2.0ms^{-1}$ on every floor.[63] However, that flow rate was checked for one scenario only (the stair door open, all other doors presumed closed). It follows that the two minimum required scenarios relevant to means of escape and firefighting, were not assessed. Those being the scenario where the flat door is open on the fire floor, with all fire-affected lobby dampers open, which is the scenario which has the strongest impact on the flow rate achieved through the open stair door. Dr. Lane emphasises these system performance and commissioning requirements:

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[62] {BLARP20000035/123}

[63] {RBK00003784}.

"8.9.8 As I have explained in Section 2, the relevant functional requirement in ADB 2013 is that:

b) The flat entrance door, where the fire has occurred, is assumed open when occupants escape;

c) The lobby door to the stair, on the fire floor, is assumed open as occupants escape enter the protected stairway, and proceed to a place of safety at their own pace." [64]

61. Dr Lane emphasises that the range of foreseeable situations which arise in the event of a fire mean that different stair and flat doors opening scenarios must be considered and used to test the performance of the system. These performance checks are important as they ensure that the system is tested under realistic conditions thereby proving that the means of escape and firefighting modes are viable and reproduceable in the event of fire. Air pressure or flow rate failure (both being inimical to resident and firefighter safety) under a given set of operating conditions can render escape or firefighting not survivable. The guidelines reinforce the importance of relevant scenarios being tested As Dr Lane states: *"The SCA Guide 2012 and 2015 versions also make clear the need to set out relevant scenarios, and I have demonstrated the significance of this above."* [65]

"5.11.51 Ultimately for this performance-based design, the designer was required to set out foreseeable scenarios under which the system was required to perform." [66]

62. The open position of fire dampers and fire doors were not the only variables that ought to have been considered in the design of the SVS. The lift shaft should also have been considered under paragraph 6 of BS EN 12101-6:2005 as part of the development of the design of the smoke control system, but unfortunately it was not.[67]

63. This lack of design detail persisted Dr Lane "*... found no evidence of any designer specifying fire resistance or smoke leakage performance for the lobby dampers.*"[68] Raising obvious safety concerns about the ability of the system to maintain compartmentation and restrain smoke movement from one part of the Tower to another.

64. The problems were not exclusive to the mechanical installation. Dr. Lane identified that that there were no software interlocks applied between the fire floor and the pressure switches of that floor, which would have ensured that only the pressure switch on the fire

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[64] {BLARP20000035/363}
[65] {BLARP20000035/176} s 5.11.50.
[66] {BLARP20000035/176}
[67] {BLARP20000035/135}
[68] {BLARP20000035/219}

floor controlled the speed of the fan on that floor. In practice this meant that the pressure instrumentation on other floors could dictate the service that the fans delivered to the fire floor. Which would have led to a scenario of the fans failing to ramp up or wind down in response the variable demand required on the fire floor. Ultimately this could have led to unsafe scenarios as Dr. Lane explains: *"On the night of the fire however, if there were open dampers on another floor, for example faulty dampers, it could cause depressurisation of the lobby on that floor and so the pressure switch on that floor (rather than the fire floor) may then control the fans*[69]*."*

65. The PSB commissioning document and technical submissions make no reference to the overall commissioning scope, including no mention of the requirement to demonstrate and stability test the 25 Pa pressure differential between the stair and the lobby or a stair door opening force of less than 100N, nor is there any mention of why all measurements were required on every floor. Neither throughout the document is there any reference of the need to assess the performance of the system over a range of reasonably foreseeable scenarios that should have formed the basis of his design.[70] Those fundamental omissions are symptomatic of wide ranging systemic design and commissioning failures.

Training and Instruction

66. There is no evidence that appropriate training was provided to representatives of either the KCTMO for maintenance purposes or the London Fire Brigade regarding how to use the system in the event of a fire. The standards mandate that the responsible person ensures that appropriate training is given before accepting the system.[71]

Premises information box: - AOV

67. On 5th May 2016 in a bi-monthly LFB - KCTMO health and safety meeting Nick Davis (LFB Station Manager for Kensington and North Kensington) requested a Premises Information Box be installed at the Tower.[72] Wray asked for confirmation of what documentation the LFB wanted in the box and Mr. Davis highlighted AOV documentation should be included. It is unclear if this information was ever passed to the LFB. However, we know from events on the night of the fire that officers were not able to properly operate the AOV system and had no meaningful documents that assist them

[69] {BLARP20000035/0269}, paragraph 7.7.32.
[70] {BLARP20000035/334}.
[71] Section 8.4 of BS 7346, {BLARP20000035/409}.
[72] {LFB00000062/3}.

in doing so.

The Tunstall auto-dialler

68. The Tunstall auto-dialler was configured to automatically transmit fire alarm signals to an alarm-receiving centre which would then summon the fire brigade. The recurring theme of the KCTMO evidence is that the ESAs were responsible for weekly testing of the SVS. The extent of the ESA's training on how to test the SVS was limited to a demonstration of the system's operation on the 2nd November 2016.[73] There is no further evidence that the KCTMO ESAs who were tasked with carrying out the weekly and monthly checks of the smoke control system, to ensure that the system was in good working order, were given any training on how the system operated or on the location of the equipment that was required to be inspected during these checks.[74] Of the weekly activations that the ESA's undertook between 20th January 2017 and 14th June 2017 there is no evidence that the fans on the roof or on level 2 operated correctly or that the lobby dampers closed or opened as required. There is also no evidence that the ESAs were provided with suitable training to inspect the fans or dampers to ensure that they were in the correct position on activation.

Time proximate to the fire

69. Importantly, just a week before the fire, on 6th June 2017, JSW notified PSB that they had received a defect from Rydon that the AOVs were not opening up and requested an appointment be arranged to attend to resolve matters[75]. This defect appears to have been detected in late May or very early June.[76] JSW seem to have regarded this as urgent, since they sent follow-up emails over the next 2 days.[77]

70. Richard Thornley on behalf of Witt and Son emailed JS Wright on 8 June 2017 as follows:

"Regarding the fault at Grenfell Tower. After checking with PSB, this site is out of the warranty period and has not been serviced[78], quote attached was done in May 2016 Please see quote attached for the service contract at Grenfell Tower, site should have already been serviced. Quote includes two service visits one every six months so it covers a twelve month period. The site under fire regulations should be service every six months

[73] {RYD00094213}
[74] {BLARP20000035/496}.
[75] PSB00000474, Email from Aftercare@JSWright, 06/06/2017.
[76] See {DCS00000015} Email from JSW, Wright Ltd, 02/06/2017.
[77] {PSB00000478}, Emails from JSW to PSB asking for update re call-out for Grenfell AOV, 07/06/2017 and 08/06/2017.
[78] Counsel's emphasis.

with it being life safety equipment."[79]

71. Mr. Witt (PSB) responded on Monday 12 June 2017:

"Apologies for the delay in replying. We have spoken with our contract engineer for this development and he has asked if we could have a quote for one visit from you as the PPM contract after July would need to be arranged by our clients as our defect period will be finished. Can you please send us a new quote for this one visit?"[80]

72. It seems an appointment was booked for this work to be done but it was not carried out prior to the fire.[81] Dr. Lane found in her P1 report that there was no evidence that this defect was rectified.[82]

73. It is likely the failures highlighted *ante* led to the system not functioning on the night.

Conclusions

74. The design failed to incorporate the ventilation performance characteristics of BS EN 12101- 6: 2005.

75. RBKCBC had accepted and approved PSB technical submission version 3. It was that submission upon which consultation took place with the LFB and upon which the system was built. PSB Technical Submission Revision 6 was submitted to BC, they neither accepted or rejected it, nor did they comment upon it. The fact of the submission evidences that the system design had been revised. However, RBKCBC then accepted a commissioning certificate as proof of compliance of a system that they had not approved the technical submission for. They therefore were out of compliance with their own procedures.

76. PSB were set an unrealistically short deadline to carry out the design work that had languished until they joined the project. Commercial pressure then overtook design rigour and shortcuts were taken in the interest of project progression.

77. It appears MF in their RIBA stage C/D work were not asked to detail SVS design options and so it was never considered. This was a case of the KCTMO directing the engineering and construction professionals not being advised by them. This precise issue ought to have been considered at a preliminary design stage. The KCTMO had not understood that

[79] PSB00000479, email from Witt to JSW, 08/06/2017. Counsel's emphasis.
[80] PSB00000479, email from JSW to Witt.
[81] RYD00092630, 12/06/2017.
[82] BLAR00000025_0028.

MF were instructed to RIBA stage D. They were not instructed to produce detailed SVS design work. The lack of understanding of the distinction between the two resulted in the SVS not being progressed when it ought to have been. That lack progress inevitably contributed to a non-compliant system. Once again safety suffered as a result of the TMO's unjustified intervention and RBKCBC's acquiescence to it.

78. There does not appear to have been any consideration of the fire resistance of the smoke ventilation system ductwork, which ought to have had a 2-hour rating[83]. To maintain the fire resistance performance of the protected stair, the Level 2 ductwork at Grenfell Tower was therefore required to achieve 120 minutes stability, integrity and insulation when tested to BS 476[84].

79. There was no analysis of the ductwork leakage contrary to BS EN 12101-7:2011, Smoke and heat control systems, and BS EN 13501-4:2007, Fire classification and construction products[85].

80. The operation of the SVS could lead to unexpected results, specifically based on operation of the manual lobby-based pressure switch when any door other than the stair door was open, and also based on untrained use of the HMI panel in conjunction with the yellow key switches.

81. The instructions provided to the fire service were wholly inadequate to allow attending firefighters to understand the full complexity of the system.

82. The Building Regulations Completion Certificate dated 7 July 2016, implies the commissioning certificate dated 28 April was accepted albeit alterations to the installation were required by the BCB after this date. Ms. Menzies opinion is that the certificate should not have been accepted by the BCB as evidence of compliance.

83. The fire resulted in just about all of the failures highlighted by the expert evidence manifesting. The expert reports identify wide ranging systemic breaches across all areas of the design specification and commissioning of the system. It is likely that those failures were contributive to the unnecessary loss of life.

Austin Stoton

June 25th 2021

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[83] {BLARP20000035/106}.

[84] Fire tests on building materials and structures.

[85] {BLARP20000035/107}.