IN THE GRENFELL TOWER PUBLIC INQUIRY

THE INQUIRY RULES 2006, RULE 9

WITNESS STATEMENT OF

HUGH MAHONEY

I, **HUGH MAHONEY** will say as follows:

1. My name is Hugh Mahoney. From around early 2013 to early 2016, I worked for PSB UK Limited ("PSB"), a Core Participant at the Public Inquiry ("the Inquiry").

2. I have been asked to provide this statement to assist in responding to a Rule 9 letter from the Inquiry directed to PSB, dated 5 June 2018. The matters contained in this statement are from my own knowledge or are matters of information or belief. The source of any matter of information or belief is identified where relevant.

3. PSB is one of the companies in the Witt UK Group. PSB is based at Witt House, Shelf Mills, Wade House Road, Shelf, Halifax, West Yorkshire, HX3 7BJ.

4. I am an experienced Engineer and have worked in the smoke control industry, developing and designing above and below ground smoke control systems for over 35 years. Details of my experience can be found at paragraphs 10-14 below.

5. During my time at PSB my title was Commercial Manager and latterly Technical Sales Manager.

6. I left PSB in February 2016 and I now work for Colt Smoke Control as a Sales Consultant.

7. PSB undertook a project (the "Project") to design and commission the smoke control system (the "System") installed at Grenfell Tower as part of the regeneration works to the building, which were completed in 2016.

8. From early 2014 when the Project began to early 2016 when I left PSB, I was involved in helping to design the System and communicating with PSB's customer on the Project, J S Wright. The purpose of this statement is to explain PSB's involvement in that design and to assist the investigation being undertaken by the Inquiry.

9. I am authorised by PSB to make this statement.

Background and Qualifications

10. After leaving school [redacted], I completed an indentured apprenticeship with a company that was originally called Richard Crittall and ZD Bury Limited but that is now known as Crown House Engineering. This apprenticeship lasted five years and covered the design, and operation of mechanical systems. I also completed a four year course at Technical College and hold a 632 City and Guilds qualification in heating and ventilation.

11. I worked at what is now Crown House Engineering until 1979. I then joined NuAire Limited, a fan manufacturing company, where I worked in a contracting department designing and overseeing the installation of ventilation systems in a number of different types of building. In around 1983, the company started developing a specialist smoke control business which later became its own smoke control company called NuAire Smoke Ventilation Limited. I worked in that business until it was sold in 1992 and then remained with them as an in-house expert for a further 8 years. My role included designing above and below ground smoke control systems.

12. After working in a couple of interim positions, I then set up my own business called Advanced Smoke Technology with a business partner in 2003, which I ran for seven years. Advanced Smoke Technology worked alongside PSB on certain projects and it was through this that I got to know Martin Booth, the Managing Director at PSB. Again, this role included designing above and below ground smoke control systems.

13. After leaving Advanced Smoke Technology I briefly worked for two Dutch smoke control companies before joining PSB. PSB brought me in for my technical expertise in above ground smoke control systems and my role at PSB largely involved the sale and design of such systems. My job title changed from Commercial Manager to Technical Sales Manager during my time at PSB, but this did not involve any change to my role or responsibilities.

14. I have always been interested in smoke control systems and the regulation surrounding them. I have watched things develop, and have also had the opportunity to contribute myself, as the industry has evolved over the last 40 or so years. During that time, I was for many years an independent member of British Standards Institute's FSH25 Committee for Smoke Control Systems and I also have a long history of involvement with the Smoke Control Association ("SCA"). I held the post of Chairman of the SCA from 1998 to 2000 and had an active role in the association as a member of both the technical and plenary committees.

PSB's Initial Involvement in the Project

15. The System at Grenfell Tower was considered part of the Mechanical, Electrical and Plumbing ("MEP") Services to be installed as part of the regeneration works at the Tower. The outline requirements for the system were initially provided to PSB by Max Fordham LLP. We took these and the other documents provided by Max Fordham and J S Wright and used them to develop a proposed design for a smoke control system to replace the one which had previously been in place at Grenfell Tower.

16. I first became involved in the Project in or around April 2014. From that point, I became involved in a series of discussions, first with Matt Smith of Max Fordham and then from late 2014 onwards with David Bradbury at J S Wright, around the proposed design of the System. I believe that Fergus MacGregor, a system designer who worked for PSB before I joined but who left the company around this time, had already had a brief discussion with Matt Smith about this potential job back in late 2012 when the proposals for the planned works were in their very early stages. But I was the one who dealt with Max Fordham when they got in contact again in 2014 and I took things forward from there.

The Smoke Control System in Place at Grenfell Tower Prior to the Regeneration Works

17. Grenfell Tower already had a smoke control system in place prior to the regeneration works. We were provided with information about this system by Max Fordham and I also visited the Tower myself in the early stages of the Project while I was in the course of designing the System to see what was already in place.

18. The pre-existing system appeared to have been there for a while and there was not much in the way of documentation for the system other than what Max Fordham put together around that time. Based on that information and my own visit, I could see that the pre-existing system was a natural ventilation system with a mechanical boost function. It had two sets of shafts, one set of inlet shafts connected to vents at low level on the south side of each common lobby and one set of outlet shafts connected to vents at high level on the north side of the lobbies.

19. The way in which the pre-existing system seemed to be designed to work was that if the smoke detector in any lobby detected smoke, the dampers covering the vents on that level (and that level only) would open automatically to provide natural ventilation of the lobby, with an option for the fire service to give the system a mechanical boost.

20. However, Max Fordham confirmed to us in our early email exchanges that the pre-existing system was effectively inoperative and there was even talk of a deficiency notice being placed on the building as a result (HM/1: PSB00000703).

The Initial Design of the System

21. Max Fordham's initial proposals for the smoke control system essentially involved stripping out the controls and equipment used in the pre-existing system and installing a new system which reused the ducts and shafts into the existing common lobbies.

22. Their proposal, as set out in the employer's requirements document they produced, was to retain the broad principles of operation of the pre-existing system, but to turn it from a

natural ventilation with mechanical boost system into a fully mechanised push-pull system (HM/2:PSB PSB00000236).

23. When I looked at these proposals, however, I could see that that could lead to problems with excessive pressure drop due to the high induct velocity within the existing builderswork shafts, which could result in inadequate flow being achieved through the shafts. As a result, I developed an alternative proposal which still reused the existing ducts and shafts as per the employer's requirements, but which could achieve the functional objectives set out in the relevant guidance in place at the time.

24. 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. They are designed to deliver protection to the protected space, in this case the stairwell, by extracting air and combustion products from the common lobby to create a pressure differential and opposing air-flows between the stairwell and the common lobby.

25. The System at Grenfell Tower was designed so that, when smoke was detected in a common lobby causing the System to function in smoke control mode, extract fans would operate to extract air and combustion products from the affected common lobby via the shafts. This would reduce the air pressure in the lobby and therefore create a pressure differential between the lobby and the stairwell while the door between them remained closed, preventing smoke from migrating into the stairwell.

26. The System incorporated pressure switches which would cause the fans to ramp down to a lower speed once this pressure differential was in place. That was to ensure that the differential was maintained but that it did not become too high, because if it was too high then that would make it difficult to open the door from the lobby to the stairwell: the system was designed so that the opening force on the door would not exceed 100N, in line with the performance criteria set out in BS EN 12101-6:2005 ("BS EN 12101"). This standard is the relevant standard for designing pressure differential systems and it is referred to in Approved Document B 2013 ("ADB 2013").

27. The System was also designed so that, when the door to the stairwell was opened and the pressure differential reduced, the pressure switches would cause the fans to ramp back up to full speed to maintain an airflow from the stairwell into the lobby, which would continue to prevent smoke from entering the stairwell. Again, this was in line with the performance criteria set out in BS EN 12101, which recommends a minimum velocity of 2.0 m/s being achieved through the open door to the stair. The calculations I carried out showed that my proposed design could easily achieve this figure (HM/3: PSB00001233).

28. Like the system in place beforehand, the System was designed to operate on only one floor at any one time, with the dampers covering the vents to the shafts on all other floors to remain closed while the System was operating in smoke control mode on the affected floor. This is in line with ADB 2013, which states that smoke control systems should be designed to control smoke in a common lobby and so protect the common stair in the event of a fire starting in a single location and being contained within a single compartment. The System did also incorporate functionality enabling it to be manually overridden to operate on a different floor level via the HMI panel and Fireman's Override Switches on each floor level. Even then, however, this was designed to allow smoke to be controlled within only one lobby at a time, primarily to aid post-fire smoke clearance, i.e. for helping to clear smoke which had seeped from the fire level onto other floor levels after the fire had already been dealt with. The override functionality incorporated into the System was, in my experience, typical for this type of system.

29. PSB's job was to design and commission a smoke control system that achieved the functional objectives of the relevant guidance as per the above. PSB's role did not extend beyond that to any of the other fire safety measures installed at Grenfell Tower as part of the broader regeneration works. Indeed, we did not have any real visibility over the design or other works being carried out by others in relation to any separate work packages, save for the installation and related construction works in relation to the System itself and the incorporation of some limited interconnectivity between the System and the general Building Management System at Grenfell Tower (which I will go on to explain below).

30. When it came to the System itself, we worked alongside Max Fordham and others to ensure that the System was in line with the employer's requirements and also to ensure that Building Control were happy with the System as part of their assessment of the regeneration

works at the Tower as a whole. Whilst PSB did not have much direct interaction with Building Control, we received comments on the system from them, generally via J S Wright, PSB's client at a number of points as the Project developed and I understand that they accepted the System as being compliant with Building Regulations once the regeneration works were complete.

Alternative Smoke Control Systems

31. There are a number of different types of smoke control system that can be installed in high rise buildings. I considered that a depressurisation system was the most suitable option in this case because the existing shafts at Grenfell Tower could accommodate sufficient airflow to enable the System to achieve the functional objectives of the relevant guidance, as stated above. This meant that the System could achieve what it needed to without disruptive building works being required throughout the height of the Tower, as per Max Fordham's requirements.

32. The other types of smoke control system that exist, on the other hand, all had significant disadvantages compared to a depressurisation system:

    1) A natural ventilation system would have involved using the existing shafts to provide natural ventilation without the use of fans. However, I did not think that the existing shafts were large enough to allow air and smoke to move from the lobby up through the north shafts at a satisfactory flow rate using this type of system.

    2) A natural ventilation with mechanical boost system would have worked in the same way as a natural ventilation system but with the addition of a mechanical boost, which could be used in the event of a fire if it was determined that natural flow alone would be inadequate in smoke ventilation conditions. Again however, even with the addition of fans, I did not think that the existing shafts were large enough to allow air and smoke to flow at an effective rate.

    3) A push-pull system would have involved using fans to push air into the south shafts (via the low level vents) into the affected lobby and pull air out of the lobby (via the high level vents) through the north shafts. As I have said, I identified based on experience that, given the size of the existing shafts, there was a risk that the velocity

of the air passing through the shafts in this type of system would lead to excessive pressure drop which would result in inadequate flow being achieved through the shafts.

4) A pressurisation system is another type of mechanical smoke control system using pressure differential principles, in this case using fans to positively pressurise the stairwell in order to prevent the migration of smoke into the stairwell. Pressurisation systems require large volumes of air to positively pressurise the stair which relies on the stair being well sealed in order to prevent undesirable leakage. As such, these systems are particularly challenging to install in existing buildings. Also, in a tall building like Grenfell Tower, air has to be injected at multiple locations throughout the height of the stair which requires a shaft to be located directly adjacent to the stair for the injection of air. In addition a large air release path would be required in the common lobby rising through the building. Grenfell Tower did not incorporate shafts of this type, meaning that it would have been highly disruptive to try to accommodate a pressurisation system.

Contractual Position and Structure of Project

33. The initial design work I carried out on the Project took place before we had a formal order from J S Wright. This is fairly typical in my line of work, since the customer usually wants an idea of the type of system we are proposing and the likely costs involved in designing, installing and commissioning such a system before committing to anything.

34. I was asked to provide a number of quotations by J S Wright during the period between November 2014 and May 2015, when the order for the design work for the System was eventually placed. A number of these quotations covered the installation of the System and the supply of all parts in addition to its design and commissioning, at J S Wright's request. J S Wright also asked us, in January 2015, to provide a quotation that was broken down into 2 phases, with phase 1 to cover the installation of a temporary natural ventilation system that was capable of being converted to a mechanical system at phase 2 (HM/4: PSB00000026).

35. In the end, however, PSB was only contracted to design the System, supply a limited number of specific equipment parts and commission the System. Rather than entering into

one overall sub-contract, J S Wright ended up placing a series of separate orders, starting with the order to carry out the design work that was placed in May 2015. PSB was not contracted to install the system (I understand that the installation was instead carried out by a company called RJ Electrics, which is a sub-contractor of J S Wright) and we were not, in the end, asked to perform our works in phases.

Development of the System Design during the Course of the Project

36. The System's design was recorded in a series of Technical Submission documents, all of which I produced other than the last version which I understand was produced in March 2016 after I left PSB.

37. The first revision of this document, dated 1 December 2014, sets out in detail how the System was designed to operate and the performance criteria which the System was designed to achieve as I have explained above (HM/5:PSB00001235).

38. The System design and the description of the System within the Technical Submission documents underwent some changes as the Project developed, as I go on to explain below. These changes largely came about as a result of input from Building Control and Max Fordham or as a result of the client clarifying aspects of what they wanted the System to do. However, the broad design of the System, in terms of how it operated and the performance criteria which it was designed to achieve in smoke control mode, remained as described in the first revision of the Technical Submission and above.

39. The principal changes to the System design as the Project developed were as follows:

    1) The detail around the design of the environmental mode incorporated into the System. Max Fordham's original employer's requirements documents had referred to the need for the System to incorporate the function to provide comfort ventilation of the communal lobbies, given that new heating mains were being installed as part of the regeneration works, but the detail around how this would operate was finalised as the Project developed. It is very common for customers to ask for comfort ventilation to be provided as an add-in to a smoke control system and therefore for the two modes,

i.e. environmental mode and smoke control mode, to be provided by one system using shared equipment, such as shared shafts. This makes a lot of practical sense as it avoids the need for additional equipment to be added unnecessarily. All comfort ventilation really does is keep air moving through the communal areas. At Grenfell Tower, this worked through the extract fan at roof level extracting air from the lobbies via the north shafts and the supply fan at walkway level supplying make-up air to the lobbies via the south shafts. I was copied into email exchanges discussing how the signal to trigger the system in environmental mode should work and how many floors should open at any one time when the system was operating in environmental mode, although the Controls team at PSB took charge of this as it was more their area. In the end, I understand that the System was designed to receive a signal telling it to operate in environmental mode from the general Building Management System, a separate piece of equipment which PSB was not involved in supplying, based on readings from temperature sensors which PSB again did not supply. I also understand that the dampers to the lobbies were ultimately programmed to open on a timed cycle on four levels at a time in rotation while the System was operating in environmental mode. Clearly, the smoke control function of a system needs to override the environmental mode in the event that smoke is detected and the controls for the System at Grenfell Tower were designed to ensure that was the case. Details around the operation of the environmental function and its interaction with the smoke control function are included in the later revisions of the Technical Submission.

2) Another item of the design which had to be finalised as we went along was the configuration and location of the smoke shafts on the lowest four levels of Grenfell Tower, namely the ground floor, mezzanine level, walkway level and walkway plus one level. The existing smoke shafts on the north and south sides of the communal lobby areas only extended as far down as the floor above walkway plus one level, which became known as level 4 (with the ground floor effectively being level 0 and so on). Because the lowest four floors were being reconfigured as part of the regeneration works to incorporate new residential accommodation as well as community spaces, the smoke shafts were to be extended down so that the System served the lower floors as well. The original employer's requirements document produced by Max Fordham had referred to extending the new system downwards but the detail as to how exactly the shaft extensions would be configured had to be finalised later, once the configuration

of the other new services and works being installed as part of the regeneration works had been agreed. I was involved in a number of exchanges with J S Wright in relation to the extension of the shafts, beginning in December 2014. J S Wright sent through a series of drawings and proposed shaft dimensions and invited my comments on these from the point of view of the air flows which would be generated through them by the System. I confirmed that I was happy with the proposals which were put forward to me on this basis. The construction works in relation to the shaft extensions were carried out by others, but I understand that the shafts ended up being extended down as far as the ceiling of the ground floor level, as single shafts on each of the north and the south sides, with vents into each of the communal lobbies on the lowest four floors so that the System served each floor level of the Building.

3) As well as the configuration of the extended smoke shafts, another detail which was finalised after the initial design work recorded in revision 1 of the Technical Submission was the specification and location of the fan sets used in the System. Initially, it was envisaged that the north and south smoke shafts would be connected at the top of the building and that they would feed into a single smoke extract fan set located at roof level. However, given that an environmental fan needed to be installed at low level and given the space limitations at Grenfell Tower, the design was changed to incorporate one smoke extract fan set in the rooftop plant room, which was used to extract via the north shafts in both environmental and smoke control mode, another smoke extract fan set at walkway level, which was used to extract via the south shafts in smoke control mode, and an environmental supply fan at walkway level which was used to supply make-up air via the south shafts in environmental mode. This arrangement is reflected in revision 5 of the Technical Submission onwards (HM/6:PSB00000213). I also confirmed to J S Wright, in an email exchange in September 2015 that the ductwork housing the smoke extract fan at walkway level needed to be fire-rated (HM/7:PSB00000044).

4) Similarly, the air inlet through which make-up air would be drawn in at the head of the stairwell when the System was operating in smoke control mode was finalised as the Project went on. I initially suggested using a Powrmatic OSR aluminium roof ventilator with a measured free area of 1.0 m^2. J S Wright later confirmed that the existing penthouse louvre already in place at the head of the stairwell had a sufficient

free area so it was agreed that this could remain in place. This is referred to as a potential change in revision 2 of the Technical Submission onwards and is confirmed in revision 5 of the Technical Submission onwards (HM/8:PSB00001236).

5) A couple of relatively minor further changes to the design specification were requested by Building Control between March and June 2015. Building Control asked us to change the specification of the fan cables used in the System from FP400 to FP600, which is a slightly higher grade of cabling, and this was reflected in revision 2 of the Technical Submission onwards. Building Control then asked us to remove a paragraph from section 1.1.2 of the Technical Submission and this was reflected in revision 3 onwards (HM/9:PSB00000209).

6) An addition was also made to the System in early 2016, when I was told that Building Control wanted two new smoke ventilators to be added, one in the entrance to the community room on the mezzanine level and one in the entrance to the boxing club on the walkway level. These new items were separate from the main System but Building Control wanted them to be monitored by our System. The Automatic Opening Ventilators in these areas were basically just windows with actuators fitted. Smoke detectors were fitted in these areas and the System was designed so that, if smoke was detected in one of these areas, the window in that area would automatically open to provide natural ventilation to the outside. Each area also had its own Fireman's Override Switch. These areas were controlled and monitored by the System, but they did not link up to the main smoke control system that operated in the communal lobbies and they were not connected to the smoke shafts or fans. J S Wright placed an order with PSB to supply and deliver the controls equipment for and to commission these two new "smoke zones" on 26 January 2016 (HM/10:PSB00000144). PSB did not supply any other equipment or carry out the installation work. The design of these two additional items is reflected in revision 4 of the Technical Submission onwards (HM/11:PSB00000976).

7) One final proposed change to the System design, which did not end up coming to anything, related to a proposal to provide a "dial up" facility via the main control panel used in the System. My understanding was that the end-client wanted to be able to receive an alert to a pre-set number in the event the System activated in smoke control

mode. RJ Electrics raised a query about this via email in February 2016 and I responded saying that this had never formed part of the specification for the Project (HM/11: PSB PSB00000991). I believe that JS Wright later asked PSB to supply an auto-dialler after I left at the end of February 2016 but that the dialler PSB supplied was not used. Instead, I understand that in the end a dialler was sourced separately and wired up to the general Building Management system rather than the PSB System.

Final Involvement in the Project

40. As I have said, I left PSB at the end of February 2016. I was effectively on gardening leave for most of February 2016 but I stayed in contact with David Harrison, the Project Manager at PSB, regarding the Project even after I started working for Colt in March 2016.

41. By the time I left PSB, the design of the System was effectively complete. I understand that after I left, David took charge of liaising with J S Wright and PSB's Controls team continued to be involved in the background, with Granville Partlow, PSB's Group Service and Engineering Manager, managing the commissioning of the System.

42. David contacted me in June 2016 in connection with some questions that Building Control had raised about the System via J S Wright and I helped him with the responses to these questions.

43. The first related to the source of make-up air to the System when it operated in smoke control mode on either the ground floor level or the mezzanine level. I believe Building Control's question arose out of the fact that the stairwell did not extend down to these two levels, meaning make-up air would not be drawn into these common lobbies from the top of the stairwell as it would be on the levels above if the System operated on one of these levels. I understand that Granville Partlow had already pointed out to J S Wright that make up air could be provided to these levels via the main entrance and that, if they wanted additional air to be provided, the automatic opening windows in the main entrance area, which did not form part of the System, could be wired up to provide that. I agreed with Granville that the existing arrangements were sufficient and that there was no requirement to provide any additional source of make-up air, as demonstrated by the results of Granville's commissioning, and produced a response along these lines for David to go back with (HM/13:PSB00001163 and HM/14:PSB00001164).

44. Building Control's other question related to providing the flow rates achieved by the System in smoke control mode in m^3/s rather than m/s. I understand that Granville had already provided the measured flow rates in m/s and offered to convert these to m^3/s based on the dimensions of the doors, but Building Control were saying they wanted the volume flow rates to be measured using some sort of device instead. This request did not make any sense to me, as the flow rate which the System was designed to achieve was a minimum velocity of 2 m/s across an open stairwell door in accordance with BS EN 12101 as I have stated above and the measurements Granville had already provided showed that this flow rate was being achieved. Also, it is standard practice for flow rates to be measured in the way PSB had done and I am not actually aware of any products being available on the market which could achieve what Building Control were asking for anyway. Again, therefore, I produced a response along these lines for David to go back with.

45. As far as I know, Building Control were satisfied with these responses and did not raise any further questions about the System.

46. The final commissioning of the System took place after I left PSB but David let me know that the works had been completed, fully commissioned and handed over, which I was pleased about.

Rule 9 Request Letter 5th June 2018

47. As the Designer of the System, I have been asked to consider questions 5(b) and 8 of the Inquiry's letter of 5th June 2018 and comment on it specifically. I did consider the relevant Building Regulations, guidance and standards when designing the System for Grenfell Tower and I set out my response to those questions below:

48. ADB 2013 states that smoke control systems should be designed to control smoke in a common lobby and so protect the common stair in the event of a fire starting in a single location and being contained within a single compartment.

49. In line with this, the System was designed to operate on only one floor at any one time, with the dampers covering the vents to the shafts on all other floors to remain closed while the System was operating in smoke control mode on the affected floor.

50. The PSB design was for a depressurisation system, in other words a system which achieved smoke control using depressurisation principles achieved by mechanical extraction.

51. BS EN 12101-6:2005 is the relevant standard for designing pressure differential systems including depressurisation systems (as referred to in guidance document ADB 2013). It sets out functional objectives and measurable performance criteria.

52. I drew upon the principles in this standard to develop a building appropriate solution. The PSB design was in line with the performance criteria of BS EN 12101-6:2005. The primary performance criteria of the design required a minimum velocity of 2.0 m/s being achieved through an open common lobby door to the stair. In achieving the recommended flow rate, the design also included provision to ensure that the opening force on the door would not exceed 100N.

53. I was aware that Granville would commission the System to meet these performance criteria on site and I understand that he has provided a witness statement to the Inquiry.

54. Achieving the functional objectives of BS EN 12101-6:2005 indicates compliance with the functional requirements of the Building Regulations.

55. I understand that Building Control accepted the System as being compliant with Building Regulations.

56. PSB's role did not extend beyond that to any of the other fire safety measures installed at Grenfell Tower as part of the broader regeneration works. Indeed, we did not have any real visibility over the design or other works being carried out by others in relation to any separate work packages, save for the installation and related construction works in relation to the System itself and the incorporation of some limited interconnectivity between the System and the general Building Management System at Grenfell Tower.

57. This ends my statement about the design of the System at Grenfell Tower.

58. I understand that this statement will form part of the evidence before the Public Inquiry and will be published on the Inquiry's website.

STATEMENT OF TRUTH

I believe that the facts stated in this witness statement are true.

Hugh MAHONEY .....

Dated 28th September 2018