Kingspan Insulation Limited

CLOSING SUBMISSIONS FOR MODULE 7 – PROFESSOR DAVID PURSER ("PP")

A. Phenolic insulation is irrelevant to the toxicity issues considered by PP

1. PP intentionally did not consider the contribution made by K15 to the toxic gases produced during the fire. During his oral evidence he explained why he considered K15 to be irrelevant to his analysis; *"I did not consider phenolic insulation at all. The reason for that was because we understood that it was a very small percentage of what was on the tower, particularly on the upper levels where most of the burning occurred"*[1]. It follows from this that the Inquiry has no evidentiary basis to conclude that K15 was a source of any toxic gases inhaled by any occupants of the Tower.

2. Furthermore, given the dynamic nature of the fire, PP's evidence was that it was simply not possible to be satisfied as to whether the source of the carbon monoxide ("CO") inhaled by any particular individual during the fire was either the PE in the ACM cladding or the PIR insulation (Celotex RS 5000). This point was well noted by the Chairman[2] in his exchange with PP concerning the contributions from ACM cladding and PIR insulation to the CO arising from the fire which ended with PP's evidence being that "*Now we are focusing very much on yields and relative contributions of different fuels, I think we are in a much more difficult area. I accept that*[3]*."*

3. So, taking the expert evidence of PP at its highest, it is impossible for the Inquiry to be satisfied:

   (i) that K15 was a source of any toxic smoke in general or any of the smoke inhaled by any particular individual; and

[1] Transcript day 297 page 164 line 23 to page 265 line 2

[2] Transcript day 297 page 197 line 2 to page 199 line 17

[3] Transcript day 297 page 199 lines 8 to 12

(ii) as to what was the source, or sources, of any CO inhaled by any particular individual. The quantities of toxic smoke produced by various different sources, including flat contents, would need to be understood, as would the dynamic manner in which those sources mixed together and exited/entered the Tower; the complexities involved are beyond the reach of PP's methods.

4. Kingspan Insulation submits that beyond these two general conclusions, PP's expert opinion evidence in relation to the production of toxic smoke has to be treated with very great caution. His analysis of the sources of the smoke at particular times and places that made up Part 5 of his report is based on a number of unsound assumptions, simplistic calculation methods, many unknown variables, and contradictions. The limitations of PP's evidence are such that it is impossible for the Inquiry to rely upon his opinions as to the source(s) of the toxic smoke present at any particular place or time during the fire.

5. PP himself recognised the inherent uncertainty of his opinions in his evidence. For example, in his Phase 2 report[4] he opined that, *"A particular area of uncertainty is the proportion of the fire and smoke plume from the exterior fire penetrating the flats at each floor and the proportion that rose outside and away from the Tower*." On more than 50 occasions throughout Section 5 of his Phase 2 report PP emphasises that his findings are just "*estimates*". A forensic analysis of his written and oral evidence suggests that the uncertainty arising from his evidence goes far wider than the contribution of the smoke plume to smoke entering each flat, important though that it is.

6. PP repeatedly conceded during his oral evidence, when covering his Section 6 analysis of the conditions in particular flats, that his analysis and his conclusions were often based on his assumptions only and may be inaccurate. For example when asked to give a window of time that the occupants of the Tower would have received a lethal dose of CO he answered: "*Now,* this *depends to some*

[4] Section 5 of PP's Phase 2 Report at paragraph 26 {DAPR0000011/9}

extent on the assumed extrapolation of the fire conditions.. so it is a very uncertain number I've got to give you."[5].

7. In any event, there would have been no smoke at the Tower without the fire. Kingspan Insulation have set out in their Overarching Submissions the compelling and unequivocal evidence of Professor Bisby, that the cause of the fire spread was the use of PE ACM panels, and not the use of combustible insulation.

B. Examination of Professor Purser's assumptions and methodology

8. In general terms, PP has simply not exhibited the forensic rigour to be expected of an expert witness. The following examples are especially relevant.

9. PP cited "*the lack of any data from further full-scale reconstruction tests or computer fire modelling work places some limitations on the extent to which I am able to determine in detail the pattern of development of the smoke and toxic gas conditions within the flats*"[6]. However, he ignored the independent, peer reviewed and published CFD modelling, carried out by Efectis[7] which, indeed, examines the pattern of development of smoke and toxic/asphyxiant gases.

10. PP does not justify or discuss either his simple linear calculation methodology to determine the source of toxic smoke in X6 flats and lobbies in his "*early period*", or most of its input variables, nor does he explain how changes to these input variables might affect his conclusions.[8] Instead he makes several

[5] Transcript day 297 page 12 line 1 and lines 10 to 12

[6] Section 5 of PP's Phase 2 Report paragraph 219 {DAPR0000011/45}

[7] {INQ00014906}, {INQ00014908}, {INQ00014909}, {INQ00014910}, {INQ00014914}, {INQ00014916}, {INQ00014918}, {INQ00014920}

[8] Section 5 of PP's Phase 2 Report paragraphs 221 to 233: The following variables are identified, each of which is uncertain: the mass of each fuel item involved in the particular fire in each flat, the mass of air entrainment into the smoke plume, the proportion of the exterior smoke plume penetrating the flat in question, the yields of gas and smoke and toxic gas from each burning item, the time to fill a particular flat or lobby, the concentration of toxic gases in a particular flat or lobby and the effects of them upon a particular person, the different routes of smoke penetration into a flat, both vertically and horizontally, the volume of gas from the smoke plume outside the Tower entering each flat, and the volume of gas and smoke generated by the burning of exterior PIR insulation that would enter a particular flat.

references to the data "fitting" his assumptions, rather than the data giving rise to evidence based conclusions.[9]

11. PP's conclusions contain generalisations and statements that are not supported by the evidence or else are contradicted by his own findings. For example: "*I have identified a key sequence of events as the early exterior fire spread outside the Flats 6 kitchens on each floor followed by rapid smoke filling of Flats 6 on each floor then rapid smoke filling of the lobbies on many floors which resulted in occupants being effectively trapped in their flats, leading to the deaths of those who were unable to escape*"[10]. However, PP does not specify over what time periods, from which flats, and ignores his own subsequent chronology of events that shows that after this early smoke filling the lobbies many occupants did escape

12. Descriptions of time and duration are imprecise, for example, his frequent use of terms like "*early period*" without any detail of specific timings. He frequently uses the phrase "*within a few minutes*" during his Report[11] which, whilst this may capture the uncertainty in his opinions, does not assist the Inquiry to make findings of fact.

C The Origin of Toxic Smoke in Flats and Lobbies During PP's "Early Period"

13. PP concluded his Phase 2 Report with his opinion that "*The smoke penetrating Flats 6 and filling the lobbies during the early period when occupants became trapped in their flats was entirely or almost entirely derived from the burning exterior and window surround materials (fuel loads 1 and 2)[12]";* and that these findings were supported by the BRE Grenfell fire reconstruction experiment. PP's report further states that in the BRE experiment; *"Toxic gas measurements of the smoke collecting in the Flat 26 kitchen indicated an equal contribution*

[9] See Transcript Day 297 page 198 lines 4 to 9, and page 200 lines 17 to 21.

[10] Section 5 of PP Phase 2 Report paragraph 77 {DAPR0000011/19}

[11] For example section 5 of PP's Phase 2 Report paragraph 10 {DAPR0000011/5}

[12] Section 5 of PP's Phase 2 Report paragraph 8 {DAPR0000011/5}

from the burning polyethylene (PE) cladding and the polyisocyanurate (PIR) insulation"…[13]

14. His opinion evidence regarding the sources of the smoke in what PP calls the "*early period*" of the fire are based on his assessment that:

    (i) there were no fires involving flat contents until 01:49.

    (ii) both PE and PIR contributed approximately equal amounts of carbon monoxide to the exterior smoke plume (100% combustion of the polyethylene mass and 50% of the PIR mass) with a concentration ratio of CO to HCN in smoke released during combustion of about 27:1;

    (iii) the polyethylene in the ACM completely burned in 3 to 4 minutes after the fire arrived at the window of the flat and all of it was converted to combustion products using moderately under-ventilated conditions;

    (iv) the PIR insulation burned in a similar 3-4 minute time window, also in moderately under-ventilated conditions, and self-extinguished quickly after the ACM-PE burned out;

15. Kingspan Insulation submits that each of these assessments is fundamentally flawed.

<u>The timing of content fires</u>

16. In particular, PP's analysis of the source of smoke in what he calls "*the early stages"* of the fire relies on the assumption that there were no flat fires before 01:49[14] . The smoke in the stair and lobbies are assumed to come only from the façade fire outside flats X6.[15] However, this ignores the important evidence that an internal fire existed in flat 36 by 01.17,[16] and Flat 46 was reported to be on fire by 01.21[17]. Flats 26, 96 and 196 were reported to be on

[13] Section 5 of PP's Phase 2 Report paragraph 9 {DAPR0000011/5}

[14] Section 5 of PP's Phase 2 report paragraph 104 {DAPR0000011/25}

[15] Transcript Day 297 page 160 line 5 to page 161 line 12

[16] Grenfell Tower Inquiry Phase 1 report dated October 2019 volume 2 p106 paragraph 10.69

[17] Grenfell Tower Inquiry Phase 1 report dated October 2019 volume 2 p108 paragraph 10.79 c

fire before 01:36 a.m[18]. It follows that PP has overlooked evidence of smoke arising from fires inside flats well before 01.49.

17. PP bases his analysis of the source of the smoke in X6 flats and lobbies in his "*early period*" upon the observations of X6 flat occupants. However PP does not consider, in his assessment of this evidence that the occupants of flats X6 evacuated very quickly, sometimes before the arrival of the exterior fire, and this was especially true on upper floors. This means that developing conditions inside flats were mostly not observed or reported by occupants.[19]

18. When a fire was fully developed in a given flat, it would have generated an overpressure that caused the smoke to be pushed out of the flat through the window. This would drive toxic smoke into the smoke plume and to the floors above. The entrainment of the effluents from the initial Flat 16 fire and the subsequent Flat X6 fires, into the exterior fire plume during the first vertical fire spread, is never considered by PP[20]. However, these fires lasted for more than 20 minutes and would have made a significant contribution to the toxicity of the plume and the smoke entering higher flats.

<u>The potential for early exterior fire outside Flats X6 to produce dense smoke within minutes in Flats X6 and communal lobbies.</u>

19. Many of the assumptions that underpin the smoke filling times calculated in PP's Phase 2 Report are not detailed. They should be given along with a justification for the use of all variable and fixed parameters[21].

[18] Professor Torero Phase 1 Report page 64 section 4.4 lines 1789 to 1793 refers to Flats X6 on the 5th, 12th and 22nd {JTOR00000001/64}

[19] Section 5 of PP's Phase 2 Report paragraph 85 {DAPR0000011/20}

[20] Section 5 of PP's Phase 2 Report paragraphs 80,90,93 and 103 {DAPR0000011/19 and 11/21}

[21] See for example Section 5 of PP's Phase 2 Report paragraphs 231 to 234.

20. The 1% and 5% values for the penetration of the exterior smoke into flats X6[22] have not been justified. The use of CFD modelling or a computational tool was not attempted to test these assumptions.[23]

21. It is also clear that the combustion of PIR would have continued long after the 3-4 minute window during which the PE ACM was consumed because it was then, as described by Professor Bisby in his evidence, impacted by heat and flames from fires in the apartments exiting through broken and missing windows. This heat source lasted for some hours[24]. This would suggest that PP has grossly over-estimated the contribution to the smoke from PIR insulation during this 3-4 minute time as he (wrongly) assumes that all missing PIR was burnt in this period.

22. As PP himself recognised[25], it is also evident, from the post-fire evidence that the higher the apartment in the Tower, the more intense the apartment fires seem to have been and therefore the more impact there would have been on the PIR, from these apartment fires.

23. The contribution of the PIR to toxic smoke[26] is highly disputable since it is based on post-fire quantification by Prof Stec[27], who surveyed the external walls of the Tower in mid-2018 and mid-2019, over a year after the fire, that 50% of the PIR insulation had been consumed around higher floors of the Tower. PP takes this 50% as applying to <u>all</u> flats X6. However, an extrapolation of the trend line for the consumed mass of insulation outside of the flats X6 in Stec's survey shows that, for the flats X6 involved in the fire during the period of the relevant calculations, the % of PIR consumed varies from 10% at the 4th floor to 50% at

[22] Section 5 of PP's Phase 2 Report paragraph 208

[23] Section 5 of PP Phase 2 Report paragraph 30 where PP states that the Inquiry decided that due to the complexity of the fire conditions CFD modelling would not assist the Inquiry in finding out the effect of the toxic gases on the actions of occupants or the firefighters.

[24] Transcript day 290, pages 17 - 20

[25] Transcript day 297 page 164 line 23 to page 165 line 2

[26] Section 5 of PP's Phase 2 Report paragraphs 36 and 37

[27] Stec A Assessment of the toxicity and extent of penetration pf smoke from combustible products on the Grenfell Tower {AASR0000010/14}

the 23rd, which would suggest that an average of 30%, would be more accurate that the assumed 50%.

24. PP's calculations of the contribution of PE and PIR to CO production, and the 27:1 ratio of CO/HCN concentration in the mixed smoke, assumes that the PE and PIR were burning under the same, static, ventilation conditions.[28] This is questionable since (i) these materials did not burn under the same ventilation conditions (PE in free atmosphere, PIR initially in the under-ventilated cavity and then in free atmosphere after the ACM burnt out), and (ii) the respective contributions of PE and PIR to CO will also depend on location and mode of fire propagation (horizontal or vertical).

25. PP's CO/HCN ratio of 26.6:1 is derived from BRE tube furnace test data. The use of data from this test method, as opposed to other test methods, is never justified or explained and there appears to have been no attempt to investigate which test method would be most relevant to the fire. The uncertainties inherent in this method are never explained or examined.

<u>The BRE Testing</u>

26. The BRE testing used by PP when considering the contributions of different fuel sources to the smoke, is wholly unreliable for the following reasons:

27. ***The quality of the measurements.*** The probes were located below the ceiling of the upper unenclosed Flat 26[29] They failed during the test[30]. Data was only available for the final stage of the experiment[31] when, in the gas layer in which the probes were sited, the O_2 level was going back to its initial value and when the CO concentration and temperature were decreasing[32] without consideration of gas dilution and the entrainment of water vapour released

[28] See Transcript Day 297 Page 176 line 4 when the Chairman asked PP "are you a fire scientist?"

[29] Section 5 of PP's Phase 2 Report paragraphs 117.

[30] Section 5 of PP's Phase 2 Report paragraph 120

[31] Section 5 of PP's Phase 2 Report paragraph 120

[32] Section 5 of PP's Phase 2 Report paragraph 180

during Flat 16 extinguishment. No quantification of the uncertainties caused by these issues is provided.[33]

28. ***The origins of the effluents***. It was impossible to differentiate what originated from the internal fire of Flat 16 and what originated from the external façade (cladding and the insulation) fire. HCN and chloride could originate from the refrigerator (coolant and insulation), the window reveals, the reveal insulation, the soft furnishings, beds and curtains and other materials contained in the initial apartment or from the façade system[34]. During the early stages of the BRE test and in the actual Grenfell fire, all the smoke flowing outside Flat 26 originated from the Flat 16 internal fire[35]

29. ***The fire spread to Flat 26.*** No furniture was installed in the Flat 26 kitchen, thus this experiment did not take account of the fire development inside that Flat.

30. ***The contribution of the façade system.*** No measurements of the residual PIR thicknesses were taken after the test. The observations are thus solely based on PP's view of the exterior appearance of the BRE test rig and therefore the 50% contribution of the PIR is highly questionable.

31. ***The ventilation conditions for burning materials.*** No detailed justification is given for the combustion conditions used in the calculations given in Table 5-4, despite the fact that they have a great influence on the yields considered in PP's further calculations.

D. The Origin of Toxic Smoke in relevant Flats

32. In his oral evidence PP repeatedly stated that the specific source of smoke which compromised the tenability of spaces in which people sought refuge was

[33] See Transcript Day 297 Page 195 when PP accepted that no gas measurements were obtained in the early stages. See also page 196.

[34] Section 5 of PP's Phase 2 Report paragraph 185 and 198

[35] Section 5 of PP's Phase 2 Report paragraph 123

the burning external cladding and insulation[36], but he provided no adequate evidence or quantitative analysis to support his statements[37].

33. PP ignores the impact of burning flat contents. Paragraph 16 details the evidence for apartment fires before 1:49 am. There is other evidence of fires in flats by around 01:52 am[38]. After 02:00, there were a large number of fully developed interior fires[39] and smoke from these fires spread to other flats even before the external fire reached them.

34. The scientific basis of PP's statements is therefore highly questionable. The number of internal fires on every face and floor of the Tower makes the major contribution of burning flat contents critical to the analysis of tenability of relevant spaces.

Conclusion

35. Whilst Kingspan Insulation agrees with PP that K15 was irrelevant to his considerations in respect of toxicity, it is submitted that the Inquiry should place no weight on PP's analysis as it lacks the necessary scientific rigour to enable proper conclusions to be drawn.

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30 September 2022

[36] For example, Transcript day 297 page 129 line 11

[37] For example he stated without further supporting evidence that the source of the smoke in the lobby of floor 10 at 01.20 was "the exterior cladding and insulation and window surrounds, and structural materials, mainly, outside the 10 floor..". Transcript day 297 page 160 line 5 to page 161 line 12.

[38] Transcript Day 84 page 175 line 16 where PP was questioned about Fig 5.23, a photograph from Dr Lane's initial Report timed at 01.36 {BLAR00000002/0027 }

[39] Report of Barbara Lane Figs 5.25, 5.26 {BLAR00000002/0029 and 0030}