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

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

Phase 1 Report – Section 11

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

REPORT OF

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Fire Safety Engineering

24th October 2018

Specialist Field	:	Fire Safety Engineering
Assisted by	:	Dr Susan Deeny, Dr Peter Woodburn, Dr Graeme Flint, Mr Tom Parker, Mrs Danielle Antonellis, Mr Alfie Chapman
On behalf of	:	Grenfell Tower Inquiry
On instructions of	:	Cathy Kennedy, Solicitor, Grenfell Tower Inquiry
Subject Matter		to examine the circumstances surrounding the fire at Grenfell Tower on 14th June 2017
Inspection Date(s)	:	6th October, 1st November, 7-9th November 2017

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

11.1 The requirement: B4 External fire spread

11.1.1 The functional requirement of B4 in Schedule 1 of the Building Regulations:

"B4(1) The external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to height, use and position of the building.

(2) The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building."

11.2 Purpose of Section 11

11.2.1 In this Section 11, I provide my analysis of the materials and products forming the external walls of Grenfell Tower in order to form an opinion on whether or not they comply with the functional requirement of B4 (1) of the Building Regulations.

11.2.2 I have therefore investigated each material and product forming the external wall, and the evidence available to me regarding their fire performance.

11.2.3 I have assessed the available test evidence for each material, available to me at this time. The test evidence available to me is provided in Appendix E of my Expert Report.

11.2.4 I have relied on the statutory guidance provided in Section 12 of ADB 2013, as the basis of my compliance assessment.

11.2.5 I have provided my definition of external surface, insulation, filler, gasket, sealant, in Appendix F of my report, and I rely on these definitions in my compliance assessment.

11.2.6 I have relied on my explanation of the fire tests forming the basis of National Class and European Class, as I have explained in Appendix F.

11.2.7 The statutory guidance sets out provisions to restrict the combustibility of external walls of high buildings. This is in order to reduce the surface's susceptibility to ignition from an external source and to reduce the danger from fire spread up the external face of the building.

11.2.8 Specifically, Section 12 of the Approved Document B "Construction of external walls" states:

"B4. ii provisions are made in Section 12 for the fire resistance of external walls and to limit the susceptibility of the external surfaces of walls to ignition and to fire spread."

11.2.9 These provisions include restrictions on the combustibility of the external surface of a building:

"12.2 Provisions are also made to restrict the combustibility of external walls of building that are less than 1000mm from the relevant boundary and, irrespective of boundary distance, the external walls of high rise buildings and those of the Assembly and Recreation purpose groups. This is in order to reduce the surfaces susceptibility to ignition from an external source and to reduce the danger from fire spread up the external face of the building"

11.2.10 And provisions to limit the external wall as a medium for fire spread:

12.5 The external wall of a building should not provide a medium for fire spread if it is likely to be a risk to health or safety. The use of combustible materials in the cladding system and extensive cavities may present such a risk in tall buildings. External walls should either meet the guidance given in paragraphs 12.6 to 12.9 or meet the performance criteria given in the BRE Report Fire performance of external thermal insulation for walls of multi-storey buildings (BR 135) for cladding systems using full scale data from BS 8414-1:2002 or BS 8414-2:2005"

11.2.11 ADB 2013 12.6 makes the provisions for the '*external surfaces'*.

11.2.12 ADB 2013 12.7 makes the provisions for the '*insulation materials/products'*.

11.2.13 ADB 2013 12.8 and 12.9 make the provisions for Cavity Barriers. Section 12.9 does not apply to Grenfell Tower and is therefore not considered any further. The cavity barrier provisions are made in ADB 2013, Section 9.

11.2.14 Therefore, the functional requirement for external walls is dealt with by means of Regulation B4 External fire spread to *adequately resist the spread of fire over the walls and from one building to another*. And Regulation B3 (d) Section 9 Concealed Spaces (Cavities) d. *if any hidden voids in the construction are sealed and sub-divided to inhibit the unseen spread of fire and products of combustion, in order to reduce the risk of structural failure and the spread of fire, in so far as they pose a threat to the safety of people in and around the building.*

11.2.15 Regarding the required fire performance of materials and products, this is dealt with in Appendix A of the Approved Document B. This states "*In such cases the material, product or structure should: a. be in accordance with a specification or design which has been shown by test to be capable of meeting that performance; or b. have been assessed from test evidence against appropriate standards, or by using relevant design guides, as meeting that performance; or*

11.2.16 I have provided my definition of relevant test evidence in Section 3 of my report. I have considered the end use application at Grenfell Tower (BS 476 – 10: 2009 Section 5.3) when assessing that relevant test evidence. I have considered any variations in test evidence when they been determined through

a carefully designed test programme or, by an assessment or expert judgement by an expert.

11.2.17 As explained in Appendix F, both European classification and National classification are recognised methods of demonstrating compliance. However, there is no guidance in either ADB 2013 or the Building Regulations 2010 on which takes precedence, in circumstances where the product is compliant with the required European Classification however fails to achieve the required National Classification or vice versa.

11.2.18 Therefore, I have concluded that External Surfaces - a material or the surface of a composite product can be either:

a) Class 0: When composed throughout of materials of limited Combustibility defined by testing to British Standards (by reference to Table A7 any test as per the National Class and Diagram 40 of ADB 2013); or

b) Class 0: A Class 1 material which has a fire propagation index (I) of not more than 12 and sub-index (i1) less than 6, defined by testing to British Standards (by reference to Section 13b of Appendix A of ADB 2013 and Diagram 40 of ADB 2013)

c) Class 0: Composed throughout of materials of limited Combustibility (Class A2 or better) defined by testing to European Standards (by reference to Table A7 European Class and Diagram 40 of ADB 2013); or

d) Class B or better: defined by testing using European Standards (by reference to Diagram 40 of ADB 2013).

11.2.19 In this Section 11 therefore, I have assessed any material used as an external surface at Grenfell Tower, with reference to each of these four allowable classifications.

11.2.20 I have also concluded in Appendix F of my report, that the insulation used at Grenfell Tower was required to be one of two classifications:

a) limited combustibility defined by testing to National Standards (by reference to Table A7, Row 8: insulation material in external wall construction referred to in paragraph 12.7); or

b) limited combustibility defined by testing to European Standards (Class A2 or better by reference to Table A7, Row 8: insulation material in external wall construction referred to in paragraph 12.7).

11.2.21 In this Section 11 therefore, I have assessed any material used as an insulation material at Grenfell Tower, with reference to each of these two allowable classifications.

11.2.22 I am aware that there are a range of opinions on whether ACP panels and their constituent parts should be considered an external surface; or by means of a

clarification issued by DCLG after the Grenfell fire, that ACP panels contain a core defined as Filler which requires consideration of the core as insulation.

11.2.23 I have provided my definition of Filler and my definition of the function of the core of an ACP in Appendix F, and therefore consider an ACP panel as a composite external surface.

11.2.24 I have relied on those definitions, when considering the relevant test evidence made available to me regarding the external surfaces at Grenfell Tower.

11.2.25 For the avoidance of any doubt, I consider an external surface formed with a composite of a polyethylene core, to be unable to comply with the functional requirement of B4(1) of the Building Regulations. I am concerned therefore, about the provisions made in Diagram 40 of the ADB 2013 which is statutory guidance, and advise these are changed as soon as possible. Please refer to my Conclusions in Section 2 of my report.

11.2.26 Regarding Grenfell Tower, the test evidence submitted to the Public Inquiry (Please refer to Appendix E of my report) includes National and European reaction to fire tests, as well as full scale test data from BS 8414-1:2002 or BS 8414-2:2005.

11.2.27 I have concluded, based on the test evidence submitted to the Public Inquiry at this time, and as that test evidence is relevant to the materials installed on Grenfell Tower:

a) the specified and installed insulation, rainscreen cladding panels and cavity barriers did not comply with the provisions made in Section 12 of the Approved Document B 2013.

b) the specified and installed insulation, rainscreen cladding panels and cavity barriers did not comply with the functional Requirement of B4 (1) of the Building Regulations.

11.2.28 This means the following materials were all noncompliant with ADB 2013 and with the functional requirement of B4(1) of the Building Regulations 2010 at the time of installation.

a) the ACP rainscreen cladding panel Reynobond 55 PE Cassette system (both colours);

b) the Styrofoam insulating core panel, Aluglaze, installed between the windows, and by the kitchen extract vents;

c) the Kingspan TP10 insulation installed around the kitchen extract fans (noting that although this was specified it may not have actually been installed as during my site investigation I observed the panel to be blue in one location which is the colour of Styrofoam. Please refer to Section 8.10.22 for further information);

d) the Celotex RS5000 and Kingspan K15 (and other Kingspan Kooltherm products as may apply) thermal insulation attached to the original concrete wall; and

e) the Celotex and Kingspan polymeric insulation boards used to insulate the window reveals, and close the new cavity formed between the old and new infill panels between the windows;

11.2.29 I have also concluded that some of the cavity barriers required by Section 9 of ADB 2013 were not installed on the night of the fire, specifically the cavity barriers required around window openings.

11.2.30 I have determined that the horizontal and vertical cavity barriers that were installed in the cavity formed by the ACP and the thermal insulation materials, were not classified for the required fire performance in ADB 2013, in the arrangement observed on Grenfell Tower.

11.2.31 This means:

a) Both the specified Siderise Lamatherm RH25G Ventilated breaks; and Siderise Lamatherm RVG full fill (non- ventilated) breaks; and

b) The installed Siderise Lamatherm RH25G in both the horizontal and vertical position.

11.2.32 Nor were the cavity barriers installed on site in accordance with the method given in the submitted test evidence, noting that test evidence was anyway not relevant to the end use application at Grenfell Tower. I have considered any variations in test evidence, when they been determined through assessment as was submitted by Siderise to the Public Inquiry. I found these not relevant to the installation at Grenfell Tower.

11.2.33 The entire building envelope system could not adequately resist the spread of fire over the walls having regard to the height, use and position of the building. I have presented herein the physical evidence that also supports my conclusion.

11.2.34 The building envelope system, designed and installed during the 2012-2016 refurbishment, was therefore non-compliant with the functional requirement of B4 and B3 (as it was relevant) of the Building Regulations 2010.

11.3 Basis of the Regulations as relevant to the construction of external walls

11.3.1 Both the Building Regulations and the provisions made in the statutory guidance document Approved Document B, recognise that there need to reduce the surface's susceptibility to ignition from an external source and to reduce the danger from fire spread up the external face of the building.

11.3.2 To reduce the risk of fire spreading across the external surface, Approved Document B puts performance limits on the materials used as part of the external wall of a building.

11.3.3 The external surfaces and insulation materials that make up the external facade must achieve a level of fire performance. Either, individually or all of the components of the external wall together, must have been shown by test to achieve the required performance.

11.3.4 Cavity barriers are required as part of the external wall build up. These are a form of construction that are necessary to restrict the spread of smoke and flames through cavities in a building.

11.3.5 As stated in BR135 for a ventilated cavity system: "*The walls are typically fitted with insulating material laid between the support railings, and the external panels are fitted to the railing system, leaving a ventilation cavity between the panels and the insulation. If the fire is able to enter the cavity, it may propagate unseen through the system if adequate fire barriers are not employed. This may result in significant risk of system collapse, or in the fire breaking out at significant distances from its origin. ...In order to counter the possibility of rapid fire spread and potential system collapse, the design and selection of materials used to construct these systems should address these issues, including the provision of fire barriers*."

11.3.6 The methods of testing materials and products to demonstrate they achieve the recommended fire classifications in Appendix A of the ADB 2013, are discussed in detail in Appendix F of my report.

11.4 Components of the external wall at Grenfell Tower

11.4.1 In Section 8 of my Expert Report I have described in detail the construction forming the external wall of Grenfell Tower, as I found on site, and through my investigation of available drawings, specifications and other documentation.

11.4.2 In Figure 11.1, I have illustrated the resulting principal components of the external wall construction.

11.4.3 In Table 11.1, I have categorised each component according to the classifications used in ADB 2013 for the key components of an external wall system: namely 'External surfaces', 'insulation material/products' and 'Cavity barriers'. The Relativity references for where I obtained this information are provided in Table 11.1.

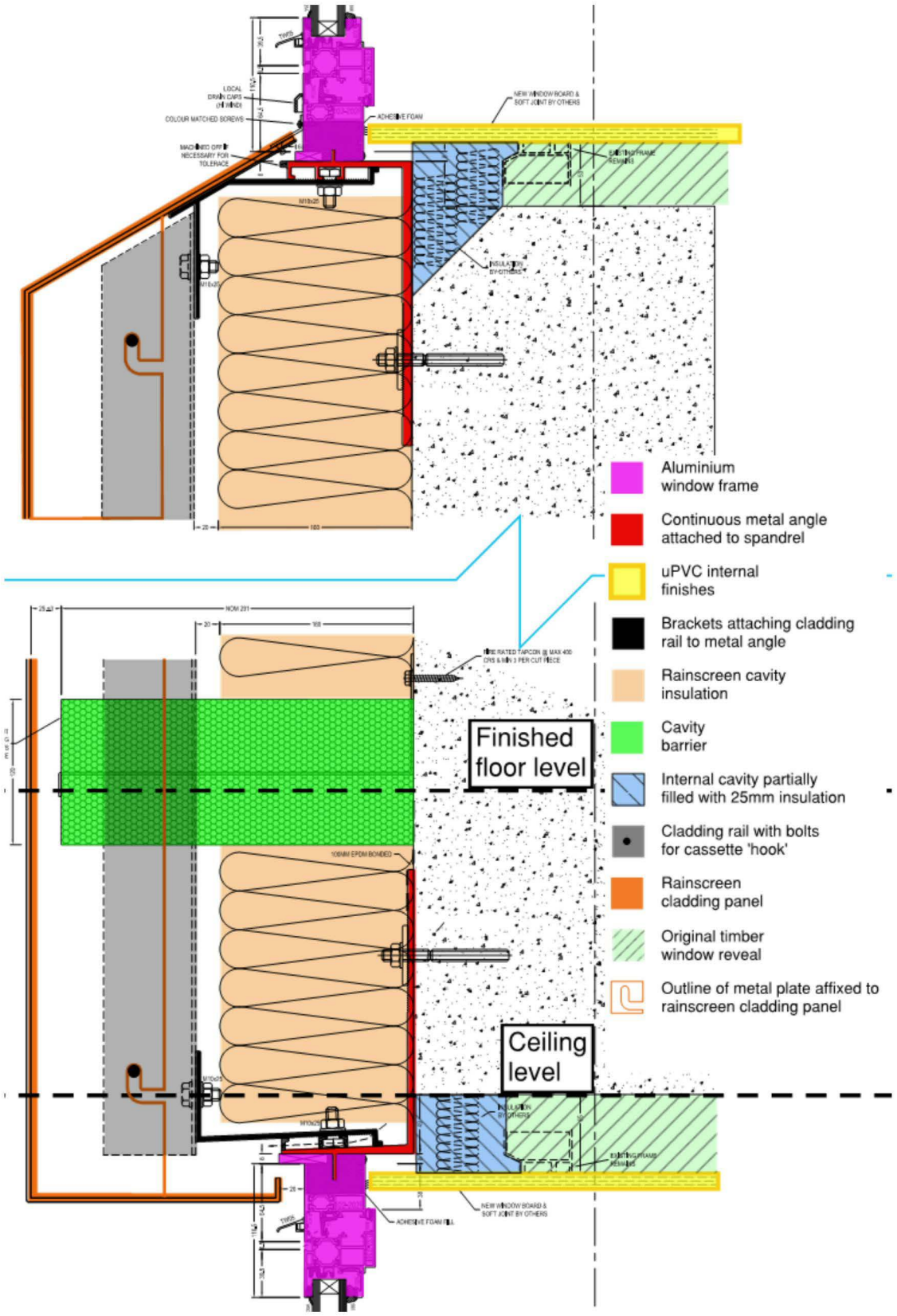


Figure 11.1 Locations of elements of construction relating to the external wall– Section view [annotated HAR00008879 & HAR00008901]

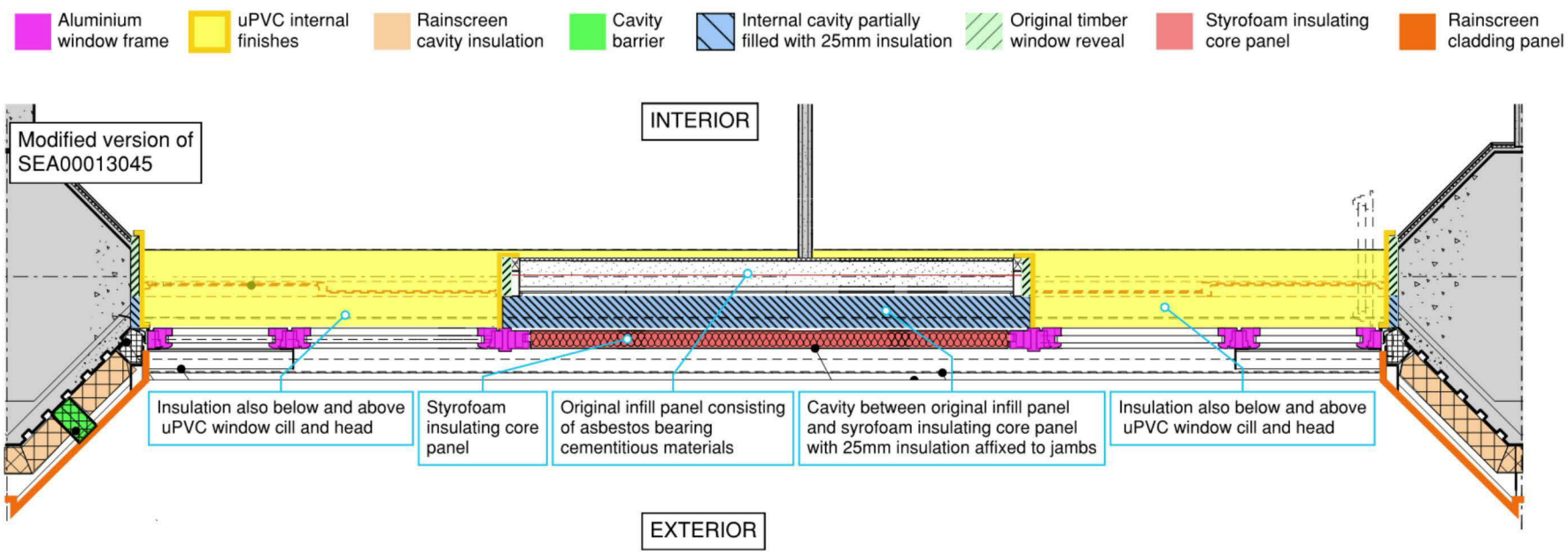


Figure 11.2 Locations of elements of construction relating to the external wall – Plan view [annotated and modified SEA00013045]

Table 11.1 Components of the external wall construction of Grenfell Tower from Level 4 to Level 23.

External wall component		**Product installed on Grenfell tower (Determined from drawings, purchase orders and site inspections observations)**
External surfaces	Rainscreen Aluminium Composite Cladding panel	Reynobond 55 PE ACP [Identified from Arconic Inc. order acknowledgements ARC00000012; ARC00000027; ARC00000043; ARC00000215] Cassette fixing (hanging) with bolts was observed onsite Two different surface finishes were applied to the ACP panels installed on Grenfell Tower Reynobond 55 PE 4mm Smoke Silver Metallic E9107S DG 5000 Washcoat – the Arconic Inc. order acknowledgements and associated CEP purchase orders confirm the total area of this product purchased for Grenfell Tower was 6586 m^2 (note this product was supplied in five different lengths and three different widths); and Reynobond 55 PE 4mm Pure White A9110S DG 5000 Washcoat- the Arconic Inc. order acknowledgement and associated CEP purchase order confirms the total area of this product purchased for Grenfell Tower was 180m^2 (note this product was supplied in 2.3m length and 1.5m width). The Reynobond 55 PE 4mm Smoke Silver Metallic E9107S DG 5000 Washcoat was specified on levels 04-23 for both the columns and the spandrels (refer to drawings C1059-200 Rev I [HAR00008581]; C1059-201 Rev D [HAR00008582]; C1059-202 Rev C [HAR00008583]) The Reynobond 55 PE 4mm Pure White A9110S DG 5000 Washcoat was only specified to be used on level 3 (refer to drawings C1059-206 Rev A; C1059-204 Rev C; C1059-205 Rev D in RYD00092653 (page 9) RYD00092653 (Page 10), RYD00092653 (Page 14) respectively)

External wall component		**Product installed on Grenfell tower (Determined from drawings, purchase orders and site inspections observations)**
	Insulated core panel – installed between windows (aluminium external surface)	Aluglaze Panels 28mm thick *Outer – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)* *Core – 25mm Styrofoam* *Inner – 1.55 Aluminium skin RAL 9010 Matt (30% Gloss)* [Identified from drawing C1059 -100 Rev I [HAR00008991] and purchase order [HAR00007785] 'Glazing panel P1' and observed on site
	Core insulating panel – installed around kitchen extract fans (aluminium external surface)	*Outer – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)* *Core – 25mm Kingspan TP10 Rigid Insulation* [Note not observed on site – Styrofoam core only observed] *Inner – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)* [Identified from drawing C1059-100 Rev I [HAR00008991] 'Glazing panel P2] Not observed on site.
Insulation materials/products	Thermal insulation attached to the existing columns and the existing concrete spandrels	Celotex RS5000 [SIG00000010, HAR00000583 and HAR00000781] And observed on site
	Thermal insulation used on the existing concrete spandrels only	Kingspan K15 was purchased, as I have concluded, from the purchase order [SIG00000012]. Kingspan Kooltherm insulation was observed installed onsite in photographic evidence only [KIN0000015] however the exact product installed cannot be determined in the photo disclosed.
	Insulation installed behind UPVC window reveals	25mm rigid insulation board. Not shown on drawings but observed onsite. Pending exact polymeric material formulation confirmation. Site evidence shows likely it is Kingspan TP10 or Celotex TB4000, based on material thickness.
	Insulation installed to seal the new cavity between old window infill and new window infill panel	25mm rigid insulation board. Not shown on drawings but observed onsite. Pending exact polymeric material formulation confirmation. Site evidence shows likely it is Celotex TB4000.

External wall component		**Product installed on Grenfell tower (Determined from drawings, purchase orders and site inspections observations)**
Cavity barriers	Vertical Cavity barriers installed on columns only	Siderise Lamatherm RH25G 90/30Ventilated breaks Observed on site (note this is not in accordance with the design specification which was Siderise Lamatherm RVG full fill (non- ventilated) breaks).
	Horizontal Cavity barriers	Siderise Lamatherm RH25G-120/60 (G – Level 3)/ or RH25G-90/30 (Level 4 upwards) Ventilated breaks [C1059-100 Rev I [HAR00008991]] Observed on site
Damp proof course	Damp proof course (note: material performance affects the spacing of cavity barriers in Table 13 of ADB 2013 – does not apply to any floor with all residential use)	EPDM [Identified from drawing C1059 -302 [HAR00008880] and observed on site]

11.5 External wall surfaces – the multiple classifications provided for in Section 12.6 of ADB 2013

11.5.1 Figure 11.3 below shows the external façade of Grenfell Tower prior to completion.

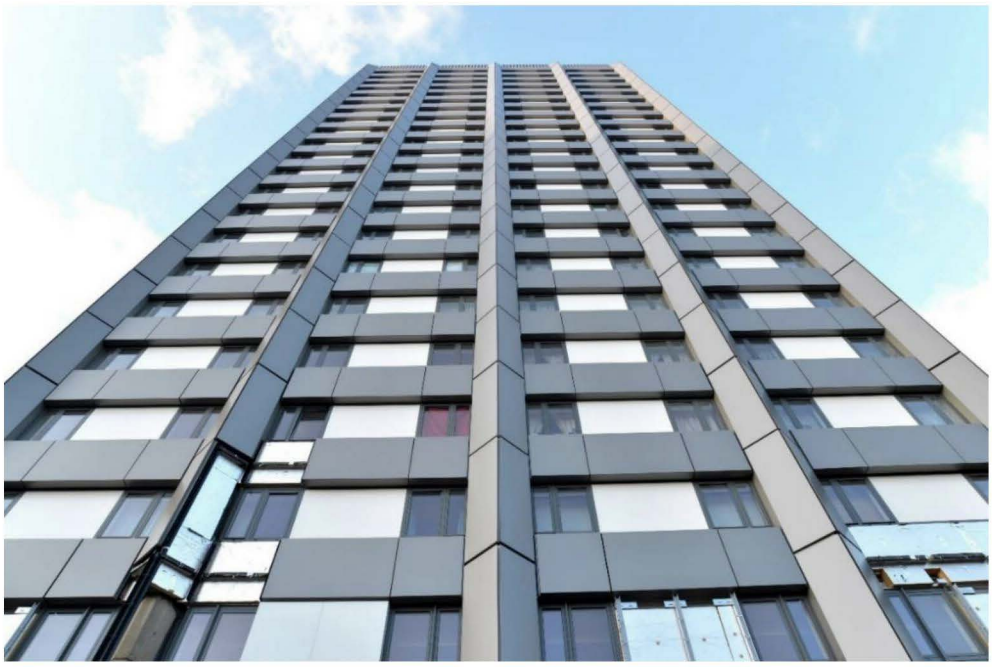


Figure 11.3: External view of Grenfell Tower prior to the fire (during refurbishment) (SEA00000367)

11.5.2 I have explained in Appendix F that Section 12.6 and Diagram 40 of ADB 2013 set out the fire performance requirements for external wall surfaces.

11.5.3 It should be noted that ADB 2013 does not define what an external wall surface is, and particularly how it relates to composite external surface materials, such as used in ACP based rainscreen cladding panels.

11.5.4 I am aware that due to this lack of definition in ADB 2013 there are differing views on what constitutes the external surfaces of Grenfell Tower.

11.5.5 My method of defining an external wall surface is described in Appendix F, and my resulting opinion is summarised as follows.

11.5.6 The ventilated rain screen system contains an outer layer (the rain screen), intended to shelter the building from the majority of direct rainfall and to resist wind load.

11.5.7 For an ACP, the core of the panel is required to transfer the shear force between the two sheets of aluminium i.e. integral to the structural performance of the panel. Some joints between panels or at the edges of the rain screen are left open.

11.5.8 The rainscreen panel is thin at 4mm, with bulk of the panel (3mm) formed of the core material. Therefore, its fire performance can only be determined by an assessment of the materials in their composite form, together, and with the exposed edges present in the relevant fire test. These exposed edges were also observed on site at Grenfell Tower.

11.5.9 I do not agree that the polymeric core is a Filler as associated with surfaces and joints of insulation materials and products, and dealt with only in Section 12.7 of the ADB 2013. I address this in Section 11.10 of my report, based on my analysis presented in Appendix F of my report.

11.5.10 The provisions made in Diagram 40 of ADB 2013 are relevant to the external surface at Grenfell Tower, and specifically Diagram 40e as the Tower was a building of height greater than 18m, and where the distance to the boundary line with adjacent buildings was more than 1m.

11.5.11 Diagram 40e is shown below in Figure 11.4:

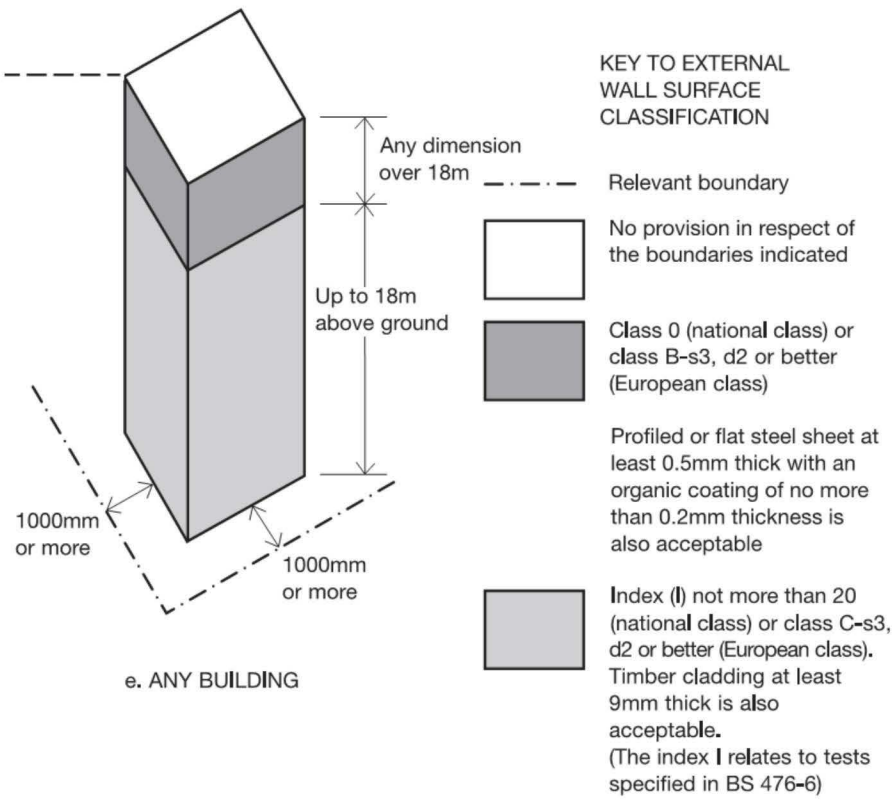


Figure 11.4 diagram 40e of ADB 2013

11.5.12 Diagram 40e of ADB 2013 provides for multiple classifications for external surfaces below 18m and for external surfaces located above 18m.

11.5.13 At Grenfell Tower Ground to Level 05 is less than 18m above ground. Levels 06 – roof level are greater than 18m above ground. This is shown in Figure 11.5.

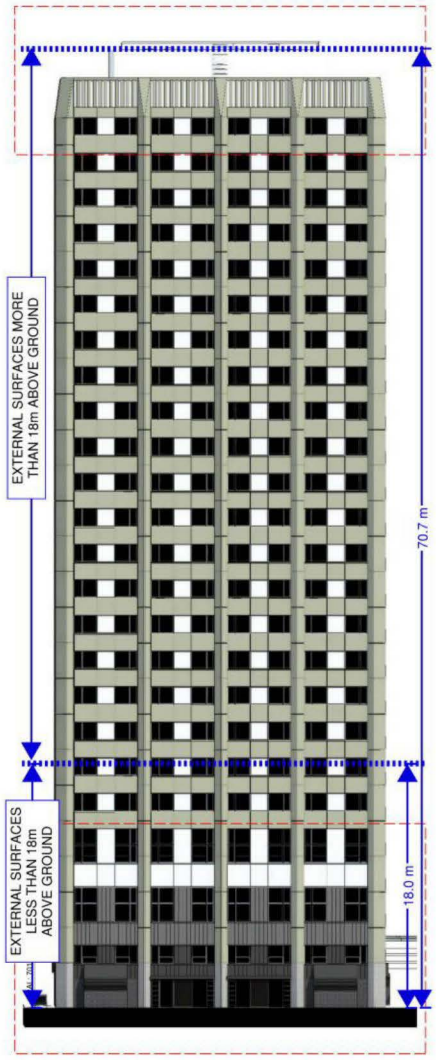


Figure 11.5 External surfaces above 8m in Grenfell Tower (SEAL-INQ001-00005101[SEA00002845])

11.5.14 I have dealt with Level 04 and above only here as the fire was observed to start on Level 04 and spread upwards (see Section 7 of my report).

11.5.15 The following provisions are made in Diagram 40.
(1) the external surfaces up to 18m - tested to National Class BS 476-6 (Index (I) not more than 20) or European Class (C-s3, d2 or better). This applies to the rainscreen cladding at level 04 and 05.

(2) the external surfaces greater than 18m above ground – tested to National Class: Class 0 or European Class: Class B-s3, d2 or better. This applies to the rainscreen cladding from Level 06 to roof level.

11.5.16 As detailed in Appendix F of my report, there are multiple performance definitions made for Class 0 in ADB 2013:

a) Class 0: when composed throughout of materials of limited combustibility defined by testing to British Standards (by reference to Section 13.a of Appendix A ADB 2013); or

b) Class 0: a Class 1 material which has a fire propagation index (I) of not more than 12 and sub-index (i1) less than 6, defined by testing to British standards (by reference to Section 13.b of Appendix A of ADB 2013); or

c) Class 0: composed throughout of materials of limited combustibility (Class A2 or better) defined by testing to European Standards (by reference to Section 13.a of Appendix A ADB 2013).

11.5.17 Therefore, with these three definitions, and the additional classification presented in Diagram 40 of Class B or better - defined by testing using European Standards - this results in four different classification routes to achieve the provisions in Diagram 40.

11.5.18 I have assessed the available test evidence on the basis of these 4 classification routes.

11.5.19 It is my opinion that two of these routes are of concern. Class B because it is a lower performance standard than the definition of a material of limited combustibility provided in Table A7 of ADB 2013, and Class 1 because this relates to a surface spread of flame test only which is an entirely different fire standard to overall material combustibility.

11.5.20 Diagram 40 currently makes provision by means of all four. To remove this difference, I recommend Class B and Class 1 be deleted from Diagram 40, as it applies to the matters being considered in this Public Inquiry - high rise residential buildings.

11.5.21 I would go so far as to suggest this should extend to any building containing a sleeping risk, such as hospitals, based on the observed fire performance during the Grenfell Tower fire.

11.6 Compliance assessment of the Rainscreen cladding panels fire safety performance at Grenfell Tower

11.6.1 I have investigated the disclosed design and construction stage documents to identify the specific rainscreen cladding products installed at Grenfell Tower.

11.6.2 Based on my review of the Arconic Inc. order acknowledgement for the cladding system of Grenfell Tower (ARC00000012; ARC00000027; ARC00000043; and ARC00000215) I conclude that Reynobond 55 PE DG5000 was purchased in two different surface finishes either Silver metallic E9107S or Pure White A9110S colours.

11.6.3 The rainscreen cladding on levels 04- 23 was specified as Reynobond 55 PE DG5000 Silver metallic E9107S. (refer to drawings C1059-200 Rev I

(HAR00008581); C1059-201 Rev D (HAR00008582); C1059-202 Rev C (HAR00008583))

11.6.4 The Reynobond 55 PE DG5000 Pure White A9110S was only specified to be installed on level 3 (refer to drawings C1059-206 Rev A; C1059-204 Rev C; C1059-205 Rev D in RYD00092653 (page 9) RYD00092653 (Page 10), RYD00092653 (Page 14) respectively).

11.6.5 I have compared the panels I observed onsite against the standard Arconic details in Section 8 of this report.

11.6.6 As the sizes of the panels, and the fixing method of the panels I observed onsite varies from the standard Arconic details, I conclude that a bespoke system (using Reynobond 55 PE panels but not in accordance with the standard Arconic systems).

11.6.7 Therefore, whilst I currently assess test evidence for the Reynobond 55 PE cassette systems (as supplied to the Public Inquiry by Arconic Inc.) as the most relevant test evidence, I note the differences I have found with the on-site application.

11.6.8 During my onsite investigation I found evidence of ACM panels installed with a black core. This is shown below in Figure 11.6.

Figure 11.6 Black core observed onsite (photograph from flat 10 on level 3)

11.6.9 I note from the disclosed classification reports *Reaction to fire classification report No. RA15-0200 according to the European Standard NF EN 13501-1+A1:2013* (ARC00000402) and *Reaction to fire classification report No. RA15-0201 according to the European Standard NF EN 13501-1+A1:2013* (ARC00000405) that Arconic supply the panels with either black cores or translucent cores. I also note that the two different core types achieve

different test results to BS EN 13823 as stated in the classification reports referenced above.

11.6.10 I note however both core types are classified with one reaction to fire performance as either Class E for the cassette system (ARC00000405) or Class C for the riveted system (ARC00000402). Please refer to Appendix E where I provide a full review of all of the test evidence disclosed

11.6.11 It should be noted that the reaction to fire performance stated above is dependent on the panels being installed with a class A2 or better substrate (ARC00000405), (ARC00000402), not the Class D Celotex insulation the panels were actually installed with on Grenfell Tower. I discuss the effect of this on the compliance of the Grenfell Tower panels later in this section.

11.6.12 My site inspection was limited to certain areas of the building. I therefore cannot rule out that panels with translucent cores might have been installed elsewhere on the building.

11.6.13 Fire tests will be carried out by Professor Luke Bisby to independently establish also, the core is PE and what formulation. I will update my report if it becomes necessary to do so, should those tests identify a core that is not formed of PE.

11.6.14 I have investigated the test evidence provided for this Reynobond product with the provisions made for external surfaces with a dimension more than 18m above ground (levels 06-23).

11.6.15 I have also investigated the test evidence provided for this Reynobond product where it is used below 18m (levels 04 and level 05) as the requirements for external surfaces with a dimension less than 18m above ground are different. That is, National Class Index I is less than 20 or European Class C-s3, d2 or better.

11.6.16 Based on the available test / classification evidence disclosed by Arconic and the British Board of Agrément (BBA), I have found that fourteen *Reynobond Architecture Wall cladding Panels* have been tested/classified for reaction to fire performance between 1997 and 2015. These are:

a) Four panels described as REYNOBOND ® 55 PE (cassette system)
b) Four panels described as REYNOBOND ® 55 PE (riveted system)
c) Three panels described as REYNOBOND 33
d) One panel described as REYNOBOND 55 FR
e) One panel described as Reynobond FR (riveted system)
f) One Panel described as Reynobond RB 160 PE

11.6.17 I have provided the list of all fire test reports provided to the Public Inquiry by Arconic Inc. in Appendix E.

11.6.18 At this stage I have only considered the Reynobond 55 PE cassette system, based on my review of purchase orders and my site inspections, and I did not observe a riveted system installed on Grenfell Tower.

11.6.19 Four of the *Reynobond Architecture Wall Cladding panels* tested/classified between 1997 and 2015 were for panels described as Reynobond 55 PE (cassette fixed) ACP, which was the type of panel and method of fixing used for Grenfell Tower. These are listed in Table 11.2. These are all European Classification reports.

11.6.20 I have received no National classification reports for Reynobond 55 PE (cassette).

11.6.21 Arconic have disclosed 5 classification reports to BS EN 13501-1 for the Reynobond 55 PE cassette system.

11.6.22 I have reviewed test evidence specific to the Reynobond 55 PE cassette system against the European Class only, as follows:

a) Class 0: composed throughout of materials of limited Combustibility (Class A2 or better) defined by testing to European Standards (Table A7 European classes); or

b) Class B or better when classified to BS EN 13501-1.

Table 11.2 Arconic Inc. European classification reports for Reynobond 55 PE (cassette) ACP

Report No.	Product	Report Description	Date of Issue	Sponsor	Applicability during construction
RA15-0201 (ARC00000405)	REYNOBOND® 55 PE (cassette system) – Black core & translucent core	NF EN 13501-1+A1:2013 Classification using BS EN ISO 19925-2.	22/09/2015	ALCOA ARCHITECTURAL PRODUCTS S.A.S.	Yes
RA13-0333 (ARC00000395)	REYNOBOND ® 55 PE (cassette system) – core colour not stated	NF EN 13501-1+A1:2013 Classification using BS EN ISO 19925-2.	04/12/2014	ALCOA ARCHITECTURAL PRODUCTS S.A.S.	Yes
RA13-0333 (ARC00000393)	REYNOBOND ® 55 PE (cassette system) – core colour not stated	NF EN 13501-1+A1:2013 Classification using BS EN ISO 19925-2.	31/01/2014	ALCOA ARCHITECTURAL PRODUCTS S.A.S.	No-This report superseded by RA13-0333 (04/12/2014)
RA11-0244 (ARC00000386)	REYNOBOND Architecture PE Cassette system	NF EN 13501-1+A1:2013 Classification using BS EN ISO 19925-2.	12/10/2011	ALCOA ARCHITECTURAL PRODUCTS	No-This Report Superseded by RA13-0333
RA05-0005B (ARC00000360)	"REYNOBOND ® 55 PE system a cassette (chants fermes) gris/vert Duragloss 5000 coating"	NF EN ISO 11925-2 NF EN 13823	07/01/2005	ALCOA ARCHITECTURAL PRODUCTS	No- test report only valid for 5 years

11.6.23 The Arconic Inc. order acknowledgements for the Reynobond 55 PE cladding panels (ARC00000012, ARC00000027; ARC00000043; ARC00000215) are dated 20/03/2015; 21/07/2015; 12/11/2015; and 06/10/2015.

11.6.24 If a report is submitted after a material is installed and meets the required standard, it shows the material met the requirements, although that was not demonstrated at the time of the installation.

11.6.25 RA05-0005B (ARC00000360) was written in 2005 and the classification report states that it is only valid for 5 years. The classification report was therefore not applicable at the time of purchase of the Panels for Grenfell Tower. I have anyway incorporated it in my review, for completeness.

11.6.26 Similarly, RA11-0244 (ARC00000386) was superseded by RA13-0333 (ARC00000393) which in turn was superseded by RA13-0333 (04/12/2014) (ARC00000395) prior to the purchase of the Reynobond 55 PE cassette panels. Neither RA11-0244 (ARC00000386) or RA13-0333 (ARC00000393) were relevant reports at the time of purchase of the panels. I have anyway incorporated it in my review, for completeness.

11.6.27 I summarise my findings in Table 11.3. Please note I have for clarity provided my conclusions for each of the 4 classifications provided for by means of Diagram 40 - as I explained above.

11.6.28 In column 1 of Table 11.3, I have listed the report reference and the test sponsor of the evidence submitted.

11.6.29 In column 2 of Table 11.3, I have listed the date of issue of the reports.

11.6.30 In column 4 of Table 11.3, I list the classification of the material provided in the test report and confirm the test standard used to provide the classification.

11.6.31 In conclusion all of the classification reports disclosed to date state that the Reynobond 55 PE cassette achieves the standard Class E.

11.6.32 Class E is not a material of limited combustibility and is substantially lower than the performance required (Class A2 or better).

11.6.33 Class E is not Class B and is substantially lower than the performance required (Class B or better).

11.6.34 It is important to note that the Class E classification stated in Table 11.3 is only achieved when the product is installed with a substrate (i.e. thermal insulation) of Class A2 or better. The thermal insulation used on Grenfell Tower was Class D (refer to 11.13.17) therefore none of the classification reports are applicable to the façade system installed on Grenfell Tower.

11.6.35 I have provided additional information in Appendix O regarding the BBA certificate available at the time of the primary refurbishment works, and why I have rejected it as an appropriate means to demonstrate assessment of relevant test evidence meeting the required performance.

Table 11.3 REYNOBOND® 55 PE (cassette system) reaction to fire performance to European Standard tests and assessment of compliance with ADB 2013 all 4 classifications provided for in Diagram 40

Report No & Sponsor	Date of issue of report	Report relevant at time of purchase	Product	Test/ classification results	Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using National Class test methods as per Table A7 of ADB 2013	Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using European Class test methods as per Table A7 of ADB 2013	Class 0 in accordance with Section 13b of Appendix A of ADB 2013	Class B or better material classified to BS EN 13501-1
RA15-0201 (ARC00000405) ALCOA ARCHITECTURAL PRODUCTS S.A.S.	22/09/2015	Yes- Product purchased after this date	REYNOBOND® 55 PE (cassette system) (translucent core)	**Class E** BS EN ISO 11925-2 - Flame Spread (Fs) (within 60s) (mm)- <150mm for both surface and edge exposure (Test report RA15-0201; RA13-0333)	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No.** Class E is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No.** Class E is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013
		Yes- Product purchased after this date	REYNOBOND® 55 PE (cassette system) (black core)	**Class E** BS EN ISO 11925-2 - Flame Spread (Fs) (within 60s) (mm)- <150mm for both surface and edge exposure (Test report RA15-0201; RA13-0333)	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013
RA13-0333 (ARC00000395) ALCOA ARCHITECTURAL PRODUCTS S.A.S.	04/12/2014	Yes- Product purchased after this date	REYNOBOND ® 55 PE (cassette system)	**Class E** BS EN ISO 11925-2 - Flame Spread (Fs) (within 60s) (mm)- <150mm for both surface and edge exposure (RA13-0333)	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013
RA13-0333 (ARC00000393) ALCOA ARCHITECTURAL PRODUCTS S.A.S.	31/01/2014	No- Report was superseded at time of purchase	REYNOBOND ® 55 PE	**Class E** BS EN ISO 11925-2 - Flame Spread (Fs) (within 60s) (mm)- <150mm for both surface and edge exposure (Test report RA13-0333)	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013

Report No & Sponsor	Date of issue of report	Report relevant at time of purchase	Product	Test/ classification results	Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using National Class test methods as per Table A7 of ADB 2013	Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using European Class test methods as per Table A7 of ADB 2013	Class 0 in accordance with Section 13b of Appendix A of ADB 2013	Class B or better material classified to BS EN 13501-1
RA11-0244 (ARC00000386) ALCOA ARCHITECTURAL PRODUCTS S.A.S.	12/10/2011	No- Report was superseded at time of purchase	REYNOBOND Architecture PE Cassette system	**Class E** BS EN ISO 11925-2 - Flame Spread (Fs) (within 60s) (mm)- <150mm for both surface and edge exposure (Test report RA11-0032)	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013
RA05-0005B (ARC00000360) ALCOA ARCHITECTURAL PRODUCTS	07/01/2005	No- test report out of validity date of 5 years after issue	REYNOBOND ® 55 PE system a cassette (chants fermes) gris/vert Duragloss 5000 coating	**Class E** FIGRA and THR600s class exceed class D limit	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No**. Class E is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013

11.7 Test evidence for Reynobond systems defined by Arconic Inc. as "Reynobond 55 PE riveted"

11.7.1 Arconic Inc. also disclosed classification reports for Reynobond 55 PE riveted system.

11.7.2 I note that the Arconic order acknowledgements (ARC00000012, ARC00000027; ARC00000043; ARC00000215) do not state whether the system supplied was cassette, riveted, or screw fixed and that the panels.

11.7.3 In Section 8, I concluded that the panels I observed onsite were not formed or fixed in accordance with the standard Arconic standard details.

11.7.4 I have therefore reviewed all of the evidence available for Reynobond 55PE irrespective of fixing type, for completeness not just the cassette test evidence.

11.7.5 My findings are presented in Table 11.7.

11.7.6 In column 1 of Table 11.4, I have listed the report reference and the test sponsor.

11.7.7 In column 2 of Table 11.4, I have listed the date of issue of the reports.

11.7.8 In column 5 of Table 11.4, I list the classification of the material provided in the test report and confirm the test standard used to provide the classification.

11.7.9 In conclusion all of the classification reports disclosed prior to 04/12/2014, conclude the riveted product was classified as Class B, by testing using European Standards BS EN 13823 and BS EN ISO 11925-2. This classification is in accordance with Section 12.6 of ADB 2013, by means of the provisions in Diagram 40, for any dimension over 18m.

11.7.10 However, since the 04/12/2014 the riveted Reynobond 55 system, was downgraded to Class C and was therefore no longer in accordance with Section 12.6 of ADB 2013, by means of the provisions in Diagram 40, for any dimension over 18m.

11.7.11 The earliest Arconic Inc. order acknowledgements for the Reynobond 55 PE cladding panels (ARC00000012) is dated 20/03/2015, therefore after the system classification was downgraded at that stage.

Table 11.4 REYNOBOND® 55 PE (riveted system) reaction to fire performance to European Standard tests and assessment of compliance with ADB 2013 diagram 40 provisions

Report No & Sponsor	**Date of issue of report**	**Report Relevant at time of purchase**	**Product**	**Test/ classification results**	**Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using National Class test methods as per Table A7 of ADB 2013**	**Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using European Class test methods as per Table A7 of ADB 2013**	**Class 0 in accordance with Section 13b of Appendix A of ADB 2013**	**Class B or better material**
REACTION TO FIRE CLASSIFICATION REPORT No. RA15-0200 ACCORDING TO THE EUROPEAN STANDARD NF EN 13501-1+A1:2013 (ARC00000415) ALCOA ARCHITECTURAL PRODUCTS S.A.S.	22/09/2015	Yes- Product purchased after this date	REYNOBOND® 55 PE (cassette system) (translucent core)	**Class C**	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class C is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No**. Class C is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013
REACTION TO FIRE CLASSIFICATION REPORT No. RA14-0339 ACCORDING TO THE EUROPEAN STANDARD NF EN 13501-1+A1:2013 (ARC00000397) ALCOA ARCHITECTURAL PRODUCTS S.A.S.	04/12/2014	Yes- Product purchased after this date	REYNOBOND® 55 PE (cassette system) (black core)	**Class C**	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class C is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**No**. Class C is a lower classification than the Class B or better required to demonstrate compliance with Diagram 40 of ADB 2013
REACTION TO FIRE CLASSIFICATION REPORT No. RA11-0032 ACCORDING TO THE EUROPEAN STANDARD NF EN 13501-1+A1:2013 (ARC00000383)	09/02/2011	No- Report was superseded at time of purchase	REYNOBOND ® 55 PE Riveted system	**Class B**	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class B is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**Yes** The material is Class B or better as required to demonstrate compliance with Diagram 40 of ADB 2013

Report No & Sponsor	Date of issue of report	Report Relevant at time of purchase	Product	Test/ classification results	Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using National Class test methods as per Table A7 of ADB 2013	Class 0 in accordance with Appendix A section 13a of ADB 2013 (Material of limited combustibility using European Class test methods as per Table A7 of ADB 2013	Class 0 in accordance with Section 13b of Appendix A of ADB 2013	Class B or better material
REACTION TO FIRE CLASSIFICATION REPORT No. RA05-0005A ACCORDING TO THE EUROPEAN STANDARD NF EN 13501-1+A1:2013 (ARC00000358)	07/01/2005	No- Report was superseded at time of purchase and out with date of validity	REYNOBOND ® 55 PE Riveted system grey/green Duragloss 5000 coating	**Class B**	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class B is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**Yes** The material is Class B or better as required to demonstrate compliance with Diagram 40 of ADB 2013
RAPPORT D'ESSAIS DE REACTION AU FEU N0 RA05-0005A SELON LES NORMES EUROPEENNES NF EN 13823 ET NF EN ISO 11925-5 (ARC00000359)	07/01/2005	No- Report was superseded at time of purchase and out with date of validity	REYNOBOND ® 55 PE system rivete gris/vert Duragloss 5000 coating	**Class B**	No evidence provided to demonstrate the material achieves the provisions of Table A7 to national classification and hence compliance with Diagram 40.	**No**. Class B is a lower classification than the Class A2 or better required to demonstrate limited combustibility in accordance with Table A7 of ADB 2013 and hence compliance with Diagram 40.	No evidence provided to demonstrate the material achieves Class 1 to BS 476-7 and I<12 i1<6 to BS 476-7 and hence compliance with Diagram 40.	**Yes** The material is Class B or better as required to demonstrate compliance with Diagram 40 of ADB 2013

11.8 BBA certificates relevant to Reynobond systems

11.8.1 As part of the disclosure, I have received three BBA Agrément certificates for "*Reynobond Architecture Wall Cladding panels".* These are:

a) Agrément Certificate 08/4510 Product Sheet 1 REYNOBOND ARCHITECTURE WALL CLADDING PANELS 1st issue 14/01/2008 (BBA00000047) (ARC00000368)

b) Agrément Certificate 08/4510 Product Sheet 1 ARCONIC CLADDING PANELS REYNOBOND ARCHITECTURE WALL CLADDING PANELS 2nd issue 04/08/2017(BBA00000046) (ARC00000415)

c) Agrément Certificate 08/4510 Product Sheet 1 ARCONIC CLADDING PANELS REYNOBOND ARCHITECTURE WALL CLADDING PANELS 2nd issue amended 22/09/2017 (BBA00000049)

11.8.2 Of these three, only the 2008 1st issue Agrément Certificate 08/4510 was published before the Grenfell Tower Fire.

11.8.3 In Appendix O, I have undertaken a specific review of the 2008 first issue BBA Agrément Certificate 08/4150 for *Reynobond Architecture Wall Cladding Panels* (ARC00000368) (BBA00000047) that was applicable during the 2012-2016 refurbishment of Grenfell Tower.

11.8.4 From my review in Appendix O, I have found the following:

11.8.5 The front page of the 2008 issue of BBA Agrément Certificate 08/4510(ARC00000368) (BBA00000047) states *that "the panels are judged to meet the Class 0 requirements"* and refers the reader to sections 6.1 to 6.6 of the certificate.

11.8.6 Section 13 of the 2008 issue of BBA Agrément Certificate 08/4510 (ARC00000368) is titled "*Conditions of use of the certificate".*

11.8.7 Section 13.1 states:

"13.1 This certificate

Relates only to the product/ system named and described on the front page"

11.8.8 The product names on the front page of the 2008 issue of BBA Agrément Certificate 08/4510 (ARC00000368) is *"Reynobond Architecture Wall Cladding Panels".*

11.8.9 This statement on the front page of the certificate implies that the Class 0 classification applies to all *"Reynobond Architecture Wall Cladding Panels"* as it does not include any limitations on what constitutes "the panels" e.g. thickness; core type; surface coating; fixing method.

11.8.10 As I explained in Appendix F the three methods by which Class 0 is defined are:

a) Limited Combustibility by National Standard testing (BS 476-4, BS476-11)

b) Class 0 – Limited Combustibility by European Standard testing (Class A2 or better to BS EN 13501-1)

c) Class 0 – Class 1 to BS 476-7 and I<12 i1<6 to BS 476-6

11.8.11 Section 6.1 to Section 6.6 of the BBA Agrément Certificate references the fire performance of three panels only. These are:

a) Standard sample with a Grey/Green Duragloss 5000 coating- B-s2, d0 to EN 13501-1: 2002

b) Fire retardant sample with a Gold Duragloss finish- B-s1, d0 to EN 13501-1: 2002

c) Fire retardant sample with a metallic grey PVDF finish- I=0 to BS 476-6 and Class 1 to BS 476-7

11.8.12 BBA confirmed to the inquiry by letter (BBA00000001) that the fire performance on the BBA certificate was only based on the following products/test reports:

a) Grey/green 55 (also known as PE), B-S2, d0, via CSTB Report RA-0005A (BBA00000048)

b) Gold FR, B-s1, d0, via CSTB Report RA06-0372 (BBA00000054)

c) Metallic Grey FR, BS 476-6: 1989, Warrington Fire Research Report 132317 (BBA00000053)

d) Metallic Grey FR, BS 476-7: 1997, Warrington Fire Research Report 132316 (BBA00000050)

11.8.13 This information was obtained through the PI disclosure process by letter (BBA00000001) only. The Agrément certificate does not identify the test evidence that was used as the basis for the statement of reaction to fire performance.

11.8.14 I have received test or classification reports as part of the disclosure from both Arconic and the BBA. From review of this information I have found that there are at least 14 variations of Reynobond Architecture Wall Cladding Panels.

11.8.15 I have reviewed all of these reports, not just the ones that the BBA has said are relevant to the 2008 issue of BBA Agrément Certificate 08/4510, to find if all Reynobond Architecture Wall Cladding Panels have the relevant test evidence demonstrating they achieve Class 0.

11.8.16 From my review I have found that, prior to the issue of BBA Agrément Certificate 08/4510 in 2008:

a) Five of the seven Reynobond Architecture Wall Cladding Panels meet one of the three ADB definitions of Class 0. These are Reynobond RB

160 PE; Reynobond 55 FR ACM metallic grey PVDF; REYNOBOND 33 (Overall thickness 3mm); REYNOBOND 33 (Overall thickness 4mm); REYNOBOND 33 (Overall thickness 2mm).

b) Of these three that achieve Class 0, only the Reynobond 55 FR ACM metallic grey PVDF is referenced on the 2008 issue of BBA Agrément Certificate 08/4510.

c) The other two Reynobond Architecture Wall Cladding Panels do not meet any of the three ADB definitions of Class 0. The reason for this is that all nine of these Reynobond Architecture Wall Cladding Panels have a European classification worse than the A2 classification required for Class 0 and there is no supporting National classification to show that they comply and are either limited combustibility, or Class 1 to BS 476-7 and I<12 i1<6 to BS 476-6.

11.8.17 Based on my review above, it is clear that the statement on the front page of the 2008 issue of BBA Agrément Certificate 08/4510 that *"the panels are judged to meet the Class 0 requirements*" is incorrect as two of the three panels specifically referenced in that certificate do not achieve Class 0 by any of the three means defined in Clause 13 of Appendix A of ADB.

11.8.18 Further detailed information on this topic is provided in Appendix O.

11.9 Other Reynobond panels for which there has been disclosed reaction to fire test evidence

11.9.1 I found through review of the purchase orders that Reynobond 55PE was purchased for use on Grenfell Tower.

11.9.2 Through the disclosure process I am aware of four other Reynobond panel types. These are: REYNOBOND 33; REYNOBOND 55 FR; Reynobond FR (riveted system); Reynobond RB 160 PE. I have therefore reviewed the evidence in these test/classification reports in order to assess whether they are relevant to the compliance of the system installed on Grenfell tower.

11.9.3 The polyethylene cores of both REYNOBOND 55 FR and Reynobond FR (riveted system) are stated to contain fire retardants. The Reynobond 55PE panels used on Grenfell Tower were the standard panels without fire retardants. The test/ classification evidence for REYNOBOND 55 FR; Reynobond FR (riveted system) is therefore not relevant to the compliance of the system as installed on Grenfell Tower

11.9.4 REYNOBOND 33 has three overall thicknesses: 2mm, 3mm and 4mm, and was classified as Class 0 in 2006.

11.9.5 As I found in Section 11.6 and Section 11.7 of this report, the Reynobond 55PE installed on Grenfell tower had an overall thickness of 4mm.

11.9.6 I have therefore compared the product description in the supporting fire test reports for BS 476-6 and BS 476-7 for the Reynobond 33 (overall thickness 4mm) and the Reynobond 55 PE in Table 11.5.

11.9.7 This is to ascertain whether the performance of Reynobond 33 (overall thickness 4mm) is relevant to the compliance of the panels used on Grenfell Tower.

Table 11.5 comparison of Reynobond 55 PE and Reynobond 33 (4mm)

Product component	**Reynobond 55 PE (product description taken from**	**Reynobond 33 (4mm)**	**Comparison**
Outer face material	Precoated aluminium sheet	3004 H46 Aluminium	No material difference
Core material	Low density polyethylene	Low density polyethylene (924 g/cm^3)	No material difference
Overall nominal thickness (mm)	4	4	No material difference
Nominal thickness of the aluminium sheets (mm)	0.5	0.3	Aluminium sheet 0.2mm thinner in the Reynobond 33
Nominal thickness of the PE Core (mm)	3	3.4	PE core of Reynobond 33 0.4mm thicker than Reynobond 55PE
Overall nominal weight per unit area (kg/m^2)	5.5	Not stated	Unknown
Colours of the core	Translucent or black.	Not stated	Unknown
Colours of the finish	Duragloss ® 5000 35 µm	Pvf 2 (70% kynar 500) coating (colour reference silver anodic 906) coil coated to a dry film thickness of 25 microns	Different surface finishes used

11.9.8 I have found in my comparison in Table 11.5 that the thickness of the PE Core, thickness of the aluminium sheets, and surface coating of the panels is different for the Reynobond 55 PE when compared with the Reynobond 33 (overall thickness 4mm).

11.9.9 The Class 0 classification of Reynobond 33 (overall thickness 4mm) is therefore not directly relevant to the system used on Grenfell Tower.

11.9.10 No assessment of this difference was made at the time of the design and construction of Grenfell Tower.

11.9.11 I have also been provided with National classification reports from the late 1990's for a product called Reynobond RB 160 PE.

11.9.12 I have compared the product description in the supporting fire test reports for BS 476-6 and BS 476-7 for the Reynobond RB 160 PE and the Reynobond 55 PE in Table 11.6.

Table 11.6 comparison of Reynobond 55 PE and Reynobond RB 160 PE

Product component	Reynobond 55 PE (product description taken from	Reynobond RB 160 PE (product description taken from	Comparison
Outer face material	Precoated aluminium sheet	Chromate pre-treated aluminium sheet	No material difference
Core material	Low density polyethylene	Low density polyethylene (920 kg/m^3)	No material difference
Overall nominal thickness (mm)	4	4	No material difference
Nominal thickness of the aluminium sheets (mm)	0.5	0.5	No material difference
Nominal thickness of the PE Core (mm)	3	3	No material difference
Overall nominal weight per unit area (kg/m^2)	5.5	Not stated	Unknown
Colours of the core	Translucent or black.	Not stated	Unknown
Colours of the finish	Duragloss ® 5000 35 µm	Pvf 2 (70% kynar 500) coating (colour reference silver anodic 906) coil coated to a dry film thickness of 25 microns	Different surface finishes used

11.9.13 From Table 11.6, I have concluded that the core and outer face material thickness/ material types are identical as between the Reynobond RB 160 PE and the Reynobond 55 PE.

11.9.14 From Table 11.6, I note however that as the surface finishes are not the same, the BS 476-6 and BS 476-7 tests for Reynobond RB 160 PE would not directly apply to the Reynobond 55 PE. The surface finish of both panel types forms less than <1% of the thickness of the panels.

11.9.15 However, neither BS 476-6 or BS 476-7 have a formal allowance for variation in the field of application of the surface coating.

11.9.16 This means that the Class 0 classification of Reynobond RB 160 (overall thickness 4mm) is therefore not directly relevant to the system used on Grenfell Tower as it cannot be assumed that the surface coating will make no difference to fire performance.

11.9.17 No assessment of the difference was made at the time of the design and construction of Grenfell Tower.

11.9.18 To conclude, there is no test evidence for the specific Reynobond 55 PE panel and none of the other evidence can be treated as directly comparable. On this basis, it is not correct to say that Reynobond 55 PE can be considered to achieve national Class 0.

11.9.19 Additionally, I have explained in detail in Appendix F why I do not consider it possible to comply with the functional requirements of the Building Regulations B4 (1), if the relevant test evidence is based on a test that does not expose the edges of the ACP to direct heat, as is the case for the testing required to achieve National Class 0.

11.10 Compliance assessment of the fire safety performance of the insulating core panels Aluglaze

11.10.1 The new windows at Grenfell Tower contained what the Studio E Stage D report [CCL0000028] describes as '*opaque white insulating blanking panels*'. These opaque panels were mounted in the window frames between glazed units. I call these '*insulating core panels*' as per the definition provided in Appendix F of the Approved Document B 2013.

11.10.2 An insulating core panel is a combination of an external sheet surface either side of an insulating material. The composite system is expressly for the purpose of providing insulation and to visually block the construction behind the panel for aesthetic reasons. In the case of Grenfell Tower, these were held in position by the aluminium, powder coated window frames.

11.10.3 The insulating core panels in Grenfell Tower were required to increase the thermal performance of the external wall (see [MAX00001501]).

11.10.4 I will therefore analyse the test evidence for the external surface of these insulating core panels for compliance with Section 12.6 of the ADB 2013. I will deal with the insulation when assessing compliance of the necessary products with Section 12.7 of the ADB 2013.

11.10.5 I have investigated the disclosed design team documents to identify the specific thermal insulating core panels installed at Grenfell Tower between the window openings.

11.10.6 The O&M manual (construction drawings (C1059-100 Rev I [HAR00008991]) specify:

"Outer – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)

Core – 25mm Styrofoam

Inner – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)"

11.10.7 This product has been identified from the purchase order [HAR00007785] as an Aluglaze panel, manufactured by Panel Systems Ltd.

11.10.8 The Panel Systems Ltd Website describes Aluglaze as:

Aluglaze is an insulating infill panel comprising polyester coated aluminium bonded to an Insulation core. The panel is then balanced with either steel or aluminium. A premium quality panel, Aluglaze is typically specified when aesthetic considerations are paramount. All RAL and Syntha Pulvin colours are available.

Our panels are vacuum bonded using the latest adhesive technology ensuring the panel matches the life span of its intended application. We also manufacture to BS EN ISO 9001:2000 and have been a holder of this standard since 1990.

11.10.9 Figure 11.8 indicates the location of the 28mm Aluglaze insulating core panel (marked in red) on the external surface of the building.

11.10.10 The aluminium forms the external surface and the Styrofoam is the insulating core (Figure 11.9)

11.10.11 Styrofoam is a trademarked brand of extruded polystyrene foam (XPS) produced by DOW chemicals. XPS is listed as a combustible material in the SFPE handbook and Table A.36 lists the ignition temperature as 356°C.

11.10.12 The Panel Systems Ltd website advises that Aluglaze panel is available with Styrofoam, phenolic, mineral fibre lamaera or PIR cores.

11.10.13 However, none of the Styrofoam core panels are listed as achieving Class 0 on the Panel systems ltd website [1].

11.10.14 No test evidence has been disclosed to the Public Inquiry regarding the Aluglaze insulating core panels installed on Grenfell tower.

11.10.15 From my review of the Panel Systems Ltd website, the Styrofoam core used in the Aluglaze panels is blue (refer to Figure 11.7b). This is in accordance with my site investigation findings (refer to Figure 11.7a).

a)

b)

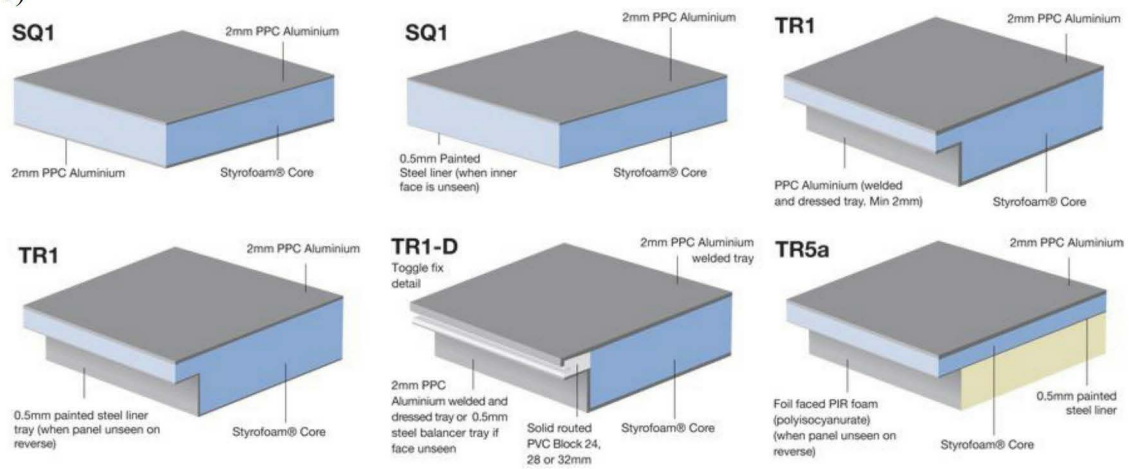


Figure 11.7 a) Photograph from flat 10 showing blue core of infill panel; b) image from Panel Systems Ltd website showing that the Styrofoam core of the Aluglaze panels is blue[1]

11.10.16 The Public Inquiry will also carry out independent testing to confirm the core is Styrofoam, as is specified on the drawings available at this stage of my investigation.

11.10.17 Please refer to Section 11.16.13 of this report for a discussion of the fire hazards of insulating core panels.

11.10.18 These insulating core panels were also found around the kitchen extract vent. I have marked the location of these panels in Figure 11.8 (in orange).

[1] https://www.panelsystems.co.uk/product/aluglaze [accessed 10/04/2018]

11.10.19 The O&M manual (construction drawings (C1059-100 Rev I [HAR00008991]) specify for the kitchen vent location:

"Outer – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)

Core – 25mm Kingspan TP10 Rigid Insulation

Inner – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)"

11.10.20 To date, I have not found any evidence on site of Kingspan TP10 being used around the kitchen vents. During my site investigation I have only found evidence of Styrofoam based products being used in the locations that I surveyed.

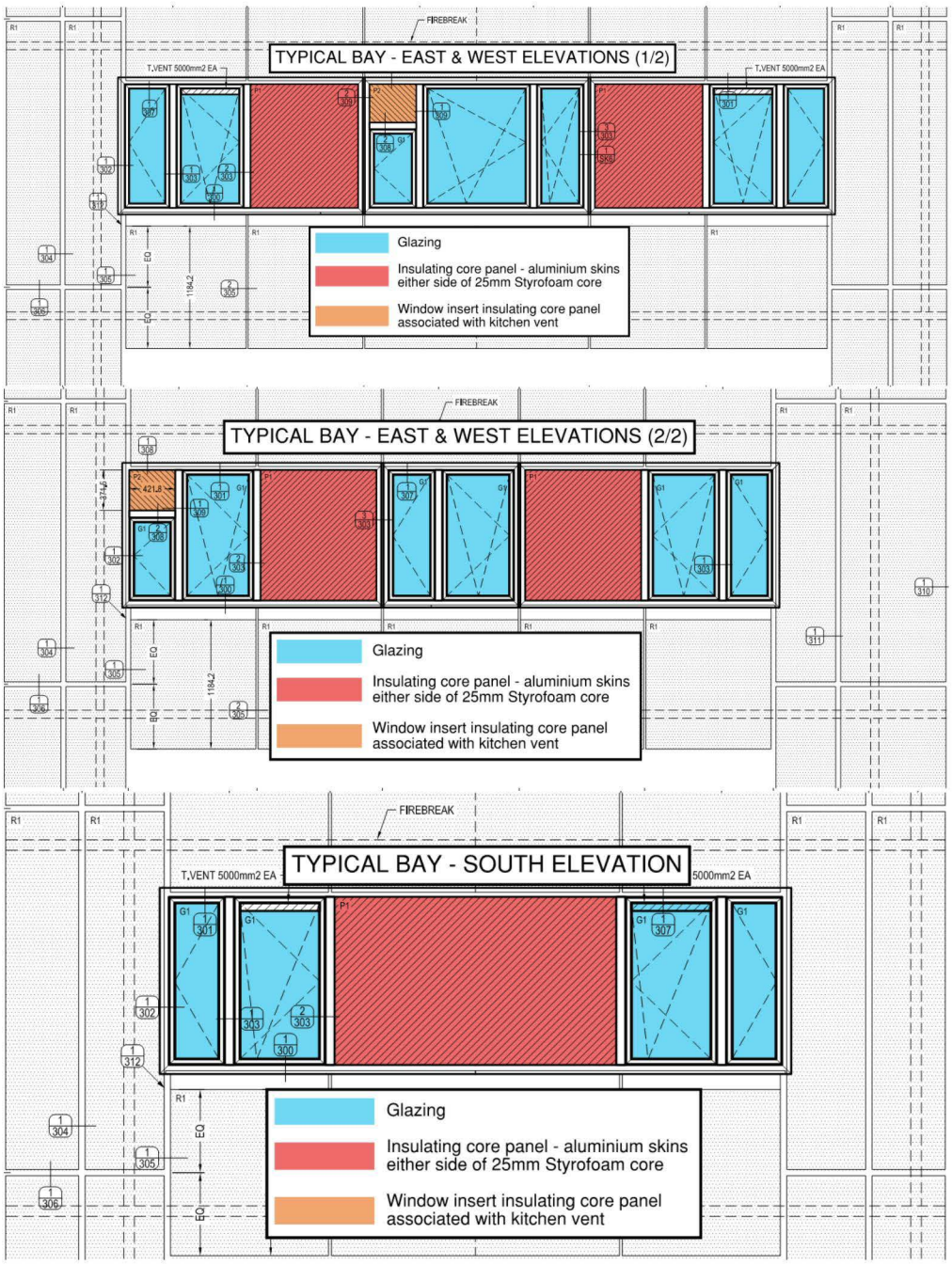


Figure 11.8 Location of insulating core panel and the type of insulation (Adapted from construction drawings C1059-200 Rev I [HAR00008581], C1059-201 Rev D [HAR00008582], C1059-202 Rev C [HAR00008583])

Figure 11.9 Insulating core panel between windows

11.11 Summary of compliance of Grenfell Tower external surfaces with the provisions made in Diagram 40 Section 12.6 of ADB 2013

In Table 11.7 I have summarised the findings of my compliance review for each material forming the external surface of Grenfell Tower. I have reviewed the available test evidence with the provisions made in Diagram 40 of ADB 2013.

Table 11.7 Summary of compliance of Grenfell Tower external surfaces with ADB 2013 12.6 Diagram 40

External surface	Product Installed	Compliance status with Diagram 40 for external surfaces any dimension over 18m in a building of height more than 18m	Compliance status with Diagram 40 for external surfaces any dimension under 18m in a building of height more than 18m
Rainscreen cladding panel	Reynobond 55 PE (Cassette) ACP 4mm thick	**Non-compliant[2].** Product achieves Class E which is a lower standard than Class B- s3, d2 No relevant National classification evidence available to date.	**Non-compliant.** Product achieves Class E which is a lower standard than Class C- s3, d2 No relevant National classification evidence available to date.
	Reynobond 55 PE (riveted) ACP 4mm thick	**Non-compliant.** Product achieves Class C which is a lower standard than Class B- s3, d2. No relevant National classification evidence available to date.	**Compliant[3]** Product achieves Class C which is a lower standard than Class C- s3, d2 No relevant National classification evidence available to date.
Insulating Core panel	*Outer – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss)* *Core – 25mm Styrofoam* *Inner – 1.55 Aluminium skin RAL 9010 Matt (30% Gloss)*	**Cannot be determined at this time** No test evidence disclosed for Aluglaze product Company website states no Styrofoam core Aluglaze product can achieve Class 0.	**Cannot be determined at this time** No test evidence disclosed for Aluglaze product Company website does not state if product can achieve I<20 or Class C or better.
	Outer – 1.5mm Aluminium skin RAL 9010 Matt (30% Gloss) *Core – 25mm Kingspan TP10 Rigid Insulation* *Inner – 1.55 Aluminium skin RAL 9010 Matt (30% Gloss)* (**Note** On drawings only)	**Cannot be determined at this time** No test evidence disclosed specific to Aluglaze product. Aluglaze with PIR core (not does not specifically state Kingspan TP10) is not listed as achieving Class 0 or Class B or better on the Panel Systems ltd website. Assessment of the test evidence for insulation is reviewed in Section 11.16.13)	**Cannot be determined at this time** No test evidence disclosed specific to Aluglaze product. Panel Systems Ltd website does not list Aluglaze with PIR core (note does not specifically state Kingspan TP10) if product can achieve I<20 or Class C or better. Assessment of the test evidence for insulation is reviewed in Section 11.16.13)

[2] Note the Class E classification is dependent on the product installed with a Class A2 or better substrate not the Class D substrate installed on Grenfell Tower.

[3] Note no evidence that the riveted system was installed on any part of Grenfell Tower.

11.12 Insulation materials/products – classifications provided for in Section 12.7 in the ADB 2013

11.12.1 The topmost storey of Grenfell Tower (level 23), as defined in ADB 2013 Diagram C6, is 62.7m.

11.12.2 Approved Document B 2013 Section 12.7 makes the following provisions for insulation materials/ products in a building with a storey more than 18 or more above ground level:

"... any insulation product, filler material (not including gaskets, sealants and similar) etc. used in the external wall construction should be of limited combustibility (see Appendix A)."

11.12.3 Limited combustibility is defined in Table A7 of ADB 2013.

11.12.4 ADB 2013 provides no definition of what constitutes insulation, filler material, nor why filler material excludes gaskets, sealants or similar.

11.12.5 Further, ADB 2013 does not clarify why gaskets, sealants and similar are not subject to the reaction to fire performance requirements of other filler material.

11.12.6 I am aware that there is a range of opinion on this issue and others consider that the core in an ACP is now *filler material* and therefore triggers the provisions made for insulation under Section 12.7 of the ADB 2013. Equally I am aware others do not at all agree this is the case.

11.12.7 As I have explained in Appendix F, I do not consider the ACP panels to be insulation nor their core to be categorised as *filler material* either. I do not agree therefore the core is subject to the provisions of Section 12.7 for insulation in ADB 2013. That is why I have dealt with those panels as an external surface in my report.

11.12.8 I have concluded (as explained in detail in Appendix F of my report), that the insulation used at Grenfell Tower was required to be one of two classifications:

a) limited combustibility defined by testing to National standards; or

b) limited combustibility defined by testing to European standards.

11.12.9 The thermal insulation I have identified within the external wall of Grenfell Tower (see Section 7) which is subject to Section 12.7 of ADB 2013 is:

a) Rainscreen cavity thermal insulation on the columns (Figure 11.10a);

b) Rainscreen cavity thermal insulation on the spandrels (Figure 11.10b)

c) Window reveals (head, jambs, cill) thermal insulation (Figure 11.11).

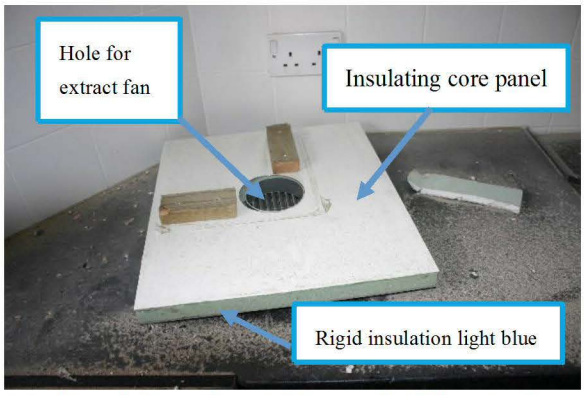
d) The insulating core panels between the window openings and around the kitchen extract fan (Figure 11.12).

11.12.10 I have investigated the test evidence provided for those products with the provisions made in ADB 2013 Section 12.7.

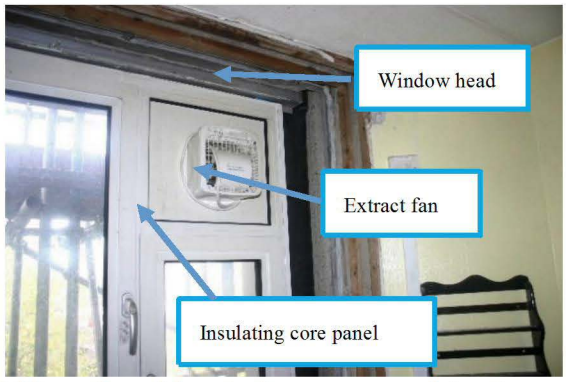
(a) (b)

Figure 11.10 Rainscreen thermal insulation affixed to (a) Columns and (b) spandrel panels

Figure 11.11 Thermal insulation behind the window opening linings



(a) Aluminium faced 25mm rigid insulation foam (Flat 10 on level 3)



(b) Non-glazed insulating core panel in place (flat 13 on level 4)

Figure 11.12 Observed insulating core panels around kitchen extract vent onsite

11.13 Compliance assessment of Celotex RS 5000 as thermal insulation in Grenfell Tower

11.13.1 I have reviewed the purchase orders for the insulation installed at Grenfell Tower and concluded that two types of insulation were installed: Celotex RS5000 (SIG00000010, HAR00000583 and HAR00000781) and Kingspan K15 (SIG00000012).

11.13.2 I have found evidence that two different types of Celotex RS5000 were ordered: RS5100 & RS5080 (SIG00000010, HAR00000583 and HAR00000781) where RS5100 is 100mm thick and RS 5080 is 80mm thick.

11.13.3 From my site inspection I observed that 100mm Celotex was installed on the columns as shown in the Figure 11.13 below.

Figure 11.13: Evidence of Celotex in place on the columns of Grenfell Tower note Celotex logo printed on insulation (circled in blue)

Figure 11.14: Evidence of Celotex in place on the columns of Grenfell Tower (expanded image of Figure 11.13)

11.13.4 From my site inspections I observed that 2 layers of 80mm Celotex were installed on the spandrels.

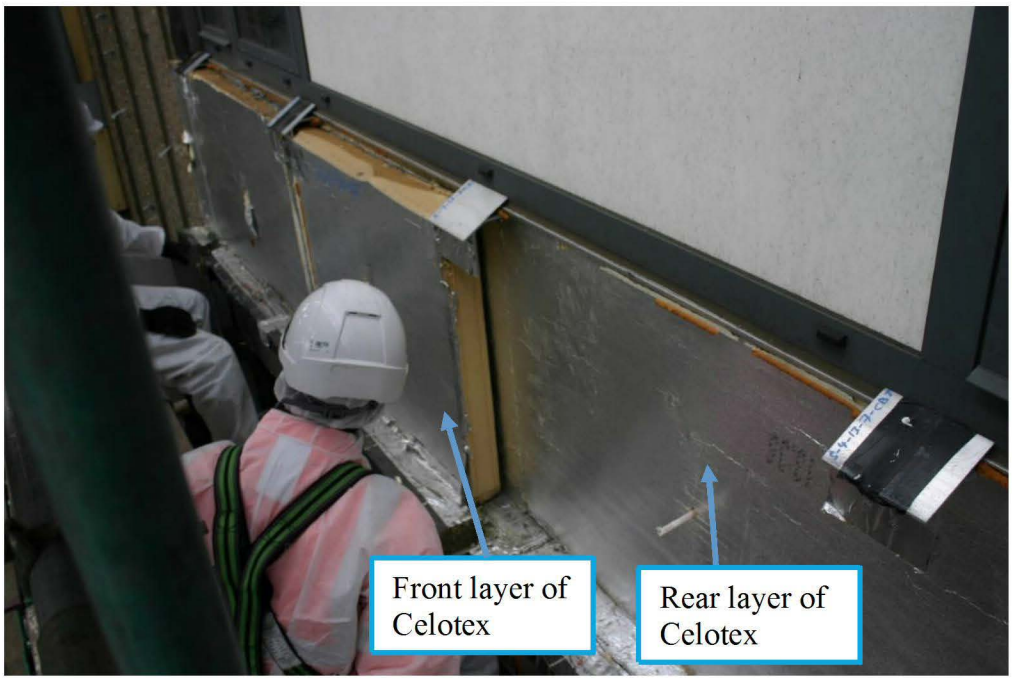


Figure 11.15 Evidence of two layers of rigid insulation in place on the spandrels of Grenfell Tower

11.13.5 I also note from my site inspections that the 80mm layers of Celotex were in fact made up of three sub layers as shown in Figure11.16.

Figure11.16 Celotex on spandrels observed to be formed of three layers

11.13.6 National class test evidence submitted to the Public Inquiry

11.13.7 I have provided the list of all fire test/ classification evidence provided to the Public Inquiry by Celotex in Appendix E.

11.13.8 Please note that Linklaters issued a letter on behalf of their client Celotex on 23/10/2018 (CEL00010054) stating:

> Within Celotex's operational team, FR5000 and RS5000 are regarded as the same product at the point of manufacture. They are designated as either FR or RS after production and prior to despatch. The different designations assist the business in assessing and tracking the market for the product. The FR5000 product was launched in 2011. Celotex commissioned a test, conducted in May 2014, to BS 8414-2:2005, of a multi component rainscreen cladding system, which included a sample of the product as one component, and thereafter, from August 2014, the product was also marketed as RS5000.

11.13.9 On this basis I have considered all of the evidence I have received to date from Celotex for both RS5000 (as stated on the purchase order for Grenfell); and FR5000.

11.13.10 The evidence disclosed shows that Celotex 5000 PIR insulation has been tested to BS 476-6 and BS 476-7. These are the National test standards for surface spread of flame performance. They are not the tests for classifying a material of limited combustibility.

11.13.11 To demonstrate limited combustibility to a National class standard, testing to BS 476-4, or BS 476-11 would be required. No test reports for these tests have been provided to me to date.

11.13.12 The tests disclosed to date are therefore not relevant evidence to demonstrate that RS5000 has the necessary fire performance of limited combustibility to either National or European methods as per ADB 2013 Section 12.7, and as I have explained in columns 9 and 10 of Table 11.8.

11.13.13 I note that the performance of an insulation material with respect to its surface spread of flame is relevant – but only when determining the location of cavity barriers in a cavity formed by that insulation and only in non-residential buildings as per Table 13 of ADB 2013.

11.13.14 With regard to the test data that is available, the purchase orders for the Celotex RS5000 (HAR00000563, HAR00000583, HAR00000637, HAR00000781, SIG00000010) are dated between 25/03/2015 and 10/03/2016. The Celotex RS5000 was purchased after the issue of the test reports in Table 11.8, therefore the reports were relevant at the time of construction.

11.13.15 If a report is submitted after a material is installed and meets the required standard, it shows the material met the requirements although that was not demonstrated at the time of the installation.

11.13.16 In Appendix E, I review additional BS476-6 and BS 476-7 testing undertaken by Celotex after the Grenfell tower fire. This information is not relevant for the compliance of the insulation installed on Grenfell Tower, however I have found that, as between different Celotex PIR insulation samples tested in

different years, there appears to be a significant variation in its performance to BS 476-6. This is discussed further in Appendix E.

Table 11.8 Celotex RS 5000 (insulation purchased and installed in Grenfell Tower) reaction to fire performance to National Class using British Standard tests

Relativity Document	Test Standard used in the evidence provided	Product	Sponsor	Classification report/ Test report/ BBA certificate number	Date of issue of report	Date test was undertaken	Test/ assessment result	Material of limited combustibility using National Classification methods in Table A7 of ADB 2013
BS 476-6:1989+A1:2009 test on Celotex FR5000 Line 1 (S-2011-379) (CEL00000378) (BBA00000004)	BS 476-6	'FR5000 Line 1' Foam type: CP400E (formulation specification 28-028) Density: 32kg/m3 Facing- Stucco silver foil facer	Celotex Ltd	275714	18/11/2011	16/11/2011	I=5.2 i1=0.6 i2=2.5 i3=2.1	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.
BS 476-6:1989+A1:2009 test on Celotex FR5000 Line 2 (S-2011-379) (CEL00000379) (BBA00000008)	BS 476-6	'FR5000 Line 2' Foam type: HP400E (formulation specification 28-028) Density: 32kg/m3 Facing- Stucco silver foil facer	Celotex Ltd	275717	18/11/2011	17/11/2011	I=5.2 i1=0.4 i2=2.6 i3=2.2	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.

Relativity Document	Test Standard used in the evidence provided	Product	Sponsor	Classification report/ Test report/ BBA certificate number	Date of issue of report	Date test was undertaken	Test/ assessment result	Material of limited combustibility using National Classification methods in Table A7 of ADB 2013
BS 476-7: 1997 test on Celotex FR5000 Line 1 (S-2011-379) (CEL00000380) (BBA00000003)	BS 476-7	'FR5000 Line 1' Foam type: CP400E (formulation specification 28-028) Density: 32kg/m3 Facing- Stucco silver foil facer	Celotex Ltd	275715	22/11/2011	21/11/2011	Class 1	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.
BS 476-7: 1997 test on Celotex FR5000 Line 2 (S-2011-379) (CEL00000381) (BBA00000006)	BS 476-7	'FR5000 Line 2' Foam type: HP400E (formulation specification 28-038) Density: 32kg/m3 Facing- Stucco silver foil facer	Celotex Ltd	275719	22/11/2011	21/11/2011	Class 1	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.

Relativity Document	Test Standard used in the evidence provided	Product	Sponsor	Classification report/ Test report/ BBA certificate number	Date of issue of report	Date test was undertaken	Test/ assessment result	Material of limited combustibility using National Classification methods in Table A7 of ADB 2013
Class 0 classification (CEL00000382) (BBA00000017)	Class 0 classification letter for FR5000 Line 1' [not relevant to Limited Combustibility]	Class O classification letter for both Line 1	Celotex Ltd	275716	22/11/2011	N/A	Class 0	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.
Class 0 classification (CEL00000383) (BBA00000012)	Class 0 classification letter for FR5000 Line 1' [not relevant to Limited Combustibility]	Class O classification letter for both Line 2	Celotex Ltd	275720	22/11/2011	N/A	Class 0	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.

Relativity Document	Test Standard used in the evidence provided	Product	Sponsor	Classification report/ Test report/ BBA certificate number	Date of issue of report	Date test was undertaken	Test/ assessment result	Material of limited combustibility using National Classification methods in Table A7 of ADB 2013
BS 476-6:1989+A1:2009 test on Celotex RS5000 (CEL00000384)	BS 476-6	Celotex RS5000	Celotex Ltd	275717A	14/07/2014	17/11/2011	Fire Propagation index (I)= 5.2 Sub index (i1) = 0.4	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.
BS 476-7: 1997 test on Celotex RS5000 (CEL00000385)	BS 476-7	Celotex RS5000	Celotex Ltd	275719A	14/07/2014	21/11/2011	Spread of flame at 1.5-minute limit (mm)=70mm Final spread of flame limit after 10 mins (mm)=70mm	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.

Relativity Document	Test Standard used in the evidence provided	Product	Sponsor	Classification report/ Test report/ BBA certificate number	Date of issue of report	Date test was undertaken	Test/ assessment result	Material of limited combustibility using National Classification methods in Table A7 of ADB 2013
Class 0 classification (CEL00000386)	Class 0 classification letter for RS5000 [not relevant to Limited Combustibility]	Celotex RS5000	Celotex Ltd	275720	14/07/2014	N/A	Class 0	Non-compliant with section 12.7 as none of the methods for demonstrating limited combustibility listed in Table A7 of ADB 2013 have been used.

11.13.17 European class test evidence submitted to the Public Inquiry

11.13.18 Five European Class fire test reports for reaction to fire have been disclosed in respect of products titled RS5025, RS5100 and RS5160 Celotex insulation materials (CEL00000549, CEL00000550, CEL00000551, CEL00000552, CEL00000553 respectively). These are all dated in August 2017 i.e. after the Grenfell Tower fire.

11.13.19 Of the three insulation types with disclosed test reports, only RS5100 was purchased and installed at Grenfell Tower.

11.13.20 The two relevant test reports for the RS5100 installed on Grenfell Tower are those identified in Relativity as CEL00000550, CEL00000552.

11.13.21 RS5080 was also purchased for delivery (as determined from the purchase orders SIG00000010, HAR000000563), however, no fire test reports have been disclosed for this thickness of insulation.

11.13.22 Two classification reports and two extended field of application reports based on the test reports listed above were disclosed to the inquiry for RS500 Series-Line 1; and RS500 Series-Line 2. These are CEL00000545, CEL00000546, CEL00000547 and CEL00000548.

11.13.23 The report titled *Extended field of application report in accordance with EN/TS 15117:2005 for RS5000 series – line 1* (CEL00000547) states that RS5000 series – line 1 is classified as Class D-s2, d0 and with the following extended field of application:

> This classification is valid for the following end use applications:
>
> i) Construction applications used over any substrate with a density equal to or greater than 870kg/m^3, having a minimum thickness of 12mm and a fire performance of A2 or better (excluding paper faced gypsum plasterboard).
>
> This classification is also valid for the following product parameters:

Product thickness	25mm to 100mm
Insulation thickness	25mm to 100mm
Product weight per unit area	1.03 kg/m^2 to 3.33kg/m^2
Insulation density	Tested density ± 15%
Thickness and weight per unit area of facings	For the tested thickness only. The test result obtained for Euroclass A1 and A2 facings will also be valid for thicker facings of the same type.
Product composition	No variation allowed
Product construction	No variation allowed

11.13.24 The report titled *Extended field of application report in accordance with EN/TS 15117:2005 for RS5000 series – line 2* (CEL00000548) states that RS5000 series – line 2 is classified as Class D-s2, d0, and with the following extended field of application:

This classification is valid for the following end use applications:

i) Construction applications used over any substrate with a density equal to or greater than 870kg/m^3, having a minimum thickness of 12mm and a fire performance of A2 or better (excluding paper faced gypsum plasterboard).

This classification is also valid for the following product parameters:

Product thickness	100mm to 160mm
Insulation thickness	100mm to 160mm
Product weight per unit area	3.30 kg/m^2 to 5.29kg/m^2
Insulation density	Tested density ± 15%
Thickness and weight per unit area of facings	For the tested thickness only. The test result obtained for Euroclass A1 and A2 facings will also be valid for thicker facings of the same type.
Product composition	No variation allowed
Product construction	No variation allowed

11.13.25 Therefore, it is my understanding, that RS5100 achieves Class D which is three classifications lower than Class A2, which is required for the material to meet the criteria for limited combustibility to European methods.

11.13.26 In summary, I conclude that the European Class test evidence for RS5100 demonstrates that RS5100 does not meet the criteria for a material of limited combustibility (however, I note that this evidence is dated after the fire).

11.13.27 **Different foam types for Celotex RS5100**

11.13.28 In Linklaters' letter to the Inquiry dated 23/10/2018 (CEL00010054), they confirm that there is a difference between Line 1 and Line 2 of the Celotex PIR. The Linklaters letter dated 23/10/2018 states:

4.2 As explained at paragraph 1.5 above, Celotex has two production lines in its Hadleigh factory on which PIR is made, called Hipchen and Hennecke. Both lines were used to make FR5000/RS5000. The Hipchen machine is a free rising foam line and uses one layer of glass fibre reinforcement in FR5000/RS5000 for boards below 60mm in depth and two layers of glass fibre reinforcement for boards of 60mm depth or greater. The Hennecke machine is a restrained rise foam line and products from this machine do not contain glass fibre. For product sold as FR5000/RS5000, the Hennecke line is typically used to manufacture boards greater than 100mm in depth and the Hipchen machine is generally used to manufacture boards of lesser depth.

4.3 The FR5000/RS5000 product is made with materials purchased from a range of third party suppliers who change from time to time. The two main chemicals are methylene diphenyl diisocyanate ("**MDI**") and a pre-mixed polyol blend. On the Hennecke line, the pre-mixed polyol blend is called "ElastoPIR 1039/501" ("**501 Polyol**"). It is purchased from BASF and contains polyol, surfactant and fire retardant.

4.4 When FR5000 was launched in 2011, 501 Polyol was used on the Hipchen line. In 2012, trials of a different pre-mixed polyol blend called "ElastoPIR 1039/503" ("**503 Polyol**") (also purchased from BASF and understood to contain polyol, surfactant, fire retardant and water) took place on the Hipchen line, prior to that blend being used more consistently on that line from August 2012. A copy of a Change Note associated with that change has been provided to the Inquiry.[14] This change was not applied to the Hennecke line which continued to use 501 Polyol. BASF has stated that the detailed formulation of 501 Polyol and 503 Polyol blends is its confidential proprietary information, although it has indicated that it would provide that information to the Inquiry, should the Inquiry request it.[15]

11.13.29 Since 2012 there has therefore been a chemical difference between the two lines of PIR foam (either FR5000 or RS5000) produced by Celotex.

11.13.30 The BS EN 13823:2010 test reports disclosed for RS5100 describe two different foam types 'CP400E 28-028' and 'HP400E 28-028'

11.13.31 I have compared the test data for each type of foam in Table 11.9.

11.13.32 By comparison, the RS5100 CP400 28-028 foam exhibits a higher average growth rate of the heat release rate of the material and higher total heat release rate from the specimen.

11.13.33 As both foam types are used to create the product RS51000 it is not possible to determine which foam type was installed in Grenfell Tower without specific testing of the samples of the installed foam.

11.13.34 This will be carried out by Professor Bisby in Phase 2.

11.13.35 I do not know which Line was installed on Grenfell Tower, nor do I know how any party could have been aware of this difference at the time of construction.

Table 11.9 Comparison of BS EN 13823:2010 test data for RS5100

BS EN 13823:2010 test data	BS EN 13823:2010 criteria for limited combustibility	RS5100 (CP400 28-028) result	RS100 (HP400E 28-038) result
FIGRA - Average growth rate of the heat release rate of the material after the fire source is switched from the auxiliary burner to the primary burner (which occurs at t= 300s) (W/s).	120	224.66 >120	193.26 >120

11.14 Compliance assessment of Kingspan K15 as thermal insulation in Grenfell Tower

11.14.1 I have reviewed the purchase orders for the insulation installed at Grenfell Tower and concluded that two types of insulation were installed: Celotex RS5000 (SIG00000010, HAR00000583 and HAR00000781) and Kingspan K15 (SIG00000012).

11.14.2 I have concluded from review of the purchase orders that 276m^2 Kingspan K15 was purchased for installation in Grenfell Tower [SIG00000012]. I have assessed K15 for that reason.

11.14.3 I note that photographic evidence has been submitted to the Public Inquiry by Kingspan [KIN00000015] showing Kingspan Kooltherm was installed on the spandrels of Grenfell Tower (refer to Figure 11.17). It is not possible to determine what Kingspan Kooltherm product was observed in the photo as the K15 purchased is only one of 10 number Kooltherm products produced by Kingspan[4]. Therefore, in the event evidence is provided that a Kooltherm

[4] Kooltherm product range https://www.kingspan.com/gb/en-gb/products/insulation/insulation-boards/kooltherm [accessed 10/04/2018]

product other than Kingspan K15 is installed at Grenfell Tower, I will assess that product also.

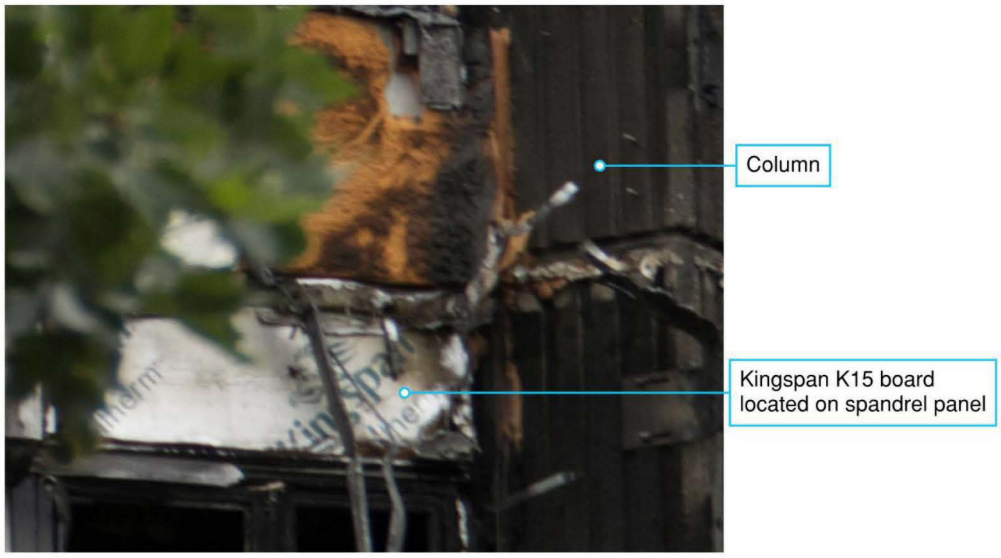


Figure 11.17 Kingspan Kooltherm insulation installed on spandrel panel [KIN00000015] (note exact product variation cannot be determined from the photo)

11.14.4 I have provided the list of all 15 reactions to fire test reports/ classification reports/ declarations of performance provided to the Public Inquiry by Kingspan Group for K15 insulation in Appendix E.

11.14.5 The Kingspan purchase order [SIG00000012] was dated 26/05/2015 therefore any test reports/ classification report after this date were not relevant at the time of purchase.

11.14.6 Two British Board of Agrément (BBA) certificates for Kingspan K15 (KIN00000054 dated November 2015; and KIN00000454 dated December 2013), were submitted to the Public Inquiry.

11.14.7 The BBA is accredited by the United Kingdom Accreditation Service (UKAS).

11.14.8 Section 1.1 of the 2013 BBA Certificate, 08/4582 (KIN00000454), describes the product as:

> *"Kooltherm K15 Rainscreen Insulation Board comprises a rigid phenolic insulation core with composite foil on both sides".*

11.14.9 The 2013 BBA Certificate, 08/4582 (KIN00000454) Section 8.1 states that Kooltherm K15 is classified as Class 0.

11.14.10 The Class 0 classification reports provided for Kingspan Kooltherm K15 (KIN00000259, KIN00000251) make reference to the test standards BS 476-6 and BS 476-7. These standards are not listed in Table A7 of ADB 2013 as methods of determining limited combustibility, as discussed in Appendix F. The relevant National standards are BS 476-4, and BS 476-11.

11.14.11 The provisions made in Section 12.7 of the ADB 2013, are based on either

a) Material of limited combustibility defined by testing to National standards; or

b) Material of limited combustibility defined by testing to European standards.

11.14.12 On the basis of the current test classification of Class 0 using BS 476-6 and BS 476-7, I conclude that Kooltherm K15 is not compliant with the provisions made in ADB 2013 12.7 for insulation products used buildings with a storey 18m or more above ground level.

11.15 Compliance assessment of the window reveal thermal insulation at Grenfell Tower

11.15.1 During my site inspection, I identified that rigid polymeric insulation had been installed around the window linings behind the UPVC surround. This is shown in Figure 11.18 and Figure 11.19.

11.15.2 I concluded from my site inspections that the foam appeared to be polymeric (i.e. PIR/PUR) in nature rather than stone or glass wool.

11.15.3 I have found no evidence in any of the design documents disclosed to the Public Inquiry, information regarding the performance specification of thermal insulation products to be fixed to the back the window linings.

11.15.4 The only evidence available to me is by means of the materials I observed during my inspection which included:

a) 25mm foil faced rigid insulation board with the green lettering printed on the foil; and

b) 25mm foil faced rigid insulation board with partial red Celotex logo printed on the foil.

11.15.5 I have identified two potential products matching the thickness of insulation and printed foil facing, as I observed on site.

11.15.6 Firstly, Kingspan Thermapitch (TP10) (Figure 11.18) which is a Polyisocyanurate (PIR) board which is available in the 25mm thickness I observed on site.

11.15.7 Secondly Celotex TB4000 which is a Polyisocyanurate (PIR) board which is available in the 25mm thickness I observed on site (Figure 11.19).

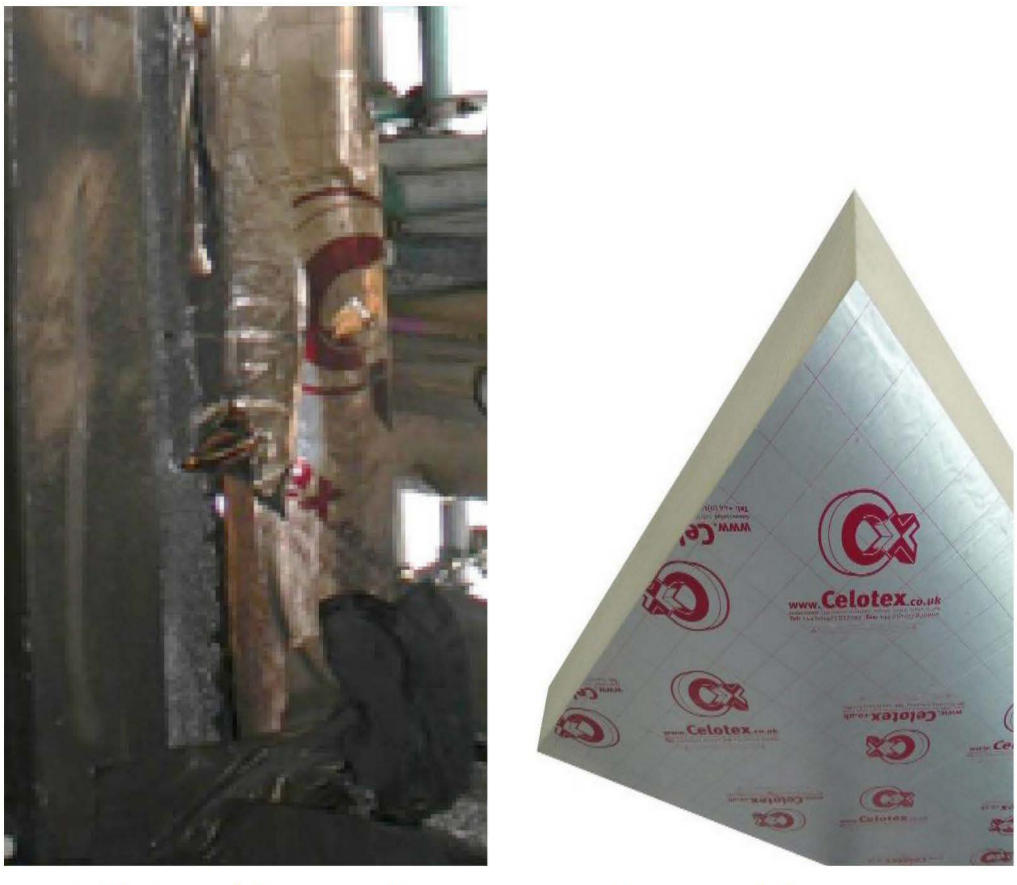
11.15.8 PIR is a combustible insulation material, that is a material that will ignite and burn when sufficient heat is applied and when an appropriate oxidiser is present (Dehann, 2007).

11.15.9 Sample testing is required to verify the precise insulation foam material installed behind the window reveals.

a) Photograph from my site inspection

b) Photograph from manufacturers webstite

Figure 11.18 Possible Kingspan TP10 thermal insulation product matching the thickness of window reveal insulation & foil lettering



a) Photograph from my site inspection

b)Photograph from manufacturers webstite

Figure 11.19 Possible Celotex TB4000 thermal insulation product matching the thickness of window reveal insulation & foil lettering

11.15.10 Additionally, no test evidence has yet been disclosed for Celotex TB4000 despite my request for this information.

11.15.11 I have however received eleven BBA Agrément certificates (with no supporting fire test data) for Celotex TB4000 between 2010 and 2017. These are BBA00000007, BBA00000010, BBA00000018, BBA00000020, BBA00000021, BBA00000022, BBA00000024, BBA00000026, BBA00000027, BBA00000028, BBA00000029, BBA00000030. The performance for TB4000 is stated as either "No Declared Performance", Class F, or Class 1. None of these classifications meet the requirement for limited combustibility for compliance with Clause 12.7 of ADB.

11.15.12 The TB4000 data sheet (dated August 2016) also lists the material as Class 1 – this is a surface spread of flame classification only and does not demonstrate limited combustibility.

11.15.13 I have provided the list of all 20 reaction to fire test reports/ classification reports/ declarations of performance/ BBA certificates provided to the Public Inquiry by Kingspan Group for TP10 insulation in Appendix E.

11.15.14 I have not found any specific purchase orders for the Kingspan TP10 insulation. However, as all refurbishment works were completed after 2016 any test reports/ classification reports after this dated after 2016 were not relevant to the compliance of the building at the time of handover.

11.15.15 Classification of Reaction to fire performance in accordance with EN13501-1:2007 + A1 :2009 for TP10 dated 20/07/2016 [KIN00000302] and Declaration of Performance Thermapitch TP10 1000.CPR.2013.TP10.004/ 1000.CPR.2013.TP10.004 dated 01/01/2016 [KIN00000280] list the TP 10 as achieving Class E. Class E does not meet the limited combustibility provision of Class A2 or better as listed in Table A7 of ADB 2013.

11.15.16 The use of TP10 as thermal insulation would therefore be non-compliant with ADB 2013.

11.15.17 It should be noted that the earliest classification report disclosed for TP10 *Reaction to fire classification report of Kingspan TP10, TF70 TW50 and TW55 in End use applications* dated 30/07/2003 lists the TP10 as Class B S2 d0. This is a better classification than the more recent 2016 classification. However, this still does not meet the limited combustibility provision of Class A2 or better as listed in Table A7 of ADB 2013.

11.15.18 Whilst confirmation of the specific products installed is required in order for me to complete my assessment of compliance against the provision of limited combustibility as per ADB 2013 12.7, I have found no evidence that allows me to conclude anything other than that the insulation used in this location is a polymeric insulation, combustible in nature.

11.16 Assessment of the test evidence for the Aluglaze insulating core panel used at Grenfell Tower

11.16.1 As I have explained in Section 11.7, I have determined through review of the Harley construction drawings and my onsite inspections that insulating core panels were installed between the window openings on the external façade of Grenfell Tower.

11.16.2 I have concluded from review of the purchase order [HAR00007785] that Aluglaze panels manufactured by Panel Solutions limited were purchased for use in Grenfell Tower.

11.16.3 The Aluglaze insulating core panels were to be constructed from a 25mm Styrofoam core either with 1.5mm aluminium sheets attached to either side.

11.16.4 Styrofoam, which is manufactured by Dow Chemical Company, is described as extruded polystyrene (EPS).

11.16.5 EPS is a combustible polymeric foam (heat of combustion of 28 kJ/g compared to 10 kJ/g of phenolic foam in the SFPE handbook 5th edition Table A.39).

11.16.6 No formal test evidence has as yet been disclosed for the Aluglaze insulating core panel at Grenfell Tower.

11.16.7 Additionally, as I have explained in Section 8, I have determined through review of the Harley construction drawings and my onsite inspections that insulating core panels were also installed around kitchen window extracts in the external façade of Grenfell Tower.

11.16.8 The insulating core panels were originally specified to be constructed from a 25mm Kingspan TP 10 core with 1.5mm aluminium sheets attached to either side. Kingspan TP10 is PIR insulation product.

11.16.9 However, during my site inspection, I found that the core of the insulating panel around the kitchen vent in flat 10 was blue (refer to Figure 11.20).

11.16.10 Images from the BBA certificate (95/3126) of the Kingspan TP10 indicate it is yellow in colour.

11.16.11 I therefore conclude that in at least one location Styrofoam has been used as the insulating core of the kitchen insert insulating core panel.

11.16.12 I am aware that MPS have removed other samples of a Styrofoam based panel from around the kitchen extract fan.

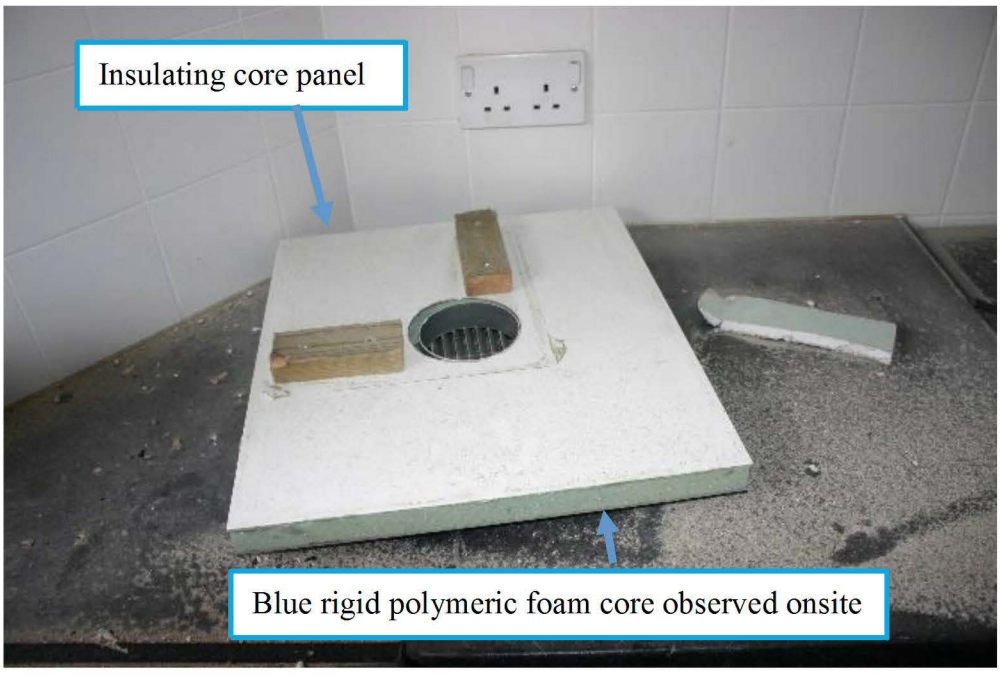


Figure 11.20 Insulating core panel around kitchen vent appeared to be Styrofoam

11.16.13 I have obtained the publicly available datasheets for Styrofoam from the panel manufactures website which describes the material as Class E[5].

11.16.14 A Class E product is less than Class A2 standard required for limited combustibility.

11.16.15 I therefore conclude on the basis of the Styrofoam data sheets, that this product cannot meet the limited combustibility provisions, as provided for in Section 12.7 in ADB 2013.

11.17 Fire behaviour of insulating core panels

11.17.1 I have concluded from review of the O& M (Operation and Maintenance) manual for the 2012-2016 renovation and from my site inspections that insulating core panels were installed between the window openings and around the kitchen extract fan on Grenfell Tower.

11.17.2 Appendix F of ADB 2013 describes the fire behaviour of insulating core panels. The guidance in Appendix F of ADB 2013 is specific for the use of panels in internal structures however the general fire behaviour is included here to give context to the likely behaviour of the panels installed as part of the external façade of Grenfell Tower. Appendix F section 2 states:

"The degradation of polymeric materials can be expected when exposed to radiated/conducted heat from a fire, with the resulting production of large quantities of smoke.

It is recognised that the potential for problems in fires involving mineral fibre cores is generally less than those for polymeric core materials.

In addition, irrespective of the type of core material, the panel, when exposed to the high temperatures of a developed fire, will tend to delaminate between the facing and core material, due to a combination of expansion of the metal facing and softening of the bond line.

Therefore, once it is involved, either directly or indirectly in a fire, the panel will have lost most of its structural integrity. Stability will then be dependent on the method of fixing to the structure.

For systems that are not fixed through both facings the stability of the system will then depend on the residual structural strength of the non-exposed facing, the interlocking joint between panels and the fixing system.

Most jointing or fixing systems for these systems have an extremely limited structural integrity performance in developed fire conditions. If the fire starts

[5] https://www.panelsystems.co.uk/wp-content/uploads/2017/06/UK-STYROFOAM-RTM-NC-X-P-291-70825-0715.pdf; https://www.panelsystems.co.uk/wp-content/uploads/2017/06/UK-STYROFOAM-LBH-X-P-291-71525-0715.pdf; https://www.panelsystems.co.uk/wp-content/uploads/2017/06/UK-STYROFOAM-LB-A-P-291-71025-0715.pdf

to heat up the support fixings or structure to which they are attached, then there is a real chance of total collapse of the panel system.

Where panels are used as the lining to a building the insulating nature of these panels, together with their sealed joints, means that fire can spread behind the panels, hidden from the occupants of occupied rooms/spaces. With some thermoplastic cores fire can also spread between the panel facings.

This can prove to be a particular problem to firefighters as, due to the insulating properties of the cores, it may not be possible to track the spread of fire, even using infra-red detection equipment. This difficulty, together with that of controlling the fire spread within and behind the panels, is likely to have a detrimental effect on the performance of the fixing systems, potentially leading to their complete and unexpected collapse, together with any associated equipment."

11.17.3 Section 3 of Appendix F of ADB 2013 states:

"*3. When compared with other types of construction techniques, these panel systems therefore provide a unique combination of problems for fire fighters, including:*

- *Hidden fire spread within panels with thermoplastic cores;*
- *Production of large quantities of black toxic smoke; and*
- *Rapid fire spread leading to flashover*
- *Hidden fire behind lining systems*

These three characteristics are common to both polyurethane and polystyrene cored panels, although the rate of fire spread in polyurethane cores is significantly less than that of polystyrene cores, especially when any external heat source is removed.

In addition, irrespective of the type of panel core, all systems are susceptible to:

- *Delamination of the steel facing;*
- *collapse of the system; and*
- *hidden fire spread behind the system."*

11.17.4 These panels formed approximately 13% of the external surface area of each storey of the Grenfell Tower between levels 4 and 23 (Calculated from C1059-200 Rev I [HAR00008581], C1059-201 Rev D [HAR00008582]).

11.18 Compliance assessment of the insulation located between the original and new window infill panels

11.18.1 During my site investigation, I identified that in at least one location an additional piece of rigid polymeric form insulation had been used to close the cavity formed between the original non-combustible infill panels (material

currently unknown but understood to consist of asbestos-bearing cementitious materials) and the new insulating core panel, at their edges, beside the windows – see Figure 11.21

11.18.2 One of the samples I observed is presented in Figure 11.21 below and please refer to Appendix C6 for further examples:

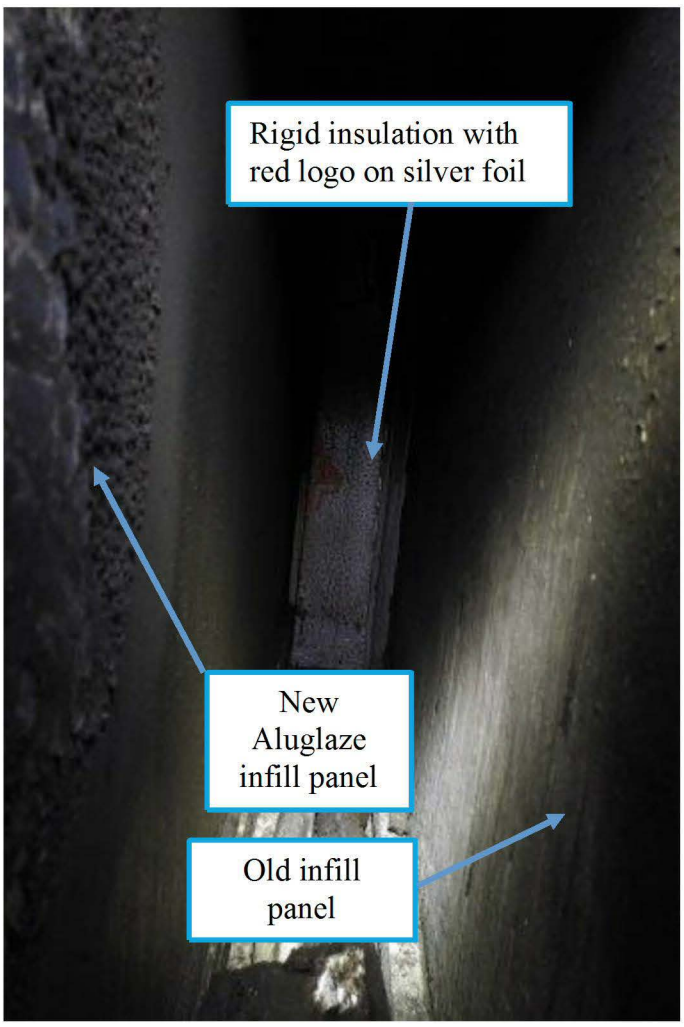


Figure 11.21 View into cavity between insulating core panel and original infill panel

11.18.3 I have found no reference to this insulation type in any of the design information or purchase orders submitted to the Public Inquiry, to date.

11.18.4 I have reviewed the site photo in Figure 11.21 which appears to show a red logo on a silver foil facing. This is consistent with the Celotex TB4000 PIR insulation, which has 'No Defined Performance', Class F, or Class 1 performance based on review of the BBA Agrément certificates in Section 11.15.11. – None of these meet the required classification of limited combustibility (with reference to Table A7 of ADB 2013).

11.19 Summary of compliance of Grenfell Tower insulation materials/products with Section 12.7 of ADB 2013

11.19.1 In Table 11.10 below I have summarised my investigation of the test evidence for the insulation products I have identified within the external wall of Grenfell Tower.

Table 11.10 Summary of compliance of the external wall thermal insulation products in Grenfell Tower

Insulation location at Grenfell Tower	**Insulation material/ product**	**Test Evidence**	**Classified as a material of limited combustibility as provided for in Section 12.7 ADB 2013**
Thermal insulation on columns and on spandrels	Celotex RS5000	Yes: National classification (2017) and European classification	**No** The product has not been tested to any of the relevant National or European fire test standards to demonstrate performance as a material of limited combustibility.
Rain screen cladding insulation on spandrels	Kingspan K15	Yes	**Non-compliant** The stated performance classification Class 0 using BS 476-6 and BS476-7 does not demonstrate the product achieves limited combustibility and BS 476-6 and BS 476-7 are not the relevant test standards.
Insulation fixed behind window reveals	25mm polymeric rigid insulation board - based on visual observation as including Kingspan TP10 and Celotex TB4000 board	Yes, for Kingspan TP10 National classification and European classification No test evidence for Celotex TB4000 received to date	**No** The National classification of Class 0 from tests BS 476-6 and BS 476-7, for Kingspan TP10 relates to surface spread of flame only. This does not demonstrate a classification of material of limited combustibility. The stated performance classification E for Kingspan TP10 is lower than the European Class A2 as required for a material of limited combustibility. The stated performance for TB4000 as no *performance determined* equates to Class F to BS EN 13501-1 which is lower than the required European Class of A2 as required for a material of limited combustibility.

Insulation location at Grenfell Tower	Insulation material/ product	Test Evidence	Classified as a material of limited combustibility as provided for in Section 12.7 ADB 2013
Insulating core panels between the window openings and around the kitchen extract fans	25mm Styrofoam	No test evidence for Styrofoam received to date	**No** The stated performance classification Class E does not achieve the class A2 or better provision to demonstrate limited combustibility in Table A7 of ADB 2013
Insulating core panels originally specified for the kitchen extract	25mm Kingspan TP10	Yes- National classification and European classification	**No.** The National classification of Class 0 from tests BS 476-6 and BS 476-7, for Kingspan TP10 relates to surface spread of flame only. This does not demonstrate a classification of material of limited combustibility. The stated performance classification E is lower than the European Class A2 as required for a material of limited combustibility.
Insulation between the cavity formed by the original and new window infill panel	25mm polymeric rigid insulation board - based on visual observation as including Kingspan TP10 and Celotex TB4000 board	Yes, for Kingspan TP10 National classification and European classification No test evidence for Celotex TB4000 received to date	**No** The National classification of Class 0 from tests BS 476-6 and BS 476-7, for Kingspan TP10 relates to surface spread of flame only. This does not demonstrate a classification of material of limited combustibility. The stated performance classification E for Kingspan TP10 is lower than the European Class A2 as required for a material of limited combustibility. The stated performance for TB4000 as no *performance determined* equates or Class F to BS EN 13501-1 which is lower than the required European Class of A2 as required for a material of limited combustibility.

11.20 Assessment of the cavity barriers installed at Grenfell Tower with ADB 2013

11.20.1 The provisions made in ADB 2013 for cavity barriers as relevant to Grenfell Tower

11.20.2 Section 12.8 of ADB 2013 provides that cavity barriers be installed in accordance with Section 9 of ADB 2013.

11.20.3 Section 9.2 of ADB 2013 states:

Provisions for cavity barriers are given below for specified locations. The provisions necessary to restrict the spread of smoke and flames through cavities are broadly for the purpose of sub-dividing:

a. cavities, which could otherwise form a pathway around a fire-separating element and closing the edges of cavities; therefore, reducing the potential for unseen fire spread; and
Note: These should not be confused with fire-stopping details, see Section 10 and Diagram 33 (see also paragraphs 9.3 to 9.7).

b. extensive cavities (see paragraphs 9.8 to 9.12).

Consideration should also be given to the construction and fixing of cavity barriers provided for these purposes and the extent to which openings in them should be protected. For guidance on these issues, see paragraphs 9.13 to 9.16 respectively.

11.20.4 Pathways around fire separating elements and closing edges of cavities

11.20.5 Diagram 33 of ADB 2013 shows where cavity barriers are required to prevent fire and smoke spread around fire separating elements. I have shown this in Figure 11.22:

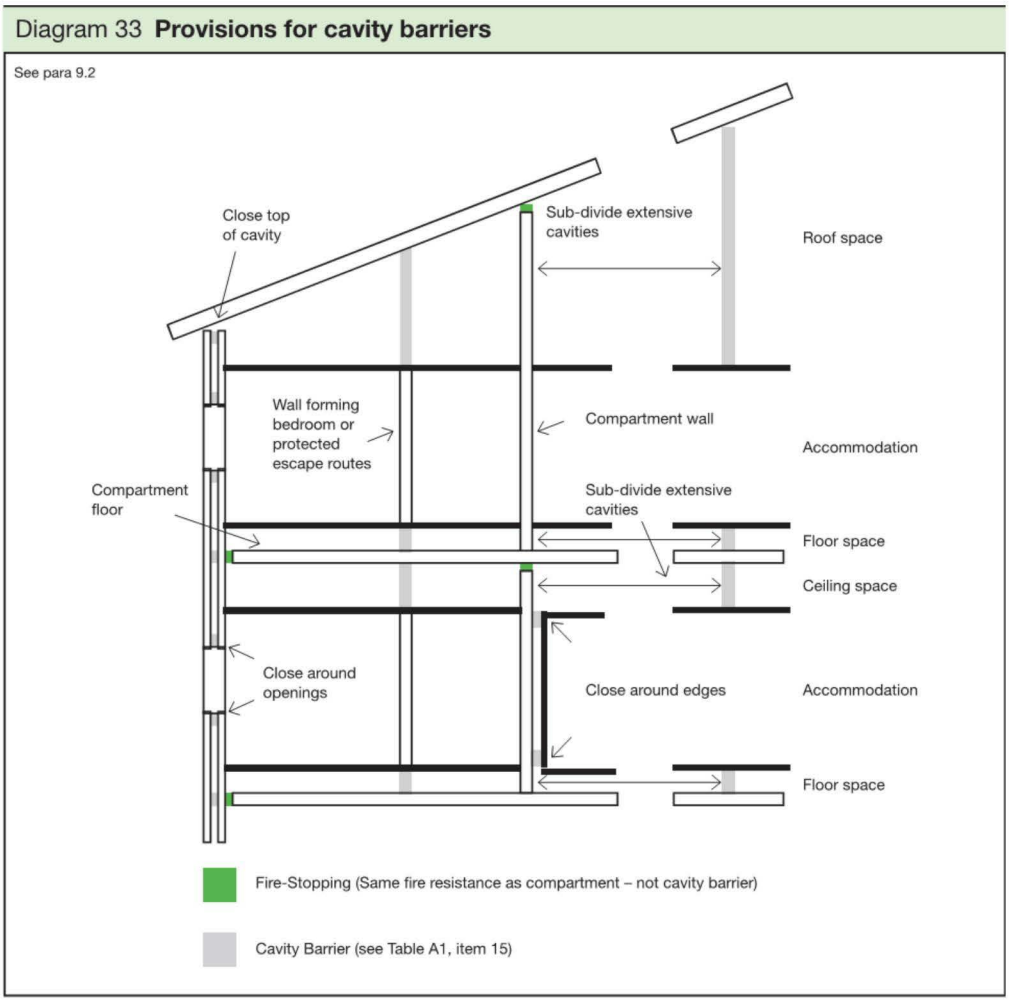


Figure 11.22: Diagram 33 of ADB 2013

11.20.6 Cavity barriers are therefore required to close the top of the cavity; close around openings in the external wall; and at the junction of fire resisting elements and the external wall.

11.20.7 **Subdivision of extensive cavities**

11.20.8 Section 9.8 of ADB 2013 states:

"Cavity barriers should be used to subdivide any cavity, including any roof space so that the distance between cavity barriers does not exceed the dimensions given in Table 13."

11.20.9 It should be noted that Table 13 states that it only applies to purpose groups 2-7. This would not include flats which are purpose group 1a in accordance with Appendix D of ADB 2013. The residential parts of the building from level 04-23 therefore would not have had to meet the cavity barrier spacing provisions of Table 13 but would have had to comply with diagram 33 for the provision of cavity barriers to prevent pathways around fire separating elements and closing edges of cavities.

11.20.10 As the fire only affected the residential areas therefore I will not review the cavity barrier provision in extensive cavities any further.

11.20.11 **Construction of cavity barriers**

11.20.12 Section 9.13 to 19.6 of ADB 2013 provides performance requirements for the Construction and fitting of cavity barriers.

11.20.13 Section 9.13 of ADB 2013 states:

"Every cavity barrier should be constructed to provide at least 30 minutes' fire resistance. It may be formed by any construction provided for another purpose is it meets the provision of cavity barriers (See Appendix A, Table A1, item 15)"

11.20.14 Appendix A, Table A1, item 15 of ADB 2013 states cavity barriers should achieve 30 mins' integrity and 15 minutes' insulation to either the relevant part of BS 476 or the relevant European standard. This performance is required from each side separately.

11.20.15 Integrity and insulation are defined in BS476-20 as follows:

11.20.16 **Integrity**-*the ability of a specimen of a separating element to contain a fire to specified criteria for collapse, freedom from holes, cracks and fissures and sustained flaming on the unexposed face* (BS 476-20:1987 section 2.9).

11.20.17 **Insulation**-*the ability of a specimen of a separating element to restrict the temperature rise of the unexposed face to below specified levels* (BS 476-20:1987 section 2.8).

11.20.18 **Summary of the provision of cavity barriers as per ADB 2013**

11.20.19 To summarise, for the external wall of Grenfell Tower, cavity barriers achieving 30 minutes integrity and 15 minutes insulation fire resistance were required:

- around the openings created by the windows;
- at the head of the rain screen cladding system to close the top of the external wall cavity;
- at the junctions of every compartment floor and the rainscreen cladding system;
- at the junctions with compartment walls separating flats and the external rainscreen cladding system; and

11.20.20 I have over marked the indicative locations of where, in my opinion, the cavity barriers listed above would have been required in Grenfell Tower in Figure 11.23 and Figure 11.24.

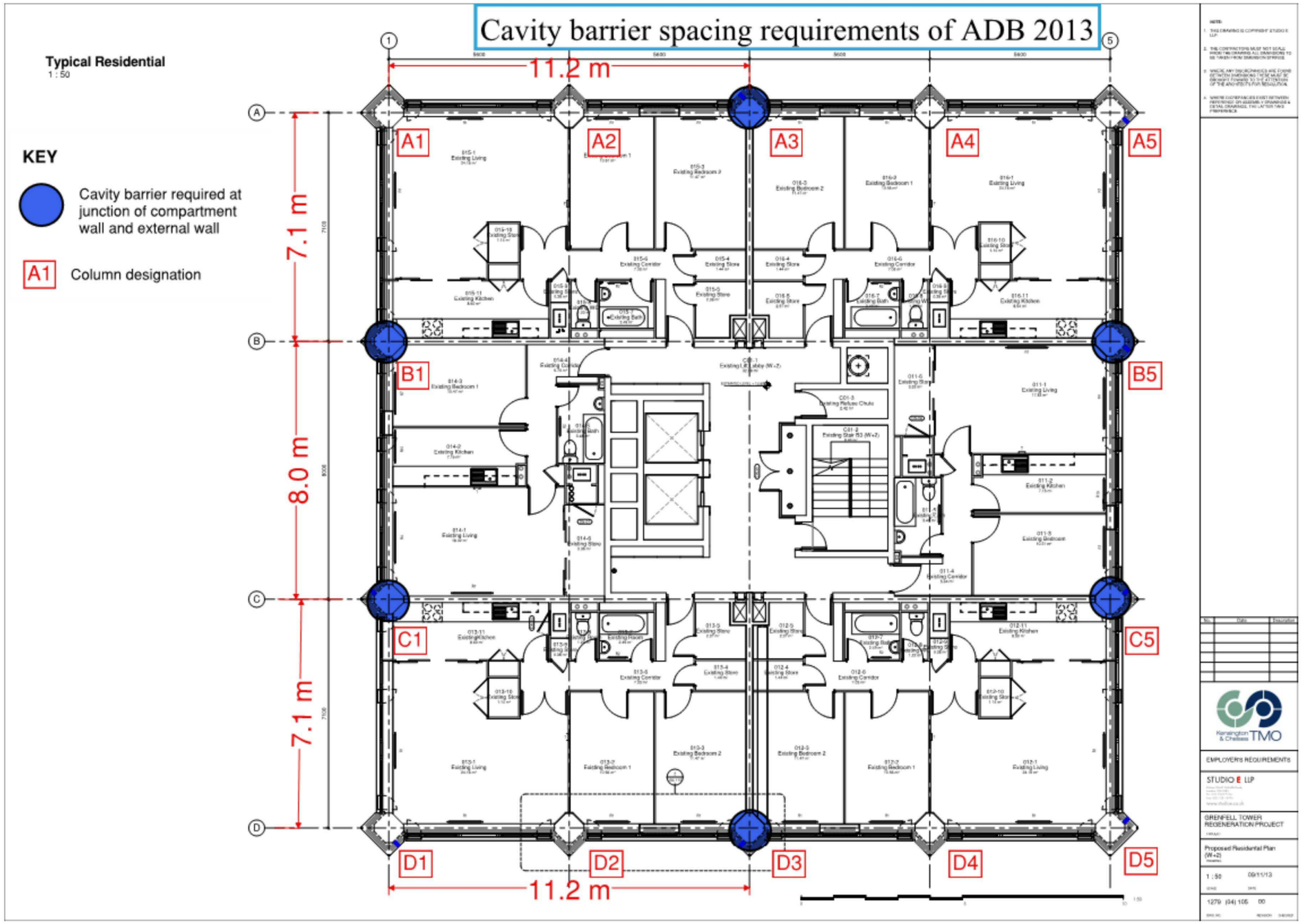


Figure 11.23 My opinion of the Cavity Barrier provisions required for compliance with ADB 2013 Specific to Level 4 and above, at Grenfell Tower (plan view) (adapted from drawing [SEA00010474]) (note horizontal cavity barriers and cavity barriers around openings not shown in the figure above for clarity please refer toFigure 11.24, Figure 11.25)

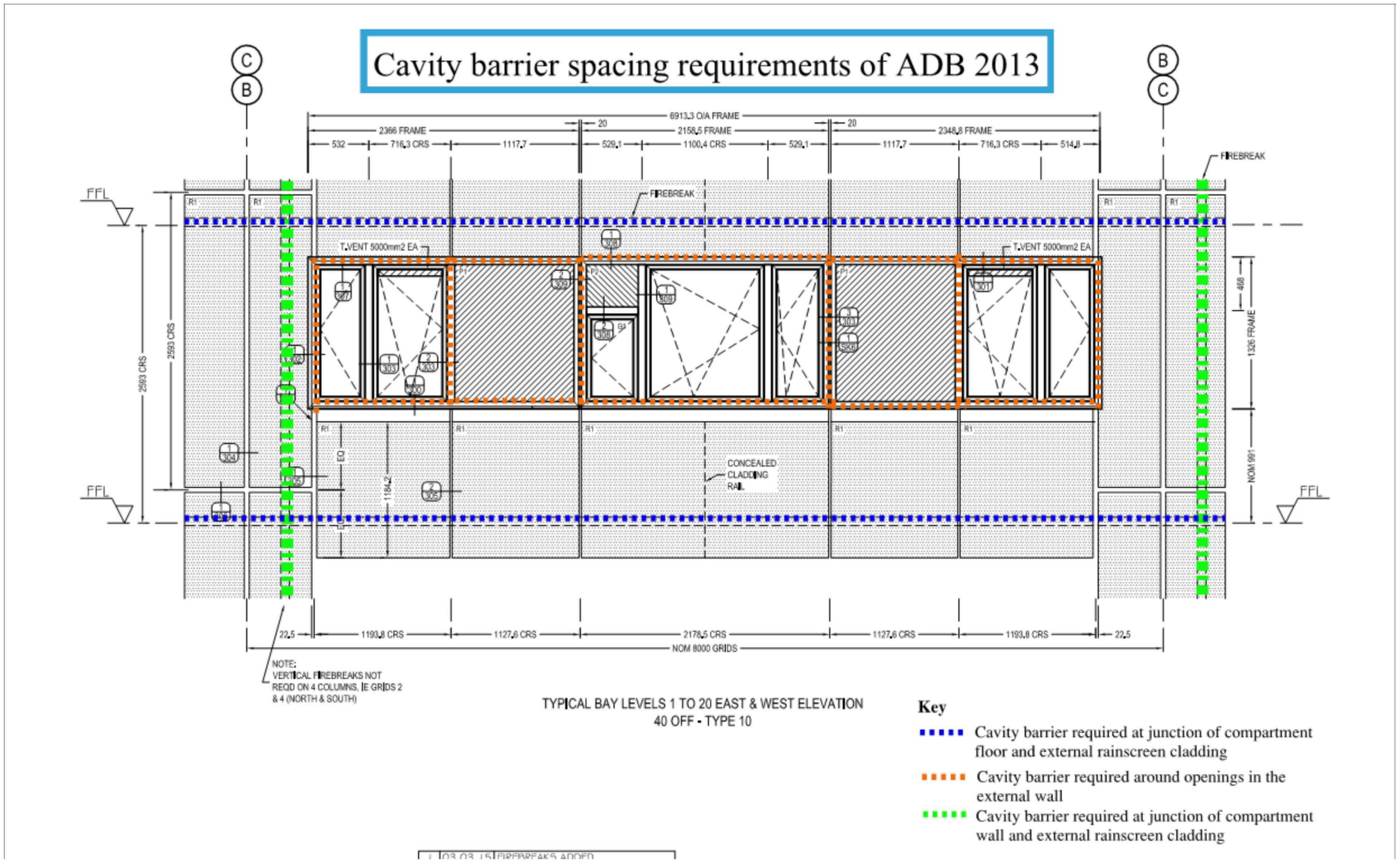


Figure 11.24 My opinion of the Cavity Barrier provisions required for compliance with ADB 2013 Specific to Grenfell Tower Level 4 and above (Elevation view) (adapted from [HAR00008581])

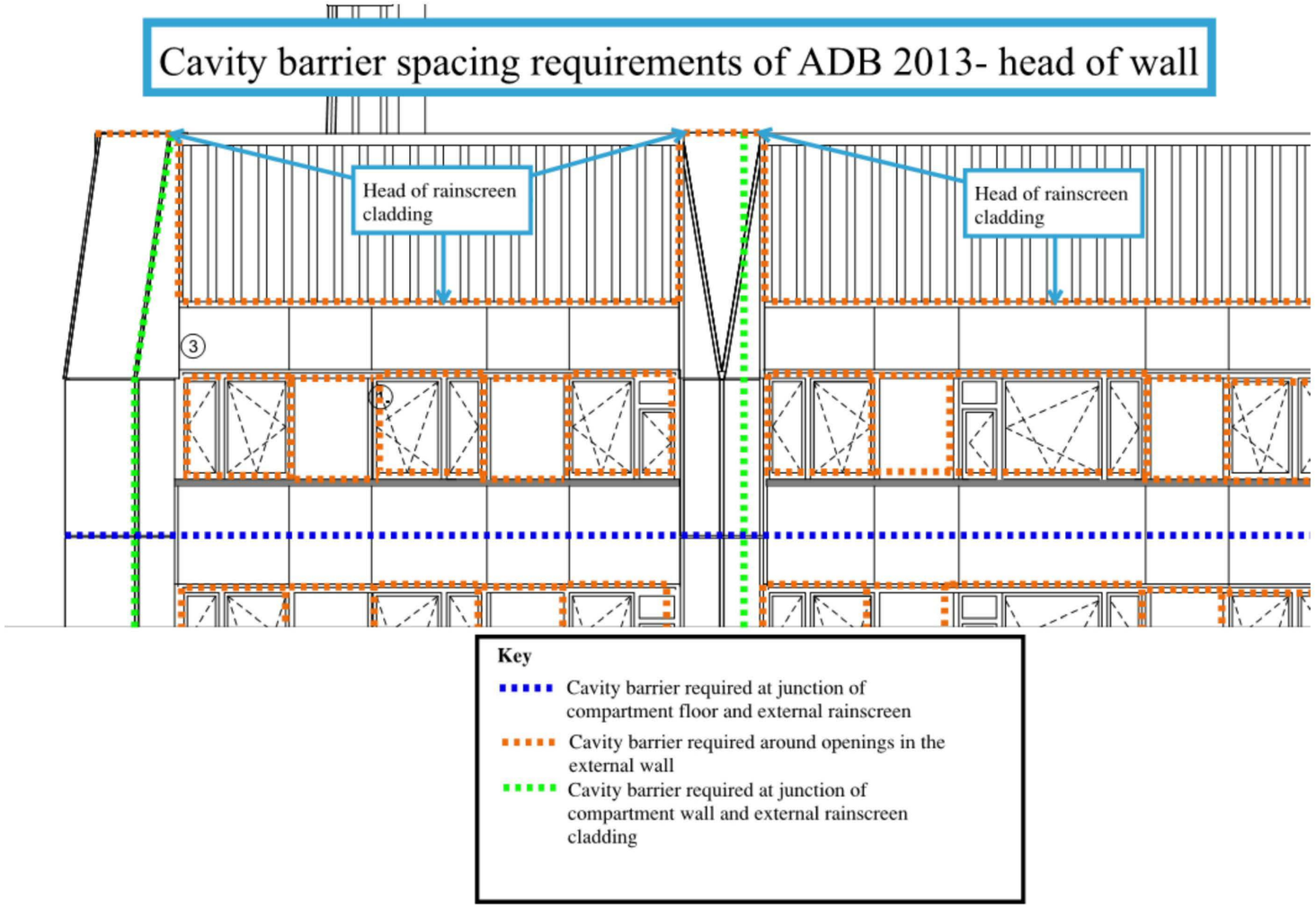


Figure 11.25 My opinion of the cavity Barrier provisions required for compliance with ADB 2013 Specific to Grenfell Tower (Head of wall) (Adapted from 1265 PL 322 Rev 03, RYD00092648)

11.20.21 Assessment of the cavity barrier specification around window openings

11.20.22 I have found no evidence that proprietary cavity barriers were specified at any stage of the design or installed during construction to close the openings created in the external cavity walls by the windows.

11.20.23 Additionally, I confirmed in my site investigations (Section 7) that no proprietary cavity barrier products were installed to close around the window openings at Grenfell Tower.

11.20.24 I have therefore investigated the products and materials specified to close the openings in the external wall created by the window openings to determine if they instead comply with the provisions made in Section 9.13 of ADB 2013 - construction provided for another purpose meeting the provisions of cavity barriers. The products and materials I have considered are the internal window linings.

11.20.25 From my site inspection I observed the uPVC to line the window head, jambs and cills and to be 10mm thick with a bullnose (rounded) finish. This is shown in Figure 11.26.

11.20.26 I observed a rigid insulation foam 25mm thick to be bonded to the underside of the uPVC board at the head, jambs and cills. An example of the charred insulation behind the UPVC surround is shown in Figure 11.27.

11.20.27 The 10mm uPVC board with 25mm insulation does not meet the criteria of section 9.13 which states:

"Cavity barriers in a stud wall or partition, or provided around openings may be formed of:

a) Steel at least 0.5mm thick;

b) Timber at least 38mm thick;

c) Polyethylene- sleeved mineral wool, or mineral wool slab, in either case under compression when installed in the cavity; or

d) Calcium silicate, cement based or gypsum based board at least 12mm thick"

11.20.28 Therefore, the as-installed materials cannot be considered to achieve at least 30 minutes integrity 15 minutes insulation with reference to Appendix A section 5 of ADB 2013.

11.20.29 I therefore conclude that every window opening in Grenfell Tower was not compliant with the provisions made in Section 9.3 of ADB 2013 to provide cavity barriers to close around openings in the external wall.

Figure 11.26 Undamaged UPVC surround of window

Figure 11.27 Charred foam insulation noted behind deformed UPVC window surround

11.20.30 Assessment of the test evidence for the Siderise Lamatherm fire breaks – horizontal condition

11.20.31 The fire resistance performance for cavity barriers is 30 minutes integrity and 15 minute insulation, in accordance with BS 476-22 or BS EN 1366-4.

11.20.32 These cavity barriers were required at the junction of each compartment floors and the external wall.

11.20.33 The O&M manual construction drawings (C1059-100 Rev I [HAR00008991]) specify the following products for horizontal 'fire breaks'.

11.20.34 *"Fire Breaks – New Build Zones*

Horizontal – Siderise Lamatherm RH25G-120/60 Ventilated breaks for 120 min integrity & 60 min insulation.

11.20.35 And

Fire breaks Refurb zones

Horizontal – Siderise Lamatherm RH25G-90/30 Ventilated breaks for 90 min integrity & 30 min insulation."

11.20.36 The "refurb zones" refers to Levels 04 -23 and the new build zones Ground – 03 where new flats were created.

11.20.37 It is not clear to me based on the evidence currently available, what is the basis for two different fire resistance periods in these areas. I will investigate this further in my Phase 2 report.

11.20.38 The fire performance specified in the O&M manual construction drawings (C1059-100 Rev I [HAR00008991]) exceed the 30 minutes integrity and 15 minutes insulation fire resistance performance required to comply with ADB 2013 Table A1.

11.20.39 The as-built detail of the horizontal cavity barriers on the lower levels (C1059-325 Rev C [HAR00006599]) shows a 368mm× 120mm deep open state cavity barrier with 25mm air gap to the cladding panel. The overall cavity width was measured from the drawing as 393mm.

11.20.40 The as-built detail of the horizontal cavity barriers on the upper levels (C1059-301 Rev F [HAR00008901]) shows a 291mm×120mm open state cavity barrier with 25mm air gap to the cladding panel. The overall cavity width was measured from those drawing as 319mm.

11.20.41 As part of the disclosure process to the Public Inquiry, Siderise have provided two fire test reports (one based on fire tests under the National classification framework, and one based on an industry standard).

11.20.42 I have provided a list of all test evidence submitted by Siderise, in Appendix E of my report.

11.20.43 They have also provided two assessment reports by Exova Warrington Fire, relevant to the open state cavity barriers (SIL00000211, SIL00000212, SIL00000223, SIL00000224).

11.20.44 I have reviewed this test evidence, with reference to the Construction drawing (drawing C1059-325 Rev C [HAR00006599])) and conclude the following.

11.20.45 Both test reports (SIL00000212, SIL00000224) and both assessment reports (SIL00000211, SIL00000223) only consider the performance of the Lamatherm CW-RSH cavity barriers installed in cavities formed between two autoclaved aerated concrete lintels.

11.20.46 This construction is substantially not representative of the onsite Grenfell Tower installation where the cavity barriers are installed between concrete and polymeric ACP rainscreen cladding panels.

11.20.47 I therefore conclude none of the disclosed evidence received to date for the horizontal open state cavity barriers is representative of the construction at Grenfell Tower and therefore cannot be relied upon as evidence of their suitable fire performance in that context.

11.20.48 The provision of the horizontal cavity barriers installed in Grenfell Tower at the time of the fire was not therefore in accordance with *"a specification or design which has been shown by test* or *assessed from relevant test standards as meeting that performance"* as required by ADB 2013 Appendix A Section A1.

11.20.49 It should be noted that the Siderise brochure (SIL00000230) states the following:

"SIDERISE RH50(G/S) - 30/30 must be installed with product logo tape on the top face, this is to ensure that the intumescent is located at the bottom of the barrier, thus closest to fire."

11.20.50 I now note this statement applies to the RH50 variant of the product only, in the Siderise online technical guidance, and not any of the RH25 versions.

11.20.51 The test evidence provided to the Public Inquiry (SIL00000212, SIL00000222), shows Class 0 foil tape capping to the vertical face of the exposed mineral wool which forms the cavity barrier; then a graphite intumescent strip applied to this foil face and finally horizontal rainscreen logo tape.

11.20.52 The intumescent strips are 75mm deep, in all the open state cavity barrier tests I have been provided with.

11.20.53 The mineral wool is either 75, 90 or 120mm deep depending on fire resistance performance of the cavity barrier.

11.20.54 The relative location of the 75mm deep graphite intumescent, on any of the mineral wool cavity barriers at the deeper size of 90mm or 120mm is not provided in the test reports.

11.20.54.1 RH50 (G/S) are both 75mm in depth – the same as the depth of the applied intumescent. It is therefore unclear why the requirement to install the cavity barrier with the product logo on the top face applies only to the RH50(G/S) product, as the cavity barrier and its intumescent are the same depth.

11.20.55 For any cavity barrier where the intumescent is not the same depth as the cavity barrier, the fire performance achieved in the test is dependent on the orientation the barrier was installed during the test. i.e. if the intumescent strip was closer to the bottom or the top of the barrier in the test.

11.20.56 The tested orientation would therefore be expected to be stated in the installation advice.

11.20.57 This would presumably become even more important for wider ventilate cavities where the gap to fill by the intumescent, increases from 25mm to 50mm as is the case for the RH50 (G/S).

11.20.58 Unfortunately, such information is not provided in any of the test reports disclosed to date or on the product literature.

11.20.59 On-site construction condition of the Siderise Lamatherm fire breaks – horizontal condition

11.20.60 On the 8th of November 2017, I was able to observe the removal of x3 ACP cladding panels at the spandrel under the living window of Flat 13 on level 04. The works were carried out by MPS with BRE staff. The works were between columns D1 to D2.

11.20.61 The resulting locations I was able to survey, have been marked on the plans in Figure 11.29.

11.20.62 I observed intact ACP cladding panels being removed, followed by the x3 cladding rails, and then x4 slabs of 80mm thick insulation.

11.20.63 I noted that the horizontal cavity barriers behind the spandrel cladding panel were fitted with the green strip facing downward.

11.20.64 The horizontal cavity barriers on the columns were not fitted in accordance with the manufacturer's specification, being that they were rough cut with gaps between barriers and the external wall, and not tightly abutted; and the cladding rails were also cut through the horizontal cavity barriers, creating a gap in horizontal line.

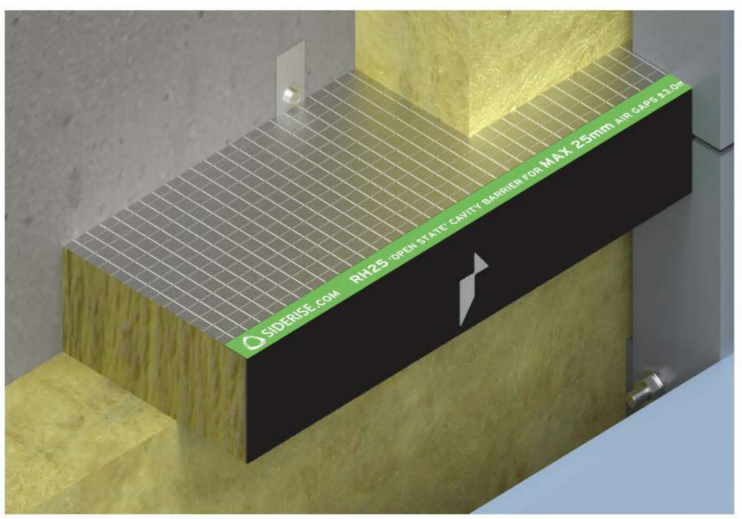
11.20.65 Example site inspection photographs of the horizontal cavity barriers are provided in Figure 11.28.

11.20.66 I will address the construction condition in detail in Phase 2 of my work.

(a) Horizontal cavity barrier affixed to column – upside down position indicated by green logo facing down

(b) Horizontal cavity barrier affixed to spandrel – upside down position indicated by absence of green logo on top surface

(c) visible gap at the junction of the horizontal cavity barriers fitted to the spandrel panels and the columns



SIDERISE RH 'Open State' horizontal cavity barrier for air gaps up to 25mm: RH25(G/S)

(d) Siderise technical data sheet illustrating correct orientation of horizontal cavity barrier (green logo on top)

Figure 11.28 Horizontal cavity barrier installations observed onsite

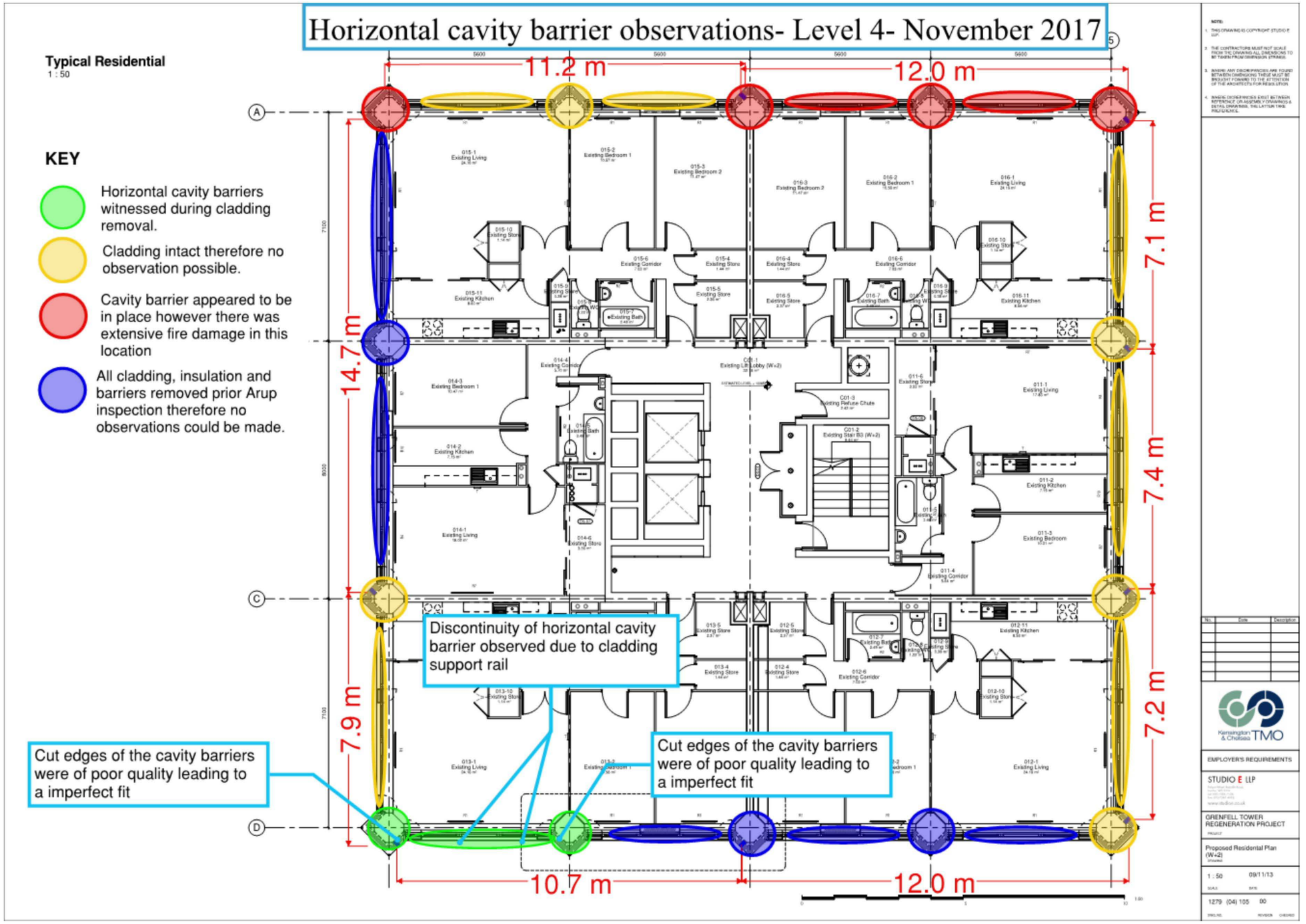


Figure 11.29 Findings from my site investigation of the cavity barrier provisions on level 4 (adapted from 1279 (04) 105 Rev 00 [SEA00010474])

11.20.67 Assessment of the test evidence for the Siderise Lamatherm fire breaks – vertical condition

11.20.68 The O&M manual construction drawings (C1059-100 Rev I [HAR00008991]) specifies the following products for vertical 'fire breaks':

"Fire Breaks – New Build Zones

Vertical – Siderise lamatherm RVG-120/60 full fill (non- ventilated) breaks for 120 min integrity and 60 mins insulation

11.20.69 And *Fire breaks Refurb zones*

Vertical – Siderise lamatherm RVG-90/30 full fill (non- ventilated) breaks for 90 min integrity and 30 mins insulation"

11.20.70 The "*refurb zones*" refers to Levels 04 -23 and the new build zones Ground – 03 where new flats were created.

11.20.71 It is not clear to me based on the evidence currently available, the basis for two different fire resistance periods in these areas. I will investigate this further in my Phase 2 report.

11.20.72 The as built drawing C1059-305 Rev D [HAR00008903] for levels 04-23 shows a 239mm×120mm fire stop in line with the compartment wall with no air gap to the rainscreen cladding panel.

11.20.73 As part of the disclosure process Siderise submitted one fire test report (SIL00000214) to the European standard test; one fire test assessment report for National Classification (SIL00000222) and a product brochure (SIL00000229) which are relevant for the RV product.

11.20.74 The Siderise product brochure (SIL00000229) states that a 120 mm vertical Siderise RV cavity barriers will achieve 120 mins integrity and 120 mins insulation (noting that the test standard used to obtain this result is not stated), when fixed under 10mm of compression, impaled on 2 Stainless steel brackets.

11.20.75 From my review of the disclosed Siderise test evidence, for the vertical fire stops, I have concluded the following.

11.20.76 The Siderise test report (SIL00000214) refers to a test of three vertical linear gap seals within a light weight aerated concrete wall to BS EN 1366-4. The specimens tested were Siderise CW full fill cavity barriers whereas Siderise RV full fill cavity barriers were specified (refer to the O&M manual construction drawings (C1059-100 Rev I [HAR00008991])).

11.20.77 It has been confirmed by letter from Plexus, dated 29/05/2018, that there is no material difference between Siderise CW and Siderise RV.

11.20.78 The test report (SIL00000214) considers the use of the Siderise CW cavity barriers when fixed between lightweight aerated concrete on either side;

whereas the onsite condition is that the cavity barrier is fixed between the ACP panel and concrete.

11.20.79 There is no allowance in the test standard BS 1366-4:2010 for the results obtained in a concrete to concrete substrate to be used to demonstrate the compliance of a cavity barrier fixed between concrete and ACP panel.

11.20.80 Siderise also disclosed a desktop assessment report by Warrington fire research Ltd for the Lamatherm CW cavity barriers (SIL00000222).

11.20.81 The assessment report (SIL00000222) classifies the use of the Siderise CW cavity barriers in cavities up to 400mm formed between curtain walling and concrete as compliant to achieve a fire resistance of 30 mins integrity and insulation. Note the assessment report does not specify exactly what type of curtain walling is acceptable.

11.20.82 The executive summary of the assessment report (SIL00000222) states that the results of the assessment for Lamatherm CW are only valid until 01/03/2009.

11.20.83 **On-site construction condition of the Siderise Lamatherm fire breaks – vertical condition**

11.20.84 On the 8th of November I undertook an inspection of the vertical cavity barrier provision on Level 4 of Grenfell Tower.

11.20.85 As I have concluded in Figure 11.23, vertical cavity barriers were required on columns A3, B1. B5. C1, C5 and D3 i.e. 6 locations in total.

11.20.86 Of the fourteen columns on level 4 I observed that nine of the fourteen columns appeared to be fitted with a vertical cavity barrier (columns A1, A3, A5, B5, C1, C5, D1, D3, D5).

11.20.87 Due to access restrictions I could not determine whether a cavity barrier was or was not installed on column B1.

11.20.88 I therefore conclude that vertical cavity barriers were installed on eight of the nine columns where they were required for compliance with ADB 2013.

11.20.89 I cannot confirm compliance/ noncompliance of the provision on the ninth column where a cavity barrier was required (B1) at this time as it was not possible to make an observation on column B1 due to access restrictions.

11.20.90 Of the nine columns where vertical cavity barriers were identified, I was only able to identify the product type installed on column D1, as the installed rainscreen cladding panels obscured my view of the cavity barriers on the other columns.

11.20.91 The cavity barrier on column D1 was observed to be an open state Siderise RH25G-120/60, as used for the horizontal fire stops.

11.20.92 This is shown in Figure 11.30.

11.20.93 This product has not been tested in the vertical orientation to achieve the required fire performance set out in ADB 2013 Table A1 fixed between concrete and ACP.

11.20.94 The intumescent seal was observed flush with the concrete surface of the original external wall. A gap was observed between the roughly cut fire break, and the rainscreen panel. I understand from the BRE this condition was observed in other locations also.

11.20.95 The provision of the vertical cavity barrier on Column D1 is therefore not installed in accordance with the relevant test evidence.

11.20.96 I have over marked my site findings of the vertical cavity barrier provision on level 4 of Grenfell Tower on the plan in Figure 11.31.

11.20.97 I conclude the vertical cavity barrier provision at Grenfell Tower was not compliant with the provisions made in Section 9.3 of ADB 2013.

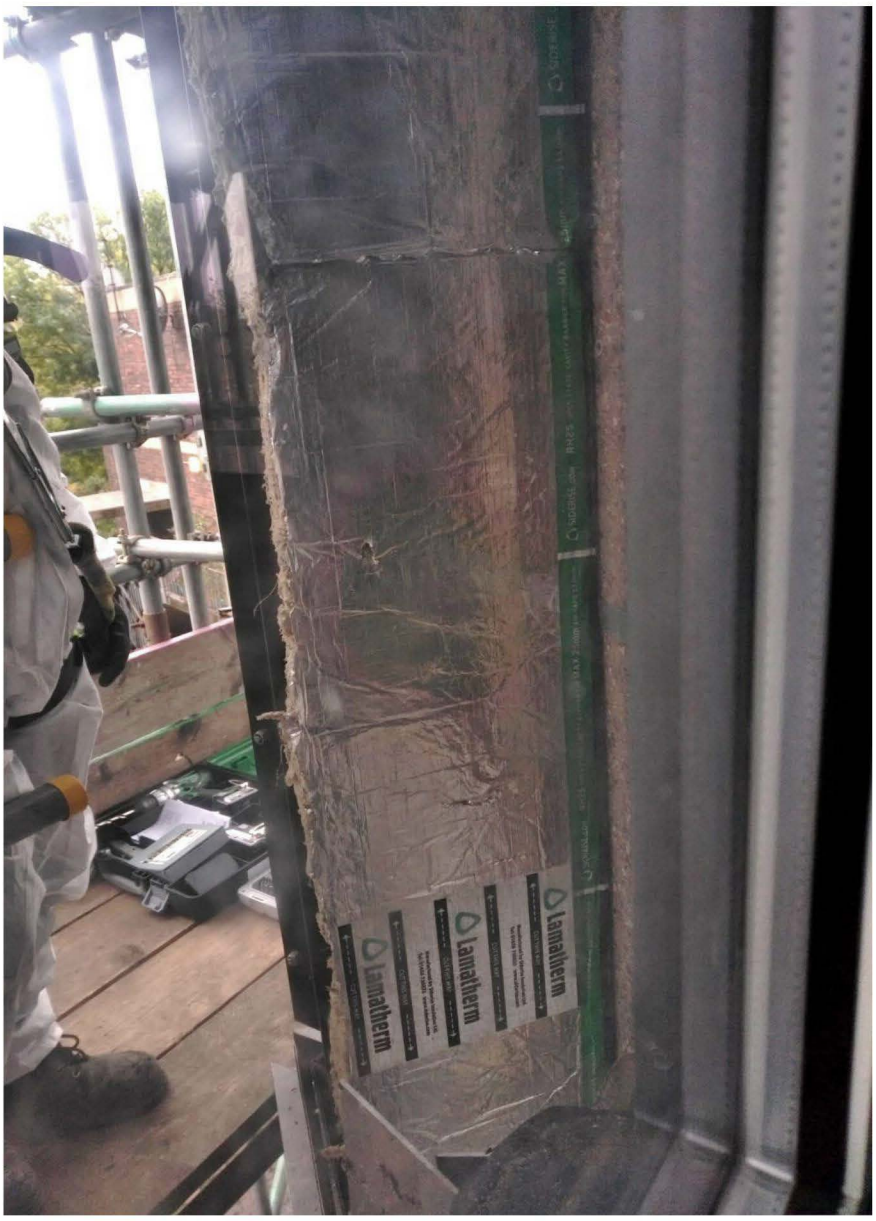


Figure 11.30 Siderise RH horizontal application cavity barrier installed vertically, with intumescent strip facing column D1 outside flat 13 (indicated by green Siderise RH logo)

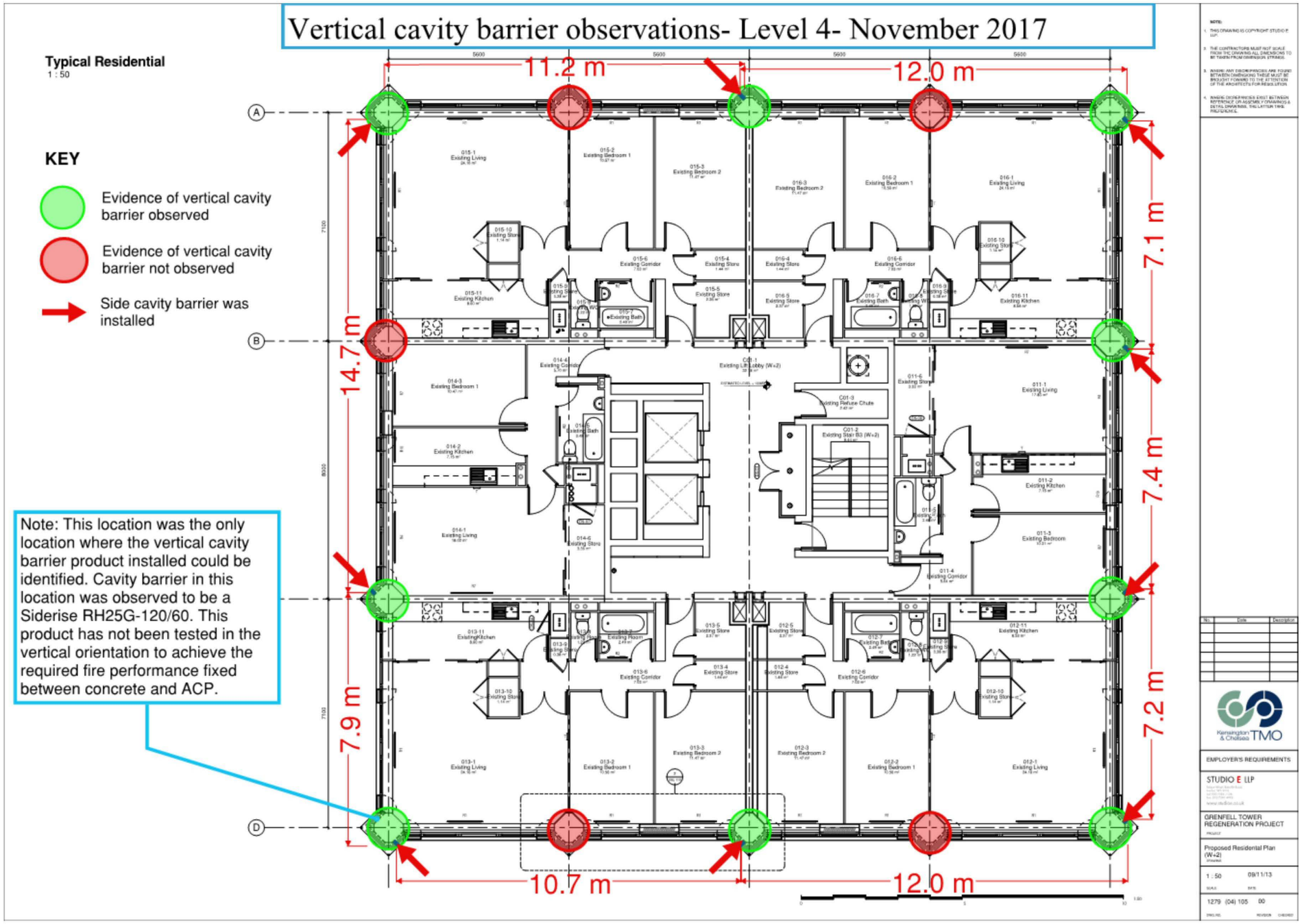


Figure 11.31 Vertical cavity barrier inspection locations on level 4 (adapted from 1279 (04) 105 Rev 00 [SEA00010474])

11.20.98 Assessment of the cavity barrier provision at the head of the rainscreen cladding system

11.20.99 A cavity barrier is required at the head of the external rainscreen cladding system to close the top of the cavity.

11.20.100 I have shown the location of the head of the rainscreen cladding in Figure 11.32 below.

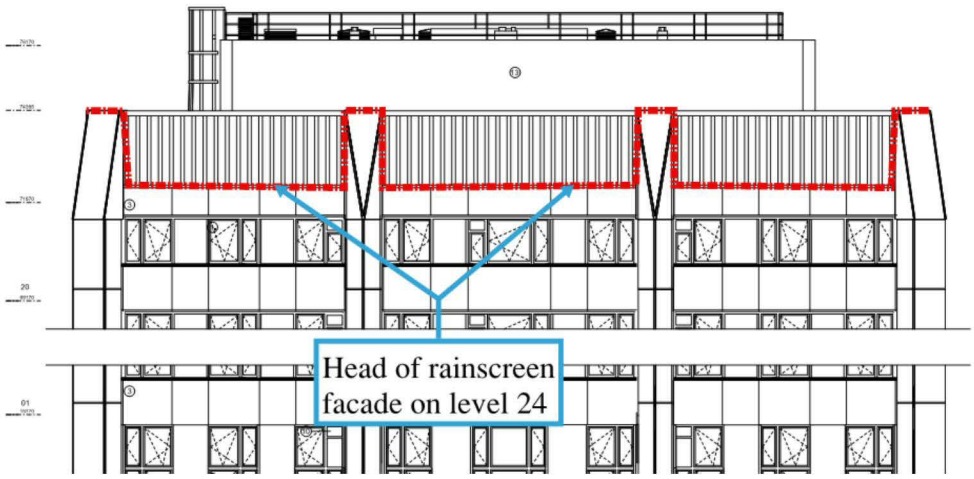


Figure 11.32 Location of the head of the rainscreen cladding at level 24 (adapted from drawing 1265 PL 322 Rev 03, RYD00092648)

11.20.101 I have found two specific as built details for the cavity barrier installation at the head of the rainscreen cladding. These were drawings C1059-217 [HAR00008911], and C1059-332 Rev A [HAR00008929].

11.20.102 I have reviewed these drawings and concluded that no cavity barriers were specified at the head of the rainscreen cladding system.

11.20.103 I have over marked my review in Figure 11.33, and Figure 11.34.

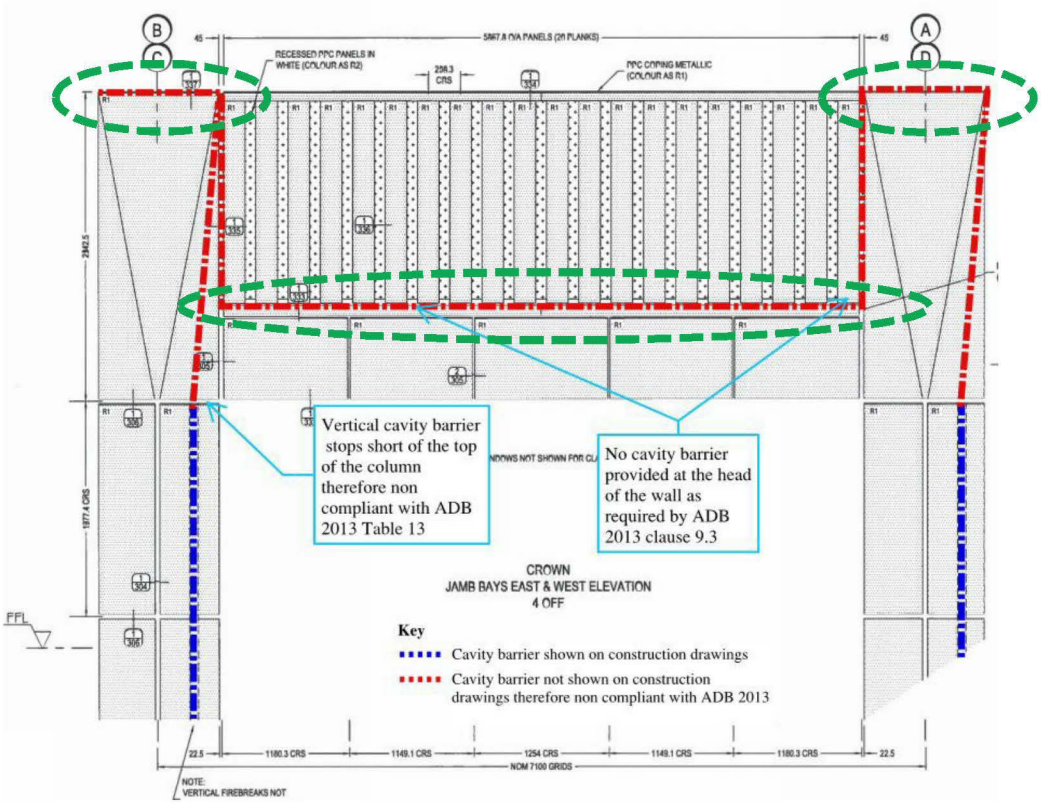


Figure 11.33 Non-compliant cavity specification in construction drawings at head of rainscreen cladding (Adapted from C1059-217 [HAR00008911]) (note top of cavity is highlighted with the dashed green circle)

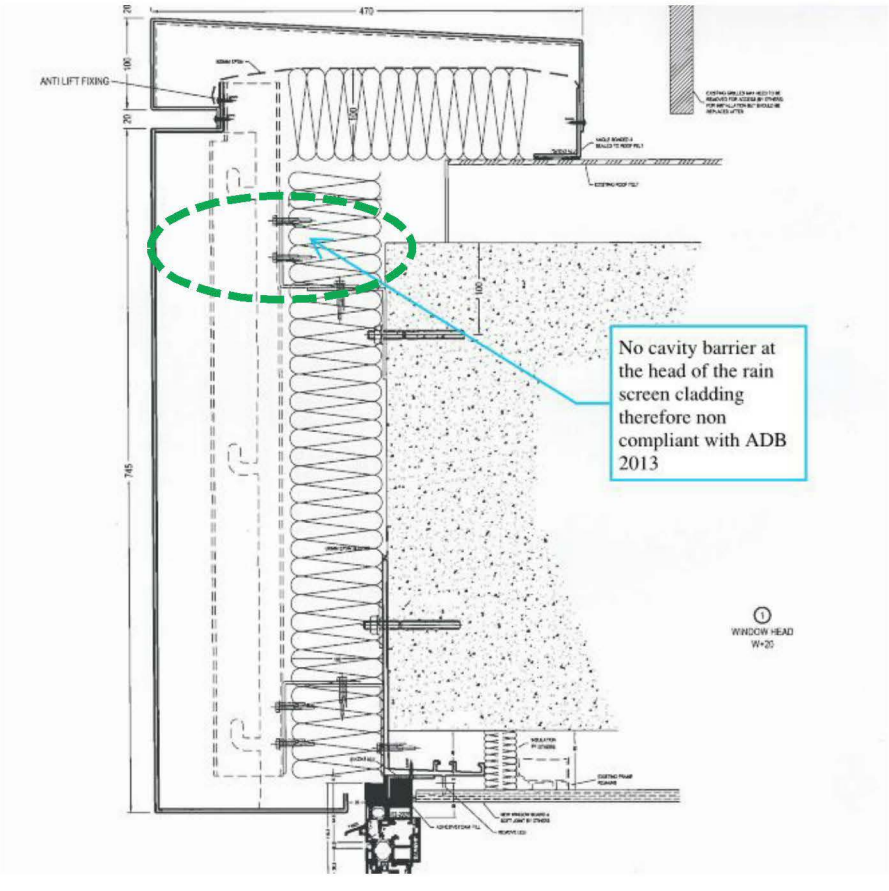


Figure 11.34 Non-compliant cavity specification in construction drawings at head of rainscreen cladding (Adapted from C1059-332 Rev A [HAR00008929]) (head of cavity highlighted with green dashed circle)

11.20.104 I therefore conclude that the construction drawings provide a noncompliant specification of cavity barriers. I was unable to survey the head of the rainscreen cladding at the crown of Grenfell Tower during my site investigation therefore cannot determine if the onsite condition was different to that specified.

11.21 Fire Stopping

11.21.1 It is noted that all of the as built drawings state *Firebreaks* to be provided either at compartment floor level or at the junction of a compartment wall and the external rainscreen façade.

11.21.2 It is unclear if this was intended to be fire stopping as required by ADB 2013 diagram 33, shown below in Figure 11.36.

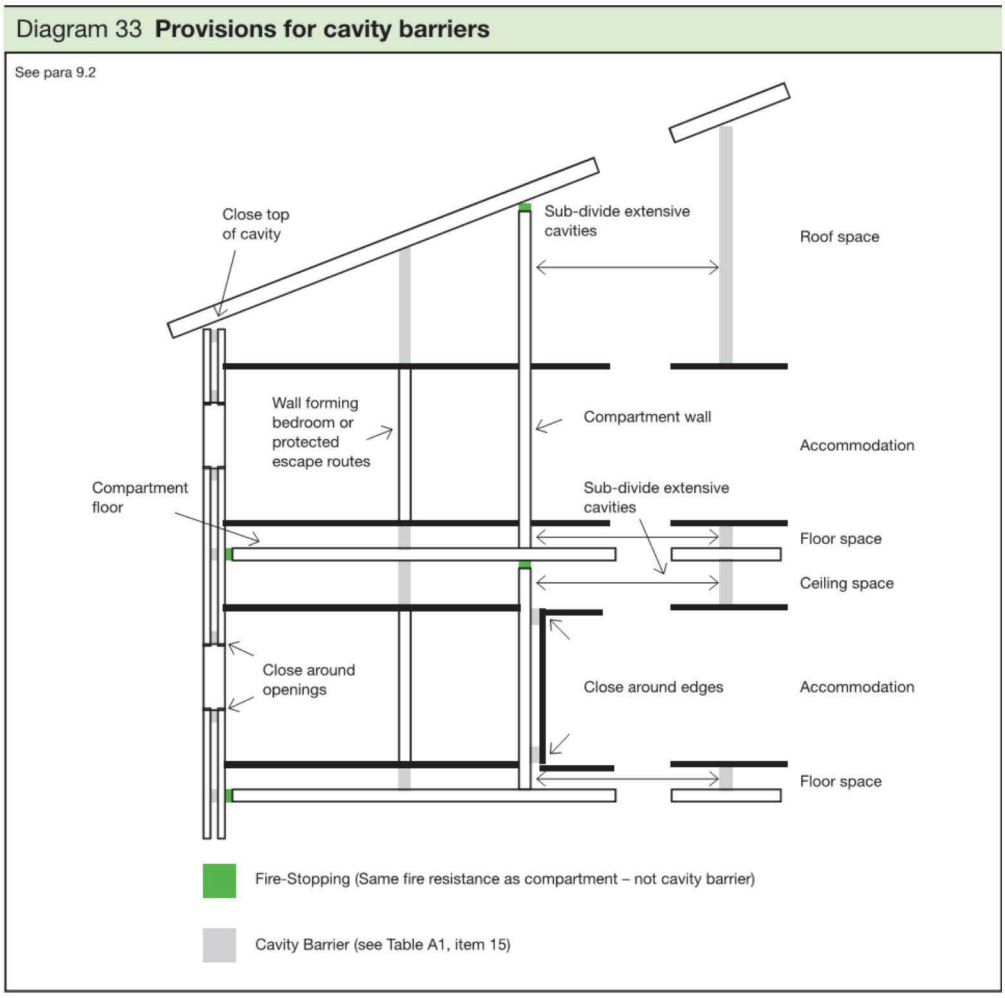


Figure 11.35: Diagram 33 of ADB 2013

11.21.3 Diagram 33 provides that Fire-Stopping should be the same fire resistance as the compartment and "not cavity barrier".

11.21.4 Cavity barriers have a required fire resistance of 30 minutes integrity 15 minutes insulation as stated in Table A1 of ADB 2013.

11.21.5 Fire stopping has a different purpose to a cavity barrier. Section 10.2 of the ADB 2013 states

"*If a fire-separating element is to be effective, every joint or imperfection of fit, or opening to allow services to pass through the element, should be adequately protected by sealing or fire-stopping so that the fire resistance of the element is not impaired.*"

11.21.6 Therefore, the required fire resistance of fire stopping for a building of this height, is 120 minutes where the compartment floors meet the external walls. And 60 minutes where the compartment walls separating flats meet the external walls in accordance with Table A2 of ADB 2013.

11.21.7 It is important to note that fire stopping is within the compartment in Diagram 33 (shown in Figure 11.36. With the cavity barriers placed within the external wall cavity.

11.21.8 I note in Section 9.14 of the ADB 2013 it states that

"*A cavity barrier should, wherever possible, be tightly fitted to a rigid construction and mechanically fixed in position. Where this is not possible (for example, in the case of a junction with slates, tiles, corrugated sheeting or similar materials) the junction should be fire-stopped*".

11.21.9 I have insufficient evidence at this stage, to be able to conclude on the matter of why there was a decision to provide fire stopping instead of cavity barrier at compartment floor and wall junctions, within the external wall cavity.

11.21.10 I can only surmise at this stage, that the designer of the cavity barriers interpreted section 9.4 of ADB 2013 as applies at Grenfell Tower as follows. That the aluminium sheeting forming the rainscreen cladding system could not provide a rigid construction to fix the cavity barrier to, therefore in accordance with ADB 2013 *the junction should be fire-stopped.* I will require further evidence from the designer, to understand this subject and provide a more detailed opinion.

11.21.11 Diagram 33 provides no guidance on the provision of cavity barriers in rainscreen cladding systems formed with an ACP.

11.21.12 I am unclear how it could apply at all when that external surface is formed of a combustible material.

11.21.13 The performance of the cavity barrier becomes irrelevant when a fire can bypass the cavity barrier through the combustible external surface to which the cavity barrier is attached.

11.21.14 I note in Section 11.19 that the Siderise "*fire breaks*" were anyway not tested within an ACP based assembly.

11.21.15 I therefore conclude that it makes no difference whether the *"fire breaks"* were intended as a fire stop of 120 minutes fire resistance/ 60 minutes fire resistance or were only ever intended to be cavity barriers, as they failed to meet the required fire resistance for either.

11.22 Compliance of the entire external wall assembly using BR135 and BS 8414-1 and BS 8414-2

11.22.1 ADB 2013 Section 12.5 states materials used in the external wall assembly should:

"Meet the guidance given in paragraphs 12.6 to 12.9 or meet the performance criteria given in the BRE Report Fire performance of external thermal insulation for walls of multi storey buildings (BR 135) for cladding

systems using full scale fire test data from BS 8414-1:2002 or BS 8414-2:2005."

11.22.2 I have found no evidence to support the materials at Grenfell Tower meet the guidance given in Paragraphs 12.6 to 12.9 of ADB 2013.

11.22.3 The cladding in Grenfell was fixed to a concrete structure therefore the relevant test is BS 8414-1 with respect considering the performance criteria of BR135 instead.

11.22.4 I have summarised the relevant test evidence for consideration with BR135, in Appendix E of my report.

11.22.5 BS 8414-1:2015 (as referenced by ADB 2013 Section 12.5), requires the complete cladding assembly to be tested. The complete assembly, which BS 8414-1:2015 defines as "*Complete cladding assembly, including sheeting rails, fixings, cavities, insulation and membranes, coatings, flashings or joints*" is to be specified by the test sponsor and affixed to the masonry test walls using their proprietary system fixings.

11.22.6 The BS8414-1 data and BR 135 classification is valid for the system as installed in the test, as follows:

The test facility allows external cladding systems to be installed as close to typical end-use conditions as possible. The test faces consist of a masonry vertical main test face, into which the combustion chamber is located, and a masonry vertical return wall or wing, set at 90° to the main test face. The test specimen should be installed with all the relevant components, and should be assembled in accordance with the manufacturer's instructions.

11.22.7 The evidence I have received to date relevant to BS 8414 and B135 is reviewed in detail in Appendix E of my report,

11.22.8 I have summarised the large scale façade test/assessment/ classification reports disclosed by Celotex below in Table 11.11.

11.22.9 I have summarised the large scale façade test/assessment/ classification reports disclosed by Kingspan where ACP were also part of the test arrangement below in Table 11.12.

11.22.10 I have compared the external wall construction at Grenfell Tower with the test evidence I have received to date.

11.22.11 In all instances the evidence received is not relevant to the external wall construction of Grenfell Tower.

11.22.12 The test evidence submitted cannot therefore be relied upon as evidence of the required fire performance in accordance with Section 12.5 of the ADB 2013.

Table 11.11 Evidence of fire performance based on large scale tests submitted to date by Celotex

Company that disclosed the large scale test evidence	Evidence reference	Report Type	Summary of key components tested or assessed	Significant differences between evidence and Grenfell installation	Compliance of Grenfell Tower façade system with ADB 2013 Section 12.5
Celotex	CEL00000374 and associated BR 135 classification report CEL00001329	BR135 assessment report and original BS 8414-2 test	• Cladding assembly attached to a steel frame • Assembly includes: - • Insulation-100mm Celotex RS5000 • Rainscreen Cladding- Marley Eternit Natura decorative rain screen board • Fixing of rainscreen to cladding rails- screw fixed • Cavity barriers- Lamatherm CW-RHS Horizontal Intumescent expanding fire break & Lamatherm CW-RSV Vertical non expanding fire breaks	• Test standard for steel framed buildings was used not BS 8414-1 which is relevant to concrete structures such as Grenfell • The insulation used in Grenfell was Celotex RS 5000 as tested however the thickness of the insulation on the spandrels on Grenfell Tower was thicker, 160mm instead of the 100mm tested. • The Marley Eternit board used in the test is a cementitious board not the combustible ACP panels used on Grenfell Tower • The cladding in the test was screwed in place whereas the ACP cassettes on Grenfell Tower were hung on the cladding rails	Non-compliant. Test/ classification report not relevant to Grenfell façade system Note this test/classification report has been withdrawn by Celotex due to errors and omissions between what was tested and what was reported in the associated documentation. Please refer to my review in Appendix E for further information.
Celotex	CEL00001116	Desktop assessment of expected performance of façade to the criteria set out in BR 135	• Cladding assembly attached to a steel frame • Assembly includes: - • Insulation-100mm Celotex RS5000 • Rainscreen Cladding- Marley Eternit Natura decorative rain screen board • Fixing of rainscreen to cladding rails- screw fixed • Cavity barriers- Lamatherm CW-RHS Horizontal Intumescent expanding fire break & Lamatherm CW-RSV Vertical non expanding fire breaks	• Test standard for steel framed buildings was used not BS 8414-1 which is relevant to concrete structures such as Grenfell • The insulation used in Grenfell was Celotex RS 5000 as tested however the thickness of the insulation on the spandrels on Grenfell Tower was thicker, 160mm instead of the 100mm tested. • The assessment report is written to extend the field of application of the test export CEL00000374 to also include the following cladding panels: 103mm brickwork; 8mm Terracotta tiles; A1 (i.e. non-combustible) cladding laminates; and solid aluminium. None of these four rainscreen cladding types are representative of the ACP panel installed in Grenfell Tower.	Non-compliant. Test/ classification report not relevant to Grenfell façade system
Celotex	P104852-1000 (30/04/2018) (CEL00009493) P104852-1001 (02/05/2018) (CEL00009494)	BR135 assessment report and original BS 8414-2 test	• Cladding assembly attached to a steel frame • Assembly includes: - • Insulation-100mm Celotex RS5000 • Rainscreen Cladding- Marley Eternit Natura decorative rain screen board • Fixing of rainscreen to cladding rails- screw fixed • Cavity barriers- Siderise RH25G-090/30/144-156 Horizontal Intumescent expanding fire break & Siderise RVG-090/030/151-159 Vertical non expanding fire breaks	• Test standard for steel framed buildings was used not BS 8414-1 which is relevant to concrete structures such as Grenfell. • The insulation used in Grenfell was Celotex RS 5000 as tested however the thickness of the insulation on the spandrels on Grenfell Tower was thicker, 160mm instead of the 100mm tested. • The Marley Eternit board used in the test is a cementitious board not the combustible ACP panels used on Grenfell Tower. • The cladding in the test was screwed in place whereas the ACP cassettes on Grenfell Tower were hung on the cladding rails.	Non-compliant. Test/ classification report not relevant to Grenfell façade system

Table 11.12 Large scale facade evidence disclosed by Kingspan which are tested/assessed in conjunction with an ACP panel

Report title	Test sponsor	Date	Prepared by	Relevance to Grenfell Tower	Reference
BS 8414-1:2015 + A1:2017 test on a ventilated façade system with Kingspan Kooltherm K15 insulation and Alpolic/fr panels.	Kingspan Insulation Ltd	14/12/17	BRE	N/a – not tested with Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000141
BS 8414-1:2015 + A1:2017 test on ventilated façade system with Kingspan (K15) thermal insulation and ACM panels Booth Muirie BML400 rivet fixed	Mitsubishi Chemical Corporation	18/01/18	BRE	N/a – not tested with Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000149
An assessment of the fire performance of two external wall systems for block A, Kew Bridge Road Phase 2 against BR 135, Third Edition	Kingspan Insulation Limited	16/10/15	BRE	N/a – neither of the proposed systems considered by the assessment use Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000159
An assessment of the fire performance of two external wall systems for Kew Bridge Road Phase 2	Kingspan Insulation Ltd	22/09/15	BRE	N/a – neither of the proposed systems considered by the assessment use Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000160
An assessment of the external wall system for the Riverlight project, London against the provisions given in Section 12 of Approved Document B, Volume 2	Kingspan Insulation Ltd	26/06/12	BRE	N/a –the proposed system considered by the assessment does not use Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000165

Report title	Test sponsor	Date	Prepared by	Relevance to Grenfell Tower	Reference
Assessment of the fire performance of an external wall system for use on high rise buildings as featured on Commercial Road, London	Kingspan Insulation Ltd	7/10/16	Exova	N/a –the proposed system considered by the assessment does not use Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000169
Assessment of the fire performance of an external wall system for use on high rise buildings as featured on Hale Village Pavilion	Bellway Homes Ltd	24/07/15	Exova	N/a – neither of the proposed systems considered by the assessment use Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000172
Assessment of the fire performance of an external wall system for use on high rise buildings as featured on T4 Premier Inn, Heathrow Airport	Kingspan Insulation Ltd	27/06/17	Exova	N/a –the proposed system considered by the assessment does not use Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000173
BS 8414-2:2015 + A1:2017 Test on a ventilated façade system with Kingspan Kooltherm insulation (100mm-thick) and Alpolic A2 panels (4mm-thick).	Kingspan Insulation Ltd	25/07/2018	BRE	N/a – not tested with Reynobond 55 PE ACM panels as installed on Grenfell Tower	KIN00000492

11.23 Overall compliance of the Rainscreen cladding system at Grenfell Tower with Regulation B4(1)

11.23.1 The functional requirement for external walls is dealt with by means of Regulation B4 External fire spread *(1) The external walls of the building shall to adequately resist the spread of fire over the walls and from one building to another*.

11.23.2 And Regulation B3 (d) Section 9 Concealed Spaces (Cavities) d. *if any hidden voids in the construction are sealed and sub-divided to inhibit the unseen spread of fire and products of combustion, in order to reduce the risk of*

structural failure and the spread of fire, in so far as they pose a threat to the safety of people in and around the building.

11.23.3 Regarding the required fire performance of materials and products, this is dealt with in Appendix A of the Approved Document B. This states "*In such cases the material, product or structure should: a. be in accordance with a specification or design which has been shown by test to be capable of meeting that performance; or b. have been assessed from test evidence against appropriate standards, or by using relevant design guides, as meeting that performance; or*

11.23.4 I have provided my definition of relevant test evidence in Section 3 of my report. I have considered the end use application at Grenfell Tower (BS 476 – 10: 2009 Section 5.3) when assessing that relevant test evidence. I have considered any variations in test evidence when they been determined through a carefully designed test programme or, by an assessment or expert judgement by an expert.

11.23.5 Regarding Grenfell Tower, the test evidence submitted to the Public Inquiry (Please refer to Appendix E of my report) included National and European reaction to fire tests, as well as full scale test data from BS 8414-1:2002 or BS 8414-2:2005.

11.23.6 I have considered any variations in test evidence when they have been determined through assessment as submitted to the Public Inquiry.

11.23.7 Based on this test evidence submitted to the Public Inquiry, and as that test evidence is relevant to the materials installed on Grenfell Tower, these are my conclusions:

a) The specified and installed rainscreen cladding panels, insulation and cavity barriers did not comply with the provisions made in Section 12 of the Approved Document B 2013.

b) The specified and installed rainscreen cladding panels, insulation and cavity barriers did not comply with the functional Requirement of B4 (1) of the Building Regulations.

11.23.8 This means:

a) the ACP rainscreen cladding panel Reynobond 55 PE Cassette system (both types);

b) the Styrofoam insulating core panel, Aluglaze, installed between the windows, and by the kitchen extract vents;

c) the Kingspan TP10 insulation *specified* for installation around the kitchen extract fans;

d) the Celotex RS5000 and Kingspan K15 (and other Kingspan Kooltherm products as may apply) thermal insulation attached to the original concrete wall;

e) the Celotex and Kingspan polymeric insulation boards used to insulate the window reveals, and close the new cavity formed between the old and new infill panels between the windows;

were all noncompliant with ADB 2013 and with the functional requirement of B4(1) of the Building Regulations 2010 at the time of installation.

11.23.9 I have also concluded that some of the cavity barriers required by Section 9 of ADB 2013 were not installed on the night of the fire, specifically the cavity barriers required around window openings.

11.23.10 I have determined that the horizontal and vertical cavity barriers that were installed in the cavity formed by the ACP and the thermal insulation materials at Grenfell Tower, were not classified for the required fire performance by ADB 2013, in that arrangement. This means:

a) Both the specified Siderise Lamatherm RH25G Ventilated breaks; and Siderise Lamatherm RVG full fill (non- ventilated) breaks

b) And the installed Siderise Lamatherm RH25G in both the horizontal and vertical position

11.23.11 Nor were those cavity barriers installed on site in accordance with the method given in the submitted test evidence, noting that test evidence was anyway not relevant to the end use application at Grenfell Tower.

11.23.12 The entire building envelope system could not adequately resist the spread of fire over the walls having regard to the height, use and position of the building. I have presented herein the physical evidence that also supports my conclusion (Figure 11.36 and Figure 11.37).

11.23.13 The building envelope system, designed and installed during the 2012-2016 refurbishment, was therefore non-compliant with the functional requirement of B4 and B3 of the Building Regulations 2010 (Refer to 11.23.1).

11.23.14 I have provided some samples of the post fire photographs taken on site in Figure 11.36 and Figure 11.37 which clearly demonstrate that the external walls of the building have not adequately resisted the spread of fire over the walls.

11.23.15 In my opinion therefore, irrespective of all of the non-compliances I have concluded in this Section 11, at the time of the fire the situation was that the use of the Reynobond 55 PE Cassette; Celotex RS 5000; Kingspan Kooltherm; Kingspan TP10; Celotex TB4000; the Aluglaze Styrofoam core insulating panels; and the Siderise Lamatherm RH25G cavity barriers; when considered separately (as per Section 12.6, 12.7 and 12.8/9) or as a single assembly (Section 12.5), were fundamentally non-compliant with the Building Regulations B4(1).

Figure 11.36 External view of burned surfaces

Figure 11.37 Internal window head-burnt insulation behind uPVC surround