Qualitative Review of Building Envelope Combustibility
Queen Elizabeth University Hospital and Royal Infirmary of Edinburgh
Interim Report (17.10.17)

- **Overview**

There is significant concern, following the fire and loss of life at Grenfell Tower (London, 2017) about the potential for external/rainscreen ACM cladding panels to contribute to the rapid spread of fire on the outside of a building leading to rapid fire spread internally, through re-entry, on multiple levels of a building. The detailed analysis of the sequence of events, the dynamics of fire spread and the contributory factors at Grenfell Tower are under investigation. In the interim it is noted that, whilst ACM cladding panels are evidently a contributory factor to the Grenfell Tower tragedy, they are not the only contributory factor and they may not be the most significant factor.

The contribution of cellulosic/polymeric insulation behind external/rainscreen ACM panels to rapid and sustained fire spread is a potentially more significant factor than the ACM Panels.

The materials used for insulation, or to maintain the rigidity, of ACM panels will, if they are cellulosic/polymeric, burn[1]. The chemical composition of these materials, which can be modified, will determine ease of ignition and/or ability to sustain combustion in a 'real world' situation. However, these attributes are classified in fire engineering codes and the Building Regulations as the outcomes of standard test(s) and not 'real world' performance of elements of construction[2].

Health Facilities Scotland (HFS) commissioned the University to review the design and construction of the external envelope of two hospitals and to evaluate the implications for fire spread of the use of Aluminium Composite Material (ACM) panels as the external cladding. This qualitative review provides an interim report to inform the quantitative scenario analysis and the discussions with HFS.

ACM panels form part, or all, of the external element of the Queen Elizabeth University Hospital (QEUH) and the Royal Infirmary of Edinburgh (RIE). However, 'combustible' materials form part of the external envelope of the building where ACM panels are not the rainscreen cladding (e.g. behind external glass panels at QEUH).

The construction of all of the external envelope elements under consideration, at QEUH and RIE, are deemed under the Building (Scotland) Regulations to be at least 'Low Risk'; however not all are deemed to be 'Non-combustible'.

The project brief focusses on the implications, in the event of ignition and external spread of a fire involving ACM cladding, for the safety of patients, and other occupants, of the hospitals. The probability of occurrence of a fire and it's spread, given mitigation provisions in hospitals, is therefore not directly considered.

[1] the materials will chemically react in the presence of oxygen and heat and release energy

[2] materials and product characteristics are classified in terms of the results of standardised tests that do not directly represent performance in any 'real' fire or the standard/non-technical definition of words such as 'ignitable, flammable, combustible, fire resistant'.

- **Queen Elizabeth University Hospital Summary**

1. Construction

i. From level four to the roof, the QEUH adult hospital has ACM panels on four facades of the building with North and South faces having the same materials, CM 1[3] and the East and West having the same materials CM 9.

ii. From level four to the roof the 'angled out' legs of the adult hospital are CM 1 except for the south west leg where the corner below the helipad is CM 11.

the materials CM1 and CM11 are the only areas in the Adult Hospital where ACM panels are used

iii. On the podium, from ground to the roof over the third floor, the outer skin of the Adult Hospital is constructed of either a glass panel, natural stone or brick with combustible insulation behind (CM 2, 4, 5, 6).

iv. There is no ACM identified in the Royal Children's Hospital. However, there are areas where there is external combustible cladding with combustible insulation behind it (CM 3).

v. The Royal Children's Hospital has combustible materials for insulation behind the non-combustible external cladding/rainscreen (e.g. CM 2, 4, 6).

vi. The Adult Hospital and the Royal Children's hospital are fully sprinklered therefore there is no specified fire resistance in the Technical Handbooks.

vii. There is fire stopping at each floor level and around all window openings for all of the materials/envelope constructions of the building[4].

2. Commentary

i. There is fire stopping at each floor level and around all window openings for all of the materials/envelope constructions of the building[4].

   a. this will prevent/mitigate against fire spread from a fire in the room through the window surround and into the combustible insulation.

   b. In the event that fire spreads into the space between the insulation and the outer cladding, irrespective of type, horizontal spread of fire along the façade will be mitigated by the vertical (intumescent) firestops that are compression fitted with the inner insulation removed before installation[4].

(the manufacturers (Lamatherm) state that for horizontally oriented firestops it is allowable for there to be up to a 25mm gap between the leading edge of the firestop and the external screen. This would allow cold smoke to spread in the cavity but the cavity would be sealed by the expansion of the firestop before temperatures capable of igniting the materials open to the cavity ignite. The manufacturers state that the firestops (cavity barriers) have 'Fire Resistance' of up to 120mins)

ii. Glazed windows would require to be subjected to localised direct flame impingement from fire in a room before failure; the inner pane of the double glazed unit would fail first *(glass fails in fire due to stresses created in a material that is not a good conductor of heat, impurities and constraints caused by differential expansion*). There would be a further period of time to failure of the second pane. The evidence is that failure is typically partial failure of glazing.

iii. The potential for fire spread from a fire in a room to the insulation behind the screen or on the external screen is mitigated by:

   a. The inner part of the exterior envelope of the building is constructed of two layers of 12.5mm thick tapered edge gyproc with staggered joints

[3] Construction Materials listed in Appendix A: these are referenced CM 'X

[4] as per specification, this is an assumption not verified by site inspection as this is outwith scope of the project

b. SHTM 85, Fire Safety – Precautions in Existing Healthcare Premises which requires: *existing hospitals should have at least 75% of Textiles and Furnishings comply with SHTM 87, Textiles and Furniture: the aim should be 100% compliance. It is reasonable to expect that internal fire spread on textiles and furnishings is mitigated and that initial ignition is difficult.*

NHS National Services Scotland have advised that QEUH is 100% compliant

c. QEUH has automatic smoke detection/heat as appropriate. This will alert the staff to a fire incident to intervene before the fire is of a size as to cause failure of glazing or spread from the room of origin by other means.

iv. The largest internal/ward fire, based on compartment size, has 21 beds. Assuming that all fire compartment walls are appropriately constructed and service/other penetrations are protected this is the maximum extent to which a fire would spread internally and threaten external fire spread. This would only occur should if the sprinkler system failed to contain the fire to the room of origin.

v. In the case of sprinkler failure and before an operating systems failure to contain a fire, there would be early detection and alarm. Emergency Management actions to extinguish the fire, evacuate patients and, if necessary, close the door to the room of origin would contain the fire for a considerable period of time.

vi. The potential for a wilful fire raising attack on the external cladding is mitigated on the Adult Hospital as the ACM panels rise from a restricted access area at level 4.

- **Royal Infirmary of Edinburgh Summary[5]**

1. Construction

i. The external perimeter façade and the internal courtyard facades at RIE are of metal composite panels. There are three types of panel:

   a. Hunter Douglas[6]: smooth external aluminium finish, 50mm thick CFC free polyurethane foam core,

   b. Kingspan[7]: profiled steel finish, 45mm thick CFC free polyurethane foam core,

the Hunter Douglas panels are Aluminium Composite Material (ACM) however the steel faced Kingspan panels have similar performance with a higher melting point for the metal facings of the panel.

   c. A third type of panel has been used in alterations; details to be confirmed by RIE.

ii. The external perimeter is primarily clad with Hunter Douglas panels; the external stair towers are clad with Kingspan panels. The panels clad the building from ground to roof level.

iii. The internal courtyards, the FM Building, HSDU and Energy Centre are clad with Kingspan panels.

iv. The inner element of the exterior envelope of the building is constructed of two layers of 12.5mm thick tapered edge gyproc with staggered joints providing Fire Resistance (loadbearing and integrity) of 60 minutes and Fire Resistance (insulation) of 15 minutes[8,9].

v. The windows are UPVC with a secondary steel frame, there are no cavity barriers around the windows[10].

vi. There is fire stopping at each floor level[11].

vii. Automatic detection to 'an enhanced' L2 system is installed[12].

viii. Automatic Fire Suppression is installed in the ground floor retail area of the building.

2. Commentary

vii. The potential for fire spread from a fire in a room to the externa cladding panels is mitigated by:

   a. The inner part of the exterior envelope of the building is constructed of two layers of 12.5mm thick tapered edge gyproc with staggered joints

   b. SHTM 85, Fire Safety – Precautions in Existing Healthcare Premises which requires: *existing hospitals should have at least 75% of Textiles and Furnishings comply with SHTM 87, Textiles and Furniture: the aim should be 100% compliance. It is reasonable to expect that internal fire spread on textiles and furnishings is mitigated and that initial ignition is difficult[13].*

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[5] the Fire Strategy Report for RIE is not available. There are details on sub-compartmentation/compartmentation and cavity barrier positioning that need to be confirmed.

[6] University of Edinburgh Test Panel 3

[7] University of Edinburgh Test Panels 1 and 2

[8] from the inside

[9] as specified in the guidance to the Building Standards Scotland Regulations for the building occupancy, height and compartment size

[10] LABC guidance does not require a cavity barrier where there is a suitable steel frame; details to be confirmed

[11] RIE FM inspections in a number of locations; photographs/details to be confirmed.

[12] in accordance with BS5938 Part 1; confirm L2

[13] Confirmation of compliance to be confirmed

c. RIE has automatic smoke detection/heat as appropriate. This will alert the staff to a fire incident to intervene before the fire is of a size as to cause failure of glazing or spread from the room of origin by other means.

viii. Glazed windows (closed) would require to be subjected to localised direct flame impingement from fire in a room before failure; the inner pane of the double glazed unit would fail first *(glass fails in fire due to stresses created in a material that is not a good conductor of heat, impurities and constraints caused by differential expansion*). There would be a further period of time to failure of the second pane. The evidence is that failure is typically partial failure of glazing.

ix. The largest internal/ward fire, based on compartment size, has 26 beds. Assuming that all fire compartment walls are appropriately constructed and service/other penetrations are protected this is the maximum extent to which a fire would spread internally and threaten external fire spread. This would only occur if early intervention by staff and/or firefighters, following detection and alarm, failed to contain/suppress the fire.

x. Upgrading/ remedial work includes installation of self-closing fire doors to each 'room' in the wards. This will restrict the spread of any fire to the room of origin. However, it is noted that there are glazed panels in the wall and the small leaf of the 'penny farthing' door set does not have a self-closer fitted.

xi. There is the potential for a wilful fire raising attack or an accidental fire within close proximity of the external cladding, this is mitigated by:

a. Hunter Douglas panel performance in standard tests[14,15,1617]:

i. British Standard 476 Part 5 "not easily ignitable",

ii. British Standard 476 Part 6, index of performance (I): 8.9p Sub-Index (I) : 4.0,

iii. British Standard 476 Part 7, Class (1) one, surface spread of flame.

b. limited, if any, combustible material build up to support fire growth after accidental ignition; including ignition by smokers.

c. CCTV coverage and general security measures reduce risk of deliberate build up of combustible materials for wilful fire raising.

xii. An accidental vehicle fire, a deliberate vehicle fire or the deliberate ignition of sufficient combustible material or explosives brought to the perimeter of the building would generate the heat release rate to ignite the cladding panels[18].

- In the event that a fire spreads on the external façade fire spread to inside of the building would be possible through open windows, in the first instance, potentially on all levels.

[14] the Hunter Douglas panels predominate on the external perimeter that is accessible

[15] the Kingspan panels are steel faced and are therefore less vulnerable

[16] a significant quantity of combustible materials/heat source would be required to produce the heat release required to raise the temperature to ignite the combustible material behind the aluminium/steel outer face of the sandwich panel. Aluminium has a melting point of around 660^{O} C, lower than steel, this temperature, or close to it, would cause the metal facing to 'fail' and expose the combustible core. Heat conducted through the metal facing would raise the temperature of the core material however the test results indicate that prior to facing failure ignition is unlikely.

[17] The University of Edinburgh tests were on small mass samples and not on the installed product. They evidenced that the core material could ignite and release energy in the form tested. This did not provide evidence of time to ignition, the energy required to cause ignition or the performance of installed products 'new' or 'damaged'.

[18] this is primarily a site risk management issue.

Appendix A

Construction Materials

1	5	6	9	10	11	12	13	14	15
Project	**Location**	**Reference**	(If col 6 completed): **External wall construction**	(If col 7 completed): **Relevant fire classifications**	(If col 6 completed): **Firestopping in Void?**	**Specialist Sub-Contractor's Description**	**Specialist Sub-Contractor's Product Reference**	**Specialist Sub-Contractor's Product Fire Certification**	**Specialist Sub-Contractor's Product Fire Certification**
The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Adults, Towers	1	Unitised curtain walling system fixed at floor slab levels incorporating double glazed units with fully encapsulated insulated aluminium spandrel panels, independent shaftwall system forming internal leaf clad with two layers of plasterboard to inner face and cement particle board to outer face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	Unitised aluminium curtain walling, incorporating double glazing units, fully encapsulated single glass spandrel panels with Celotex FR5000 insulation, internal steel tray panel.	25NM-SGH	Internal surface spread of flame of curtain walling Class 0 to BS 476-7. Celotex FR5000: Fire propagation BS476 part 6- Pass; Surface spread of flame BS476 part 7- Class 1. Firestopping achieved with proprietary Siderise CW-FS tested and assessed on proven fire performance to BS 476 :Part 20, and tested to EN 1364-4.	Structal confirm the installation is compliant at the time of construction and in accordance with the relevant Building Regulations at Financial Close.

The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Adults & Childrens, Podium	2	Stick curtain walling system fixed at floor slab levels incorporating double glazed units with insulated ceramic unit spandrel panels on cement particle board to outer face of independent shaftwall system forming internal leaf/structural framing system clad with two layers of plasterboard to inner face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	**Prater:** Spandrel units with 6mm clear toughend float glass unit with ceramic frit to surface 2, 80mm Kingspan K15 insulation, galvanised steel liner sheet **Others:** Y-Wall board, insulated SFS system or concrete cores.	Curtain Walling	Glass: Noncombustable (Decision 94/611/EC) Structal: Rockwool Duoslab Rated A1 when tested to EN 13501-1 classification using test data from reaction to fire test. Alucobond BS476, part 6≤12i≤6, Surface spread of flame BS476 part 7-Class 1 therefor meets class 0 national building regulations. Firestopping achieved with proprietary Siderise CW-FS tested and assessed on proven fire performance to BS 476 :Part 20, and tested to EN 1364-4. K15 Insulation: Low Risk Galvanised Liner: Noncombustable (Decision 94/611/EC)	

The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Childrens	3	Trespa Meteon rainscreen cladding panels on carrier system incorporating Kingspan Kooltherm K15 thermal insulation fixed to cement particle board on outer face of structural framing system with two layers of plasterboard to inner face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	**Prater:** Trespa Meteon panels, 80mm Kingspan K15, aluminium helping hand system & intumescent fire stopping.**Others:** Y-Wall board, insulated SFS system.	Trespa Rainscreen System	Trespa Meteon: TBCKingspan K15: Low Risk	
The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Adults, Podium, Main Entrance Area	4	StoneLite faced cladding panels with honeycomb backing on carrier system incorporating Kooltherm K15 thermal insulation fixed to cement particle board to outer face of structural	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall	**Prater:** Stonelite natural stone aluminium honeycomb backed panels, 80mm Kingspan K15, aluminium helping hand system & intumescent fire stopping. **Others:** Y-Wall board, insulated SFS system.	Natural Stone Cladding	Stonelite Panels: Low Risk Kingspan K15: Low Risk	

			framing system with two layers of plasterboard to inner face		junctions				
The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Adults & Childrens, Podium	5	Forticrete cavity blockwork facing masonry, Kingspan Kooltherm K15 thermal insulation fixed to cement particle board on outer face of structural framing system with two layers of plasterboard to inner face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	**Prater:** Novastone Blockwork **Others:** Y-Wall board, insulated SFS system.	Brickwork	Novaston Blockwork: Noncombustable	

The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Adults & Childrens, Podium	6	Sto cement-free render on EPS insulation board incorporating fire retardant additive fixed back to cement particle board on outer face of structural framing system with two layers of plasterboard to inner face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	**Prater:** Stotherm Vario render system inc EPS insulation & Lamella fire breaks. **Others:** Y-Wall board, insulated SFS system or concrete cores.	Render	Sto Vario Insulated Render System: BR 135 Test Report demonstrating suitability for use,	
The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Adults & Childrens, Plantrooms	7	Kingspan KS 1000MR EcoSafe micro-rib insulated wall panels on structural framing to primary structural frame	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	**Prater:** RUUKKI SP2D PIR Composite Panel**Others:** Y-Wall board, insulated SFS system.	RUUKKI Composite Cladding	RUUKKI SP2D: Low Risk	

The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Childrens, Main Entrance Area	8	Rheinzinc seamed cladding system on 25mm WBP plywood on carrier system incorporating Kooltherm K15 thermal insulation fixed to cement particle board on outer face of structural framing system with two layers of plasterboard to inner face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	**Prater:** 0.8mm Rheinzink blue grey standing seam, tyvek breather membrane, 25mm FR Class 0 plywood board, 80mm Kingspan K15, aluminium helping hand system & intumescent fire stopping. **Others:** Y-Wall board, insulated SFS system.	Zinc Cladding Rainscreen System	Rheinzink: Non-combustable Plywood: Low Risk Kingspan K15: Low Risk	

The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Adult, Towers	9	Unitised curtain walling system incorporating double glazed units with fully encapsulated spandrel panels formed of Reynobond aluminium panels incorporating Kingspan Kooltherm K12 thermal insulation, independent shaftwall system forming internal leaf clad with two layers of plasterboard to inner face and cement particle board to outer face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	Unitised aluminium curtain walling, incorporating double glazing units, fully encapsulated composite aluminium spandrel panels - Alucobond PE, with Celotex FR5000 insulation, internal steel tray panel.	25NM-SGH	Internal surface spread of flame of curtain walling Class 0 to BS 476-7.Celotex FR5000: Fire propagation BS476 part 6- Pass; Surface spread of flame BS476 part 7-Class 1. Alucabond BS476, part 6≤12i≤6, Surface spread of flame BS476 part 7-Class 1 therefor meets class 0 national building regulations. Firestopping achieved with proprietary Siderise CW-FS tested and assessed on proven fire performance to BS 476 :Part 20, and tested to EN 1364-4.	Structal confirm the installation is compliant at the time of construction and in accordance with the relevant Building Regulations at Financial Close.

The Queen Elizabeth University Hospital and Royal Hospital for Children, Glasgow	Helipad Area and Core Towers	11	Alucobond aluminium cladding panels on carrier system incorporating Kooltherm K15 thermal insulation fixed to cement particle board on outer face of independent shaftwall system forming internal leaf clad with two layers of plasterboard to inner face	Reaction to fire of external wall cladding to be low risk in accordance with non-domestic technical handbook section 2.7.1	Intumescent firestops are provided horizontally at each floor level, around all window & door openings and vertically at all compartment wall junctions	**Prater:** Booth Muirie BM120 rainscreen system, incorporating Alucabond Plus ACM panel, 80mm Kingspan K15, aluminium helping hand system & intumescent fire stopping.**Others:** Y-Wall board, insulated SFS system. **Structal**: Alucobond PE rainscreen panel, Rockwool duoslab insulation	ACM Rainscreen System **Structal:** SUK-RS	Alucabond Plus: Low RiskKingspan K15: Low Risk	Structal confirm the installation is compliant at the time of construction and in accordance with the relevant Building Regulations at Financial Close.