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BRE Global Client Report

BS 8414-1:2015 + A1:2017 test referred to as DCLG test 6.

Prepared for: DCLG

Date: 25th August 2017 (Issue 1.0)
12th September 2017 (Issue 1.1)

Report Number: B137611-1037 (DCLG test 6) Issue 1.1

BRE Global Ltd
Watford, Herts
WD25 9XX

Customer Services 0333 321 8811

Prepared for:
Department for Communities and Local Government
2 Marsham Street
London
SW1P 4DF

Version history

12/09/2017	Issue 1.1	Amendment to section 4.4.

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1 Introduction

This report is one of a series, commissioned by the Department for Communities and Local Government (DCLG) intended to establish how different types of Aluminium Composite Material (ACM) panels in combination with different types of insulation behave in a fire.

Following the fire at Grenfell Tower in London on 14 June 2017, the Government established an Independent Expert Advisory Panel to advise on immediate measures that should be put in place to help make buildings safe. On 6 July the Independent Expert Advisory Panel recommended a series of full scale BS 8414 tests be carried out in order to help building owners make decisions on any further measures that may need to be put in place.

This series of tests includes 6 combinations of cladding systems. The detailed design of each test specimen was carried out by a cladding company appointed by DCLG. The design of the cladding systems have been reviewed by the Independent Expert Advisory Panel and other industry bodies to ensure that they are representative of the systems that are in common use on buildings, including the way they are fixed. The cladding systems have been or will be installed by a Company appointed by DCLG and each one has been or will be independently assessed during the installation to ensure that it meets the design specification.

The six test specimens incorporate each of the three common types of ACM panel, with core filler materials of unmodified polyethylene, fire retardant polyethylene and limited combustibility mineral. The two insulation materials specified for use in the testing are rigid polyisocyanurate foam (PIR) or stone wool.

The test method, BS8414 Part 1:2015 + A1:2017[1] describes a method of assessing the behaviour of non-load bearing external cladding systems, rain screen over cladding systems and external wall insulation systems when applied to the face of a building and exposed to an external fire under controlled conditions. The fire exposure is representative of an external fire source or a fully developed (post-flashover) fire in a room, venting through an opening such as a window aperture that exposes the cladding to the effects of external flames.

This report applies to the cladding system as detailed. The report only covers the details as tested. It is important to check that the cladding system tested relates to the end use application when installed on a building. Such checks should be made by a suitably competent person.

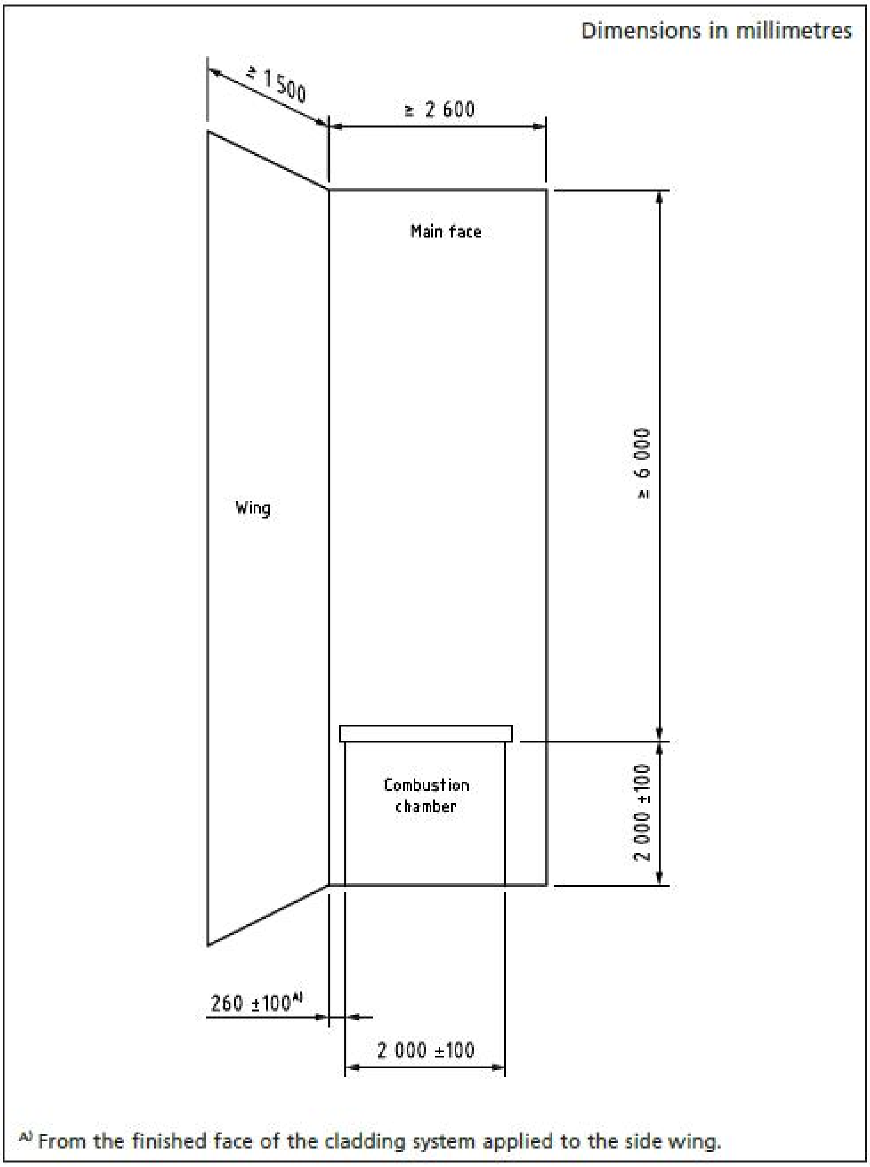
All measurements quoted in this report are nominal unless stated otherwise.

2 Details of test carried out

Name of Laboratory:	BRE Global Ltd.
Laboratory Address:	Bucknalls Lane, Garston, Watford, Hertfordshire, WD25 9XX.
Test reference:	DCLG test 6
Date of test:	16/08/2017
Sponsor:	Department for Communities and Local Government
Sponsor address:	2 Marsham Street, London, SW1P 4DF.
Method:	The test was carried out in accordance with BS 8414-1:2015 + A1:2017
Deviations:	None

3 Details of test apparatus used

The product was installed to wall number 2 of the BS 8414-1 BRE Global test facility. This apparatus is defined in the test Standard[1] and consists of a masonry structure with a vertical main test wall and a vertical return wall at a 90º angle to and at one side of the main test wall. See *Schematic 1*. The main wall includes the combustion chamber.



Schematic 1. Test apparatus dimensions as specified by test Standard[1].

Note: The test apparatus may be constructed left- or right-handed.

4 Description of the system

4.1 Installation of specimen

BRE was not involved in the design, installation, procurement or specification of the materials and cladding system that was submitted for testing. The tested system was defined by the Test Sponsor.

4.2 Description of substrate

The test specimen was installed to wall number 2 of the BRE Global Cladding Test Facility. This is a multi-faced test rig constructed from steel with a masonry finish onto which the cladding system was applied.

4.3 Description of product

Figures 10-14 were provided by the Test Sponsor to show the design and detailing of the installed system.

The tested cladding system build up is given in order from the masonry substrate to the external finish:

- 90mm-high×64mm-wide×220mm-deep×4mm-thick aluminum 'L'-shaped brackets fixed with a single 90mm-long×ϕ8mm stainless steel screw anchor and plastic plug – see *Figures 6&7*;
- 180mm-thick stone wool dual density insulation board (supplied 1200mm×600mm and cut to size) – see *Figure 5;*
- 120mm-wide×60mm-deep×2mm-thick aluminum 'T'-section framing and 40mm-wide×60mm-deep×2mm-thick aluminum 'L'-section framing – see *Figures 4&5;*
- 75mm-wide×240mm-deep stone wool vertical cavity barriers (stated integrity/insulation performance: 90/30mins), with 10mm compression – see *Figures 3&4*;
- 75mm-wide×205mm-deep stone wool with intumescent horizontal cavity barriers (stated integrity/insulation performance: 90/30mins) – see *Figures 3&5*;
- 4mm-thick front face Aluminum Composite Material (ACM) panels, with a white finish – see *Figure 9*.

The densities of the insulation and the cavity barriers have been determined and are reported in *Appendix A*.

The 4mm-thick ACM panels consisted of, from outward face in:

- 0.5mm-thick aluminium sheet;
- 3.0mm-thick limited combustibility mineral filler;
- 0.5mm-thick aluminium sheet.

The filler between the aluminium sheets was screened using the BS EN ISO 1716:2010[3] test methodology. The results are given in *Appendix B*.

4.4 Installation sequence

Onto the masonry support structure the 90mm-high×64mm-wide×220mm-deep×4mm-thick aluminium 'L'-shaped brackets were fixed in position on low density polyethylene isolation pads (5mm-thick), with a single 90mm-long×ϕ8mm stainless steel screw anchor and plastic plug – see *Figures 6&7*. On the main face the horizontal spacing between the brackets varied between 340mm and 500mm – see *Figure 3*. On the wing wall the horizontal spacing between the brackets was 600mm as specified in the manufacturer's details. The vertical spacing between the brackets was 960mm and where horizontal cavity barriers were present a spacing of 410mm was used.

The system included vertical and horizontal cavity barriers - see *Figures 3-5*. On the main face, two 75mm-wide×240mm-deep stone wool vertical cavity barriers, with 10mm compression, were fixed in position with a clear distance of 1980mm between them - see *Figures 3&4*. The vertical cavity barriers were skewered to ¾-depth on steel brackets fixed into the masonry wall with one 70mm-long×ϕ4mm anchor. Two steel brackets were used for each length of 1200mm of stone wool cavity barrier - see *Figure 4*. The vertical cavity barriers were trimmed to fit under the 'T'-rail - see *Figure 4*.

On the wing wall, one 75mm-wide×240mm-deep stone wool vertical cavity barrier, with 10mm compression, was fixed in position at the edge of the system, approximately 1250mm from the external face of the main wall. Once installed in position the stone wool vertical cavity barriers were compressed by the ACM panels to fully close the 50mm ventilated cavity.

A pre-fabricated, welded window pod constructed from 5mm-thick aluminum was fixed onto the edge of the combustion chamber opening with eight (two on top, three on both vertical edges) 90mm-long×ϕ8mm stainless steel screw anchor and plastic plugs – see *Figure 8.*

A set of four 75mm-wide×205mm-deep intumescent horizontal cavity barriers were butted up to the continuous vertical barriers and fixed in rows at approximate (top-top) heights of:

- 0m above the combustion chamber opening,
- 2395mm above the first cavity barrier,
- 2330mm above the second cavity barrier,
- and close to the top of the ventilated system (1635mm above the third cavity barrier, 6360mm above the combustion chamber opening).

The horizontal cavity barriers were fixed through the entire depth on face turned steel brackets – see *Figure 4*. Two steel brackets were used for a length of 1200mm of stone wool cavity barrier fixed into the masonry wall with one 70mm-long×ϕ4mm anchor, positioned above the cavity barrier. The horizontal intumescent cavity barriers were installed with a maximum gap of 25mm to the back face of the panel in accordance with the manufacturer's recommendation.

The 180mm-thick stone wool insulation boards (supplied 1200mm×600mm and cut to fit) were installed in position through the substructure bracket fixing systems and fixed to the support structure (masonry wall) with two 225mm-long×ϕ8mm plastic anchors, with 30mm embedment (at each horizontal joint) and one 250mm-long×ϕ8mm stainless steel anchor with a 80mm-diameter washer per full size panel – see *Figure 5*. The insulation panels were installed with the long edge orientated vertically.

After the insulation was fixed in position, the 120mm-wide×60mm-deep×2mm-thick aluminium 'T'-section and 'L'-section framing were installed at horizontal spacings of 480mm. The horizontal spacing between successive sections of aluminium 'T'-section or 'L'-section framing was 970mm as shown in *Figure 5*. The aluminum vertical rails, with a typical length of 2300mm, were positioned to compress the stone wool insulation with approximately 10mm embedment, with each rail fixed to the brackets with 2×4.8×16mm self-drilling, self-tapping, stainless steel screws. The aluminum rails were installed with a 30mm gap at the floor levels to allow for structural movement. Three brackets supported each section of rail: the middle bracket was fixed while the top and bottom brackets were connected with movement holes – see *Figures 6&7*.

The external ACM panels of the system were installed on to the rail substructure with one fixed point (ϕ6mm hole) in the middle and twenty (per full size panel) oversize (ϕ8.5mm holes) fixings into the rail substructure, at 450mm horizontal spacings and 375mm vertical spacings. A nominal gap of 20mm was provided between the panels to maintain the ventilation of the cavity – see *Figure 8*. The measured gaps after installation varied between 20mm and 25mm. The full size ACM panel dimensions measured 950mm-wide×2310mm-high.

In accordance with the requirements of the test Standard[1], the cladding system measured:

Requirement	Actual measurement
≥6000mm above the top of the combustion chamber	6497mm
≥2400mm width across the main wall	2510mm
≥1200mm width across the wing wall	1280mm
260mm (±100mm) wing wall-combustion chamber opening	162mm
2000mm x 2000mm (±100mm) combustion chamber opening	2000mm×1960mm

4.5 Test conditions

Test Date: 16/08/17

Ambient Temperature: 21°C

Wind speed: < 2 m/s

Frequency of measurement: Data records were taken at five second intervals.

Thermocouple locations *(Figure 2)*:

Level 1 – External (50mm in front of the finished face).

Level 2 – External (50mm in front of the finished face).

Level 2 – Midpoint of cavity between panel and insulation.

Level 2 – Midpoint of insulation layer.

5 Test results

5.1 Temperature profiles

Figures 15-18 provide the temperature profiles recorded. *Figure 9* shows the system before the test.

Parameter	**Result**
T_s, Start Temperature	21˚C
t_s, Start time	105 seconds after ignition of crib.
Peak temperature / time at Level 2, External	508˚C at 1325 seconds after t_s.
Peak temperature / time at Level 2, Cavity	370˚C at 1530 seconds after t_s.
Peak temperature / time at Level 2, Insulation	298˚C at 1605 seconds after t_s.

5.2 Visual observations

Table 1: Visual Observations – refer to *Figure 1*.
Height measurements are given relative to the top of the combustion chamber.
Unless otherwise specified, observations refer to the centre line above the combustion chamber.

Time* (mins:secs)	**t_s (seconds)**	**Description**
00:00		Ignition of crib.
01:19		The flames from the combustion chamber impinge on the cladding system.
01:45	0	Start time (ts) criteria achieved: External temperature 2.5m above the top of the combustion chamber in excess of 221°C (=200°C+Ts).
01:50	5	Flames impinge on panels 1C&1D.
02:15	30	Detachment of coating on panels 1C&1D.
02:30	45	Flame tips above base of panels 2C&2D to Level 1 thermocouples.
02:58	73	Detachment of coating from the base of panel 2C.

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Time* (mins:secs)	t_s (seconds)	Description
3:28	103	Flame tips to mid-height of panels 2D&2D.
4:49	184	Distortion of panels in flame impingement area.
6:28	283	Panel 1A distorting.
6:38	293	Detachment of coating from panel 1A.
8:13	388	Non-flaming debris falling from cladding system.
8:36	411	Flaming debris falling from cladding system.
9:24	459	Insulation visible beneath panels 1C&1D.
9:42	477	Sustained flaming of debris at the base of the cladding system.
11:26	581	Window pod begins to distort and detach.
12:26	641	Flaming visible behind panels 2C&2D.
13:15	690	Debris continues to fall from cladding system.
13:24	699	Distortion of lower edge of panel 2D.
14:05	740	Non-flaming debris falling from cladding system.
15:00	795	Flame tips to base of panels 3D&3E.
15:43	838	Remaining section of panel 1C consumed.
16:41	896	Consumption at base of panel 2C.
17:25	940	Intermittent flaming from consumed edges of panel 2C.
18:23	998	Flame tips to Level 2 thermocouples.
20:00	1095	Consumption of panels 2B&2C up to mid-height along the centre line of the combustion chamber (approximately 1000mm-wide).
21:08	1163	Remaining section of panel 2C beginning to distort away from the cladding system.

Time* (mins:secs)	t_s (seconds)	Description
23:06	1281	Intermittent flaming visible at the junction of panels 2C&2D and at the base of panels 3C&3D
24:35	1370	Flaming visible behind the base of panels 3C&3D.
26:45	1500	Partial consumption of panel 1A.
28:13	1588	Continued consumption of panel 1A to expose insulation.
29:15	1650	Intermittent flaming observed behind panel 1A.
30:00	1695	Crib extinguished.
31:14	1769	Intermittent flaming behind panel 1A continues.
32:41	1856	No visible flaming.
38:40	2215	No significant visual change since the last observation.
40:13	2308	Non-flaming debris falls from the system.
60:00	3495	Test terminated

*Time from point of ignition.

6 Analysis of fire performance and classification

The primary concerns given in BR 135[2] when setting the performance criteria for these systems are those of fire spread away from the initial fire source and the rate of fire spread.

In order for a classification to BR 135[2] to be undertaken, the cladding system must have been tested to the full test duration requirements of BS 8414-1[1] without any early termination of the test. If the test criterion is met, then the performance of the system under investigation is evaluated against the following three criteria;

- External fire spread
- Internal fire spread
- Mechanical performance

Failure due to external fire spread is deemed to have occurred if the temperature rise above T_s (the mean temperature of the thermocouples at level 1 during the 5 minutes before ignition) of any of the external thermocouples at level 2 exceeds 600°C for a period of at least 30 seconds within 15 minutes of the start time (t_s).

Failure due to internal fire spread is deemed to have occurred if the temperature rise above T_s of any of the internal thermocouples at level 2 exceeds 600°C for a period of at least 30 seconds within 15 minutes of the start time (t_s).

No failure criteria are defined for mechanical performance. However, BR 135[2] notes that ongoing system combustion following extinguishing of the ignition source shall be included in the test and classification reports together with details of any system collapse, spalling, delamination, flaming debris and pool fires. The nature of the mechanical performance should be considered as part of the overall risk assessment when specifying the system.

The cladding system was tested in accordance with BS 8414-1[1] without any early termination of the test and can therefore be evaluated against the performance criterion of BR 135[2].

Parameter	**Results**	
	Fire spread test result time, t_s (min)	**Compliance with parameters in Annex A BR135:2013**
External fire spread	>15 minutes	Compliant
Internal fire spread (Cavity)	>15 minutes	Compliant
Internal fire spread (Insulation)	>15 minutes	Compliant
Mechanical performance	See section 5.2	

7 Post-test damage report

7.1 Summary

The cladding system was damaged across the full height – see *Figures 19-25*. The extent of the damage increased from black discolouration of the ACM panels at the edges of the flame damage zone to complete consumption of panels, rail substructure and substantial discolouration of the insulation directly above the combustion chamber opening up to a height of approximately 5000mm above the combustion chamber.

The wing wall was less severely damaged than the main wall with one area of panel consumption located on panel 1A. There was ACM panel discolouration up to panel 2A and distortion of the panel above this. Beneath the ACM panels on the wing wall, insulation discolouration (concentrated in the region of panel consumption) was limited to below the height of the third cavity barrier.

7.1.1 ACM panels

The damage to the ACM panels following the test was:

Panel 0E – The panel remained intact. No significant damage observed.

Panel 0B – The panel remained intact. There was damage on the base of the panel extending to a height approximately 500mm above the floor. The top 150mm of the panel was also damaged.

Panel 0A - The panel was intact. The surface of the panel was discoloured and distorted across approximately 80% of the surface of the panel.

Panel 1E - The panel remained intact. Some damage along the edge of the panel adjacent to panel 1D.

Panel 1D - Extensive damage to the panel. Approximately 90% of the panel was consumed during the test. A section of the panel adjacent to panel 1E remained attached to the frame.

Panel 1C - The panel was fully consumed.

Panel 1B - The panel was extensively damaged and approximately 40% of the central section of the panel had been consumed during the test. Two sections of the panel at the top and base remained attached to the framing system.

Panel 1A - The panel distorted and was discoloured across approximately 80% of the surface. The panel remained in place. An opening in the panel, approximately 400mm x 400mm ($0.16m^2$), exposed the stone wool insulation beneath.

Panel 2E - The panel remained intact. There was a small section of damage on the bottom corner of the panel adjacent to panel 2D.

Panel 2D - The panel was extensively damaged. A section of panel, 1600mm-high x 500mm-wide ($0.8m^2$), had been consumed exposing the insulation beneath. The remaining panel was distorted and damaged.

Panel 2C - The panel was extensively damaged. A triangular section of panel, approximately 1600mm-high x 1200mm-wide ($0.96m^2$), was consumed during the test. The remaining panel was distorted and damaged but remained attached.

Panel 2B – The panel remained intact. Damage and distortion was observed across the full height.

Panel 2A - The panel remained intact. Damage and distortion was observed across the full height. The area of damage was adjacent to panel 2B and approximately 900mm wide at the base, approximating a triangle, reducing to 20mm at the top of the damage. The main area of damage (approximately 0.97m^2) stopped 150mm from the top edge of the panel.

Panel 3E - The panel remained intact. A small amount of damage to the panel on the bottom right hand corner was observed.

Panel 3D - The panel remained intact but suffered distortion. There was an area of damage to the panel approximately 750mm-wide x 200mm-high (0.15m^2).

Panel 3C - The panel remained intact but suffered distortion. There was an area of damage the full width of the panel with a maximum height of 400mm,adjacent to panel 3D, which tapered to 180mm at panel 3B (approximately 0.27m^2).

Panel 3B - The panel remained intact but suffered distortion. There was a small area of damage on the bottom left hand corner of the panel.

Panel 3A - The panel remained intact but suffered distortion. There was a small area of damage to the bottom edge closest to the main wall (approximately 600mm-wide).

7.1.2 'T' and 'L' rail substructure

Damage to the rail substructure was most severe on the main wall with damage up to the height of the third cavity barrier.

The rail substructure supporting panels 0E, 0B, 0A and 1E remained intact.

The 'T' section at the junction of panel 1E and 1D remained intact but was heavily distorted up to the height of the second cavity barrier.

The three sections of rail substructure directly above the combustion chamber opening, and below the second cavity barrier, were fully consumed.

The 'T' section at the junction of panels 1C and 1B was damaged: two small sections of the frame remained intact (immediately above the first horizontal cavity barrier and below the second horizontal cavity barrier), the remainder was fully consumed.

The section of frame at the junction of main and wing wall remained intact with some discolouration immediately above the first horizontal cavity barrier.

The 'L' sections beneath panel 1A remained intact with some damage at mid-height of the section of framing located at the midpoint of panel 1A.

The 'L' sections supporting panel 2E remained intact.

The 'T' section at the junction of panel 2E and 2D remained intact with some distortion and discolouration above the second cavity barrier.

The 'L' section at the midpoint of panel 2D remained intact with some distortion and heat damage across the full height.

The 'T' section at the junction of panels 2D and 2C was damaged. The bottom two thirds of the framing was no longer on place.

The 'L' section at the midpoint of panel 2C was damaged. The top section of the framing was in place (approximately 1500mm-long) but distorted and damaged. The lower section of the framing was no longer in place.

The 'T' section at the junction of panels 2C and 2B remained intact. There was some distortion at the base and patches of discolouration for the full height of the section.

The section of frame at the junction of main and wing wall remained intact with some discolouration immediately above the second horizontal cavity barrier.

The 'L' sections beneath panel 2A remained intact. The centrally mounted section had some discolouration where the section crossed the second horizontal cavity barrier. The section at the outside edge of the wing wall remained undamaged.

The rail substructure supporting the third row panels remained intact with some discolouration on the main wall. The central 'T'-section was darkly discoloured across the full height and also sustained a small area of damage at the intersection with the third cavity barrier.

The section of frame at the junction of main and wing wall remained intact with some discolouration and a small area of distortion at the intersection with the third cavity barrier.

7.1.3 Stone wool insulation

With reference to *Figure 1*. The damage refers to the insulation beneath the panel reference quoted.

The damage to the stone wool insulation was:

Panel 0E - slight damage to the top section of the insulation adjacent to the combustion chamber. Fixings remained intact.

Panel 0A – slight damage to the insulation adjacent to combustion chamber. Metal fixings remained intact. Plastic fixings had melted at mid-height of the main-wing wall junction.

Panels 1E, 2E, 3E&3A - the insulation appeared undamaged. Fixings remained intact.

Panels 1D, 1C and 1B - the insulation appeared pale and bleached of its original colour between the first and second horizontal cavity barriers. All plastic fixings had melted. There was a section of discolouration approximately 600mmx1100mm-max height (0.5m^2) directly above the centre line of the combustion chamber opening.

Panel 1A - the insulation remained intact. The section of insulation adjacent to the main wall, approximately 600mm-wide, was pale and bleached of its original colour. The remaining insulation appeared undamaged. The plastic fixings securing the insulation had melted, the metal fixings were in place.

Panel 2D - the vertical section of insulation, approximately 500mm-wide, spanning between the 'T' and 'L'-shaped railings was discoloured. The remaining insulation to the right appeared pale and bleached of its original colour. No plastic fixings remained.

Panels 2C&2B - the insulation remained intact and appeared pale and bleached of its original colour. There was an area of soot staining in the top right hand corner. No plastic fixings remained.

Panel 2A - the insulation remained intact. The section of insulation adjacent to the main wall, approximately 600mm-wide, was discoloured. The remaining insulation appeared undamaged. No plastic fixings remained.

Panels 3D, 3C&3B – the insulation remained intact with dark discolouration from the mid-point of panel 3D to the main-wing wall junction. Plastic fixings remained intact.

7.1.4 Horizontal (intumescent) cavity barriers

The section of cavity barrier at the junction of panels 0E and 1E did not activate.

The first row of horizontal intumescent cavity barrier at the base of panels 1D and 1C had collapsed across the central 1200mm of the combustion chamber opening where the supporting window pod had been consumed.

There was activation of the cavity barrier across the width of the wing wall (junction of panel 0A and 1A).

The cavity barrier at the junction of panels 1E and 2E did not activate. There was evidence of some discolouration of the intumescent strip.

The cavity barrier between panels 1D & 2D, 1C & 2C and 1B &2B had activated. Sections of the intumescent had fallen away exposing the insulation beneath.

There was activation of the cavity barrier across the width of the wing wall (junction of panel 1A and 2A).

The cavity barrier at the junction of panels 2E and 3E did not activate. There was evidence of some discolouration of the intumescent strip.

The cavity barrier between panels 2D & 3D, 2C & 3C and 2B &3B had activated. The intumescent remained in place.

There was activation of the cavity barrier across the width of the wing wall (junction of panel 2A and 3A).

The cavity barrier at the top of panel 3E did not activate.

The cavity barrier at the top of panels 3D and 3C had activated and the intumescent remained in place.

There was partial activation of the cavity barrier across the top of the wing wall.

7.1.5 Vertical (compression) cavity barriers

From the height of the combustion chamber opening to the height of the third horizontal cavity barrier, the vertical cavity barrier on the inside edge of the main wall (adjacent to the wing wall), was distorted with patches of discolouration for the full height.

From the height of the combustion chamber opening to the height of the second horizontal cavity barrier, the vertical cavity barrier on the outside edge of the main wall, was distorted.

The vertical cavity barrier on the outside edge of the wing wall appeared to be undamaged.

8 Reference

1. BS 8414-1:2015 + A1:2017, 'Fire performance of external cladding systems – Part 1: Test method for non-load bearing external cladding systems applied to the masonry face of the building', British Standards Institution, London, 2015.

2. Colwell, S and Baker, T. BR 135, "Fire performance of external thermal insulation for walls of multistorey buildings", Third Edition, published by IHS BRE press, 2013.

3. BS EN ISO 1716:2010 (*"Reaction to fire tests for products. Determination of the gross heat of combustion (calorific value)",* British Standards Institution, London, 2010.

9 Figures

9.1 Diagrams of finished face of the cladding system

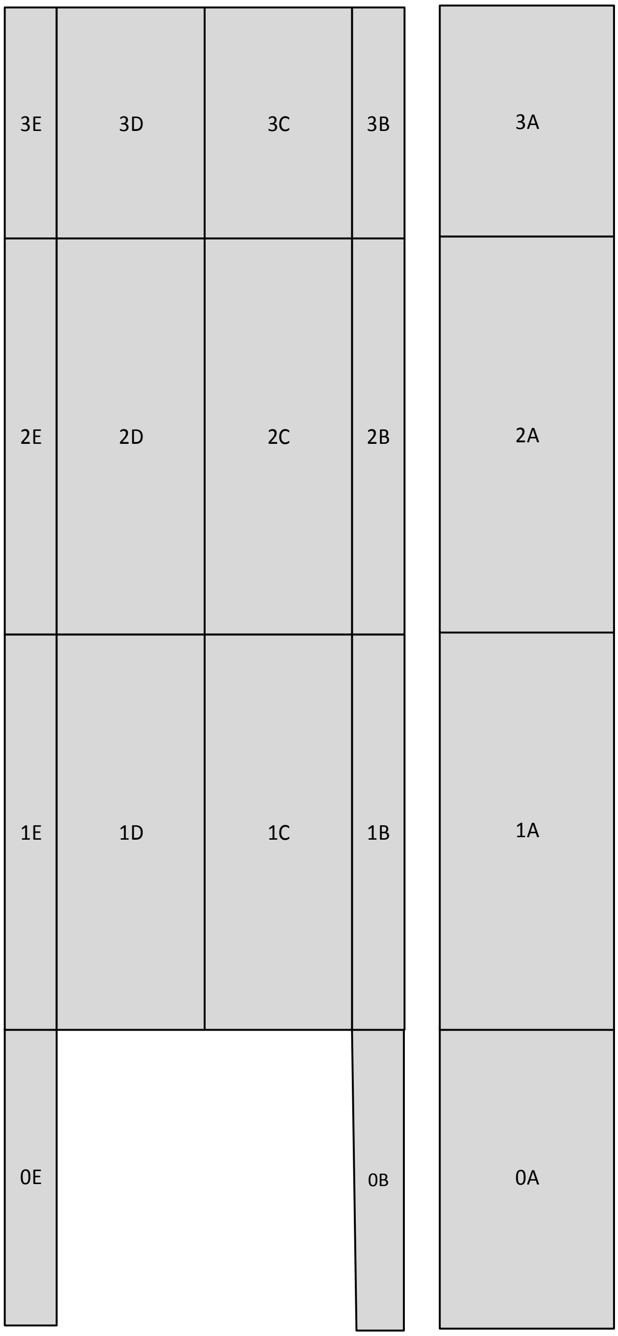

Figure 1. Layout of panels and labelling system used for reporting purposes. Not to scale.

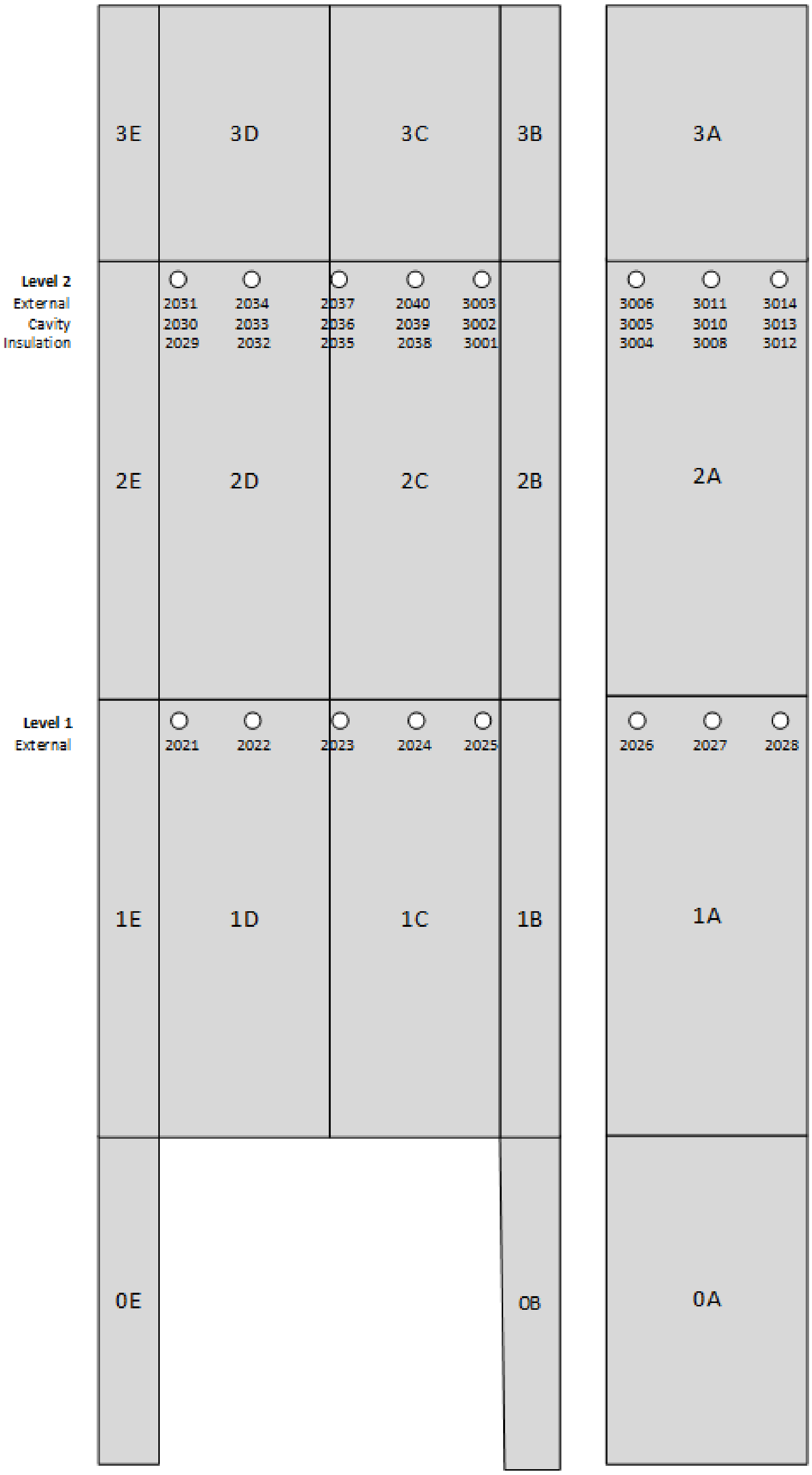

Figure 2. TC positions and panel labelling system (0A – 3E). Not to scale.

9.2 Installation photographs

Figure 3. Location of ‘L’ brackets and cavity barriers.

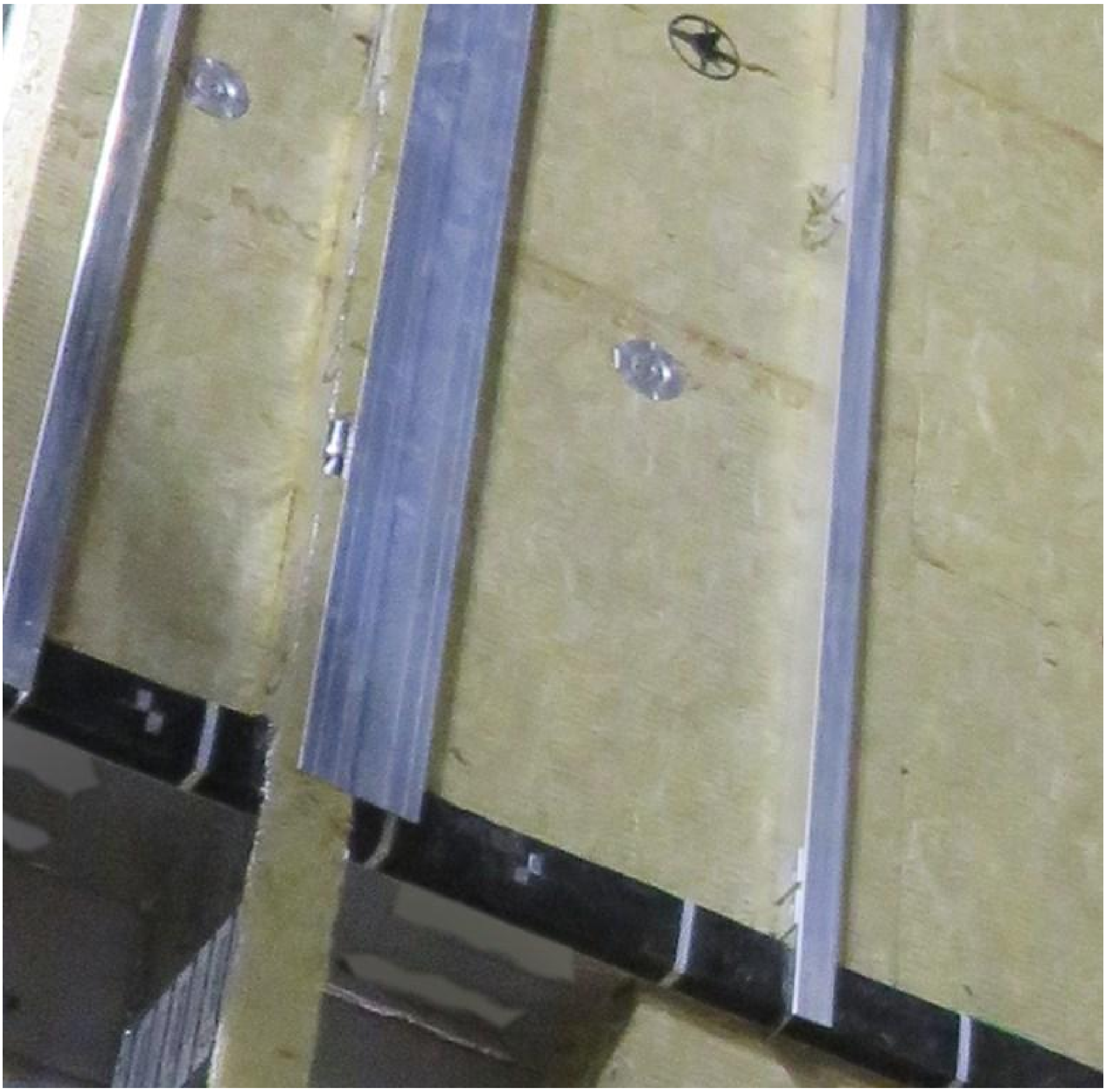

Figure 4. Horizontal intumescent cavity barrier fixed through the entire depth on face turned steel brackets, at the intersection with a vertical cavity barrier.

Figure 5. Partial installation of cavity barriers, stone wool insulation and railing substructure.

Figure 6. Example of aluminium rail fixed to ‘L’ bracket through movement holes.

Figure 7. Example of aluminium rail fixed to ‘L’ bracket through fixed holes.

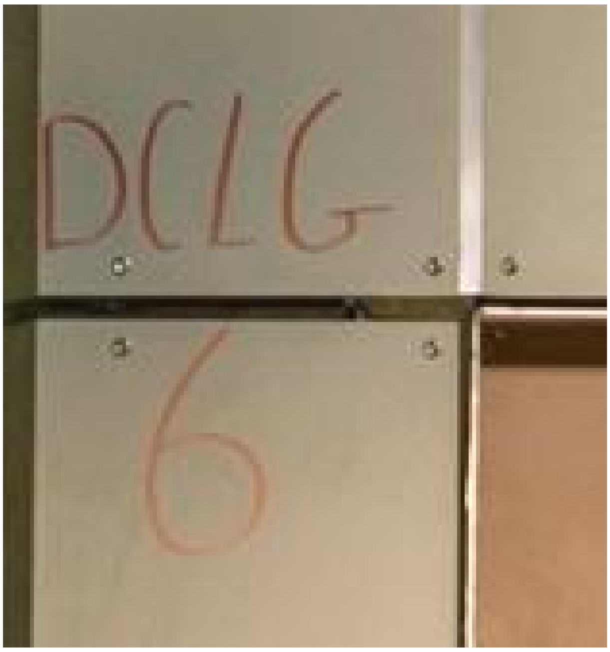

Figure 8. Detail at corner of combustion chamber opening. Panels riveted in place and nominal 20mm vertical gap left for ventilation purposes.

Figure 9. Completed installation prior to test.

9.3 System drawings

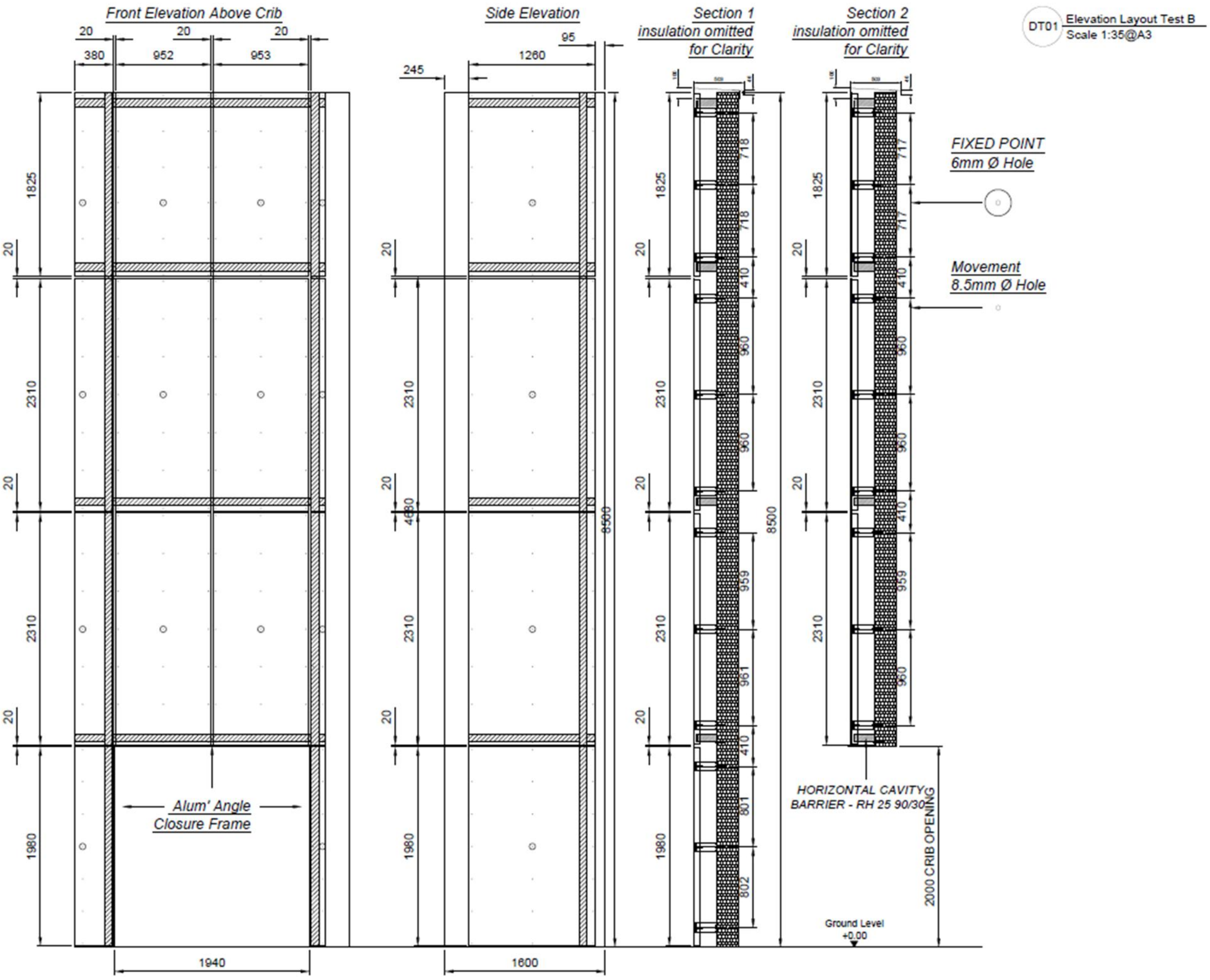

Figure 10. Front elevation, side elevation and vertical sections for the system (supplied by the Test Sponsor).

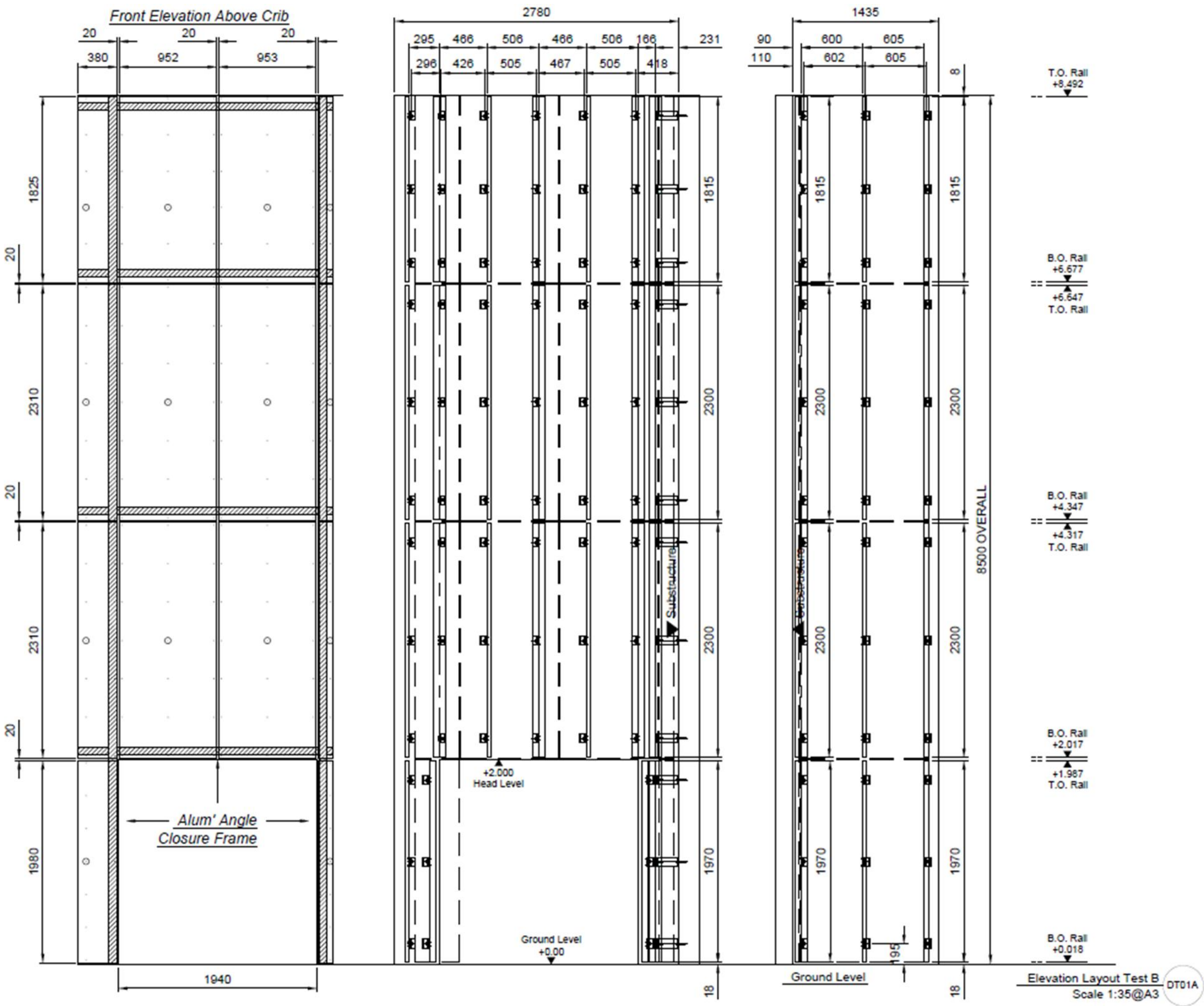

Figure 11. Front elevation, side elevation and vertical sections for the substructure system (supplied by the Test Sponsor).

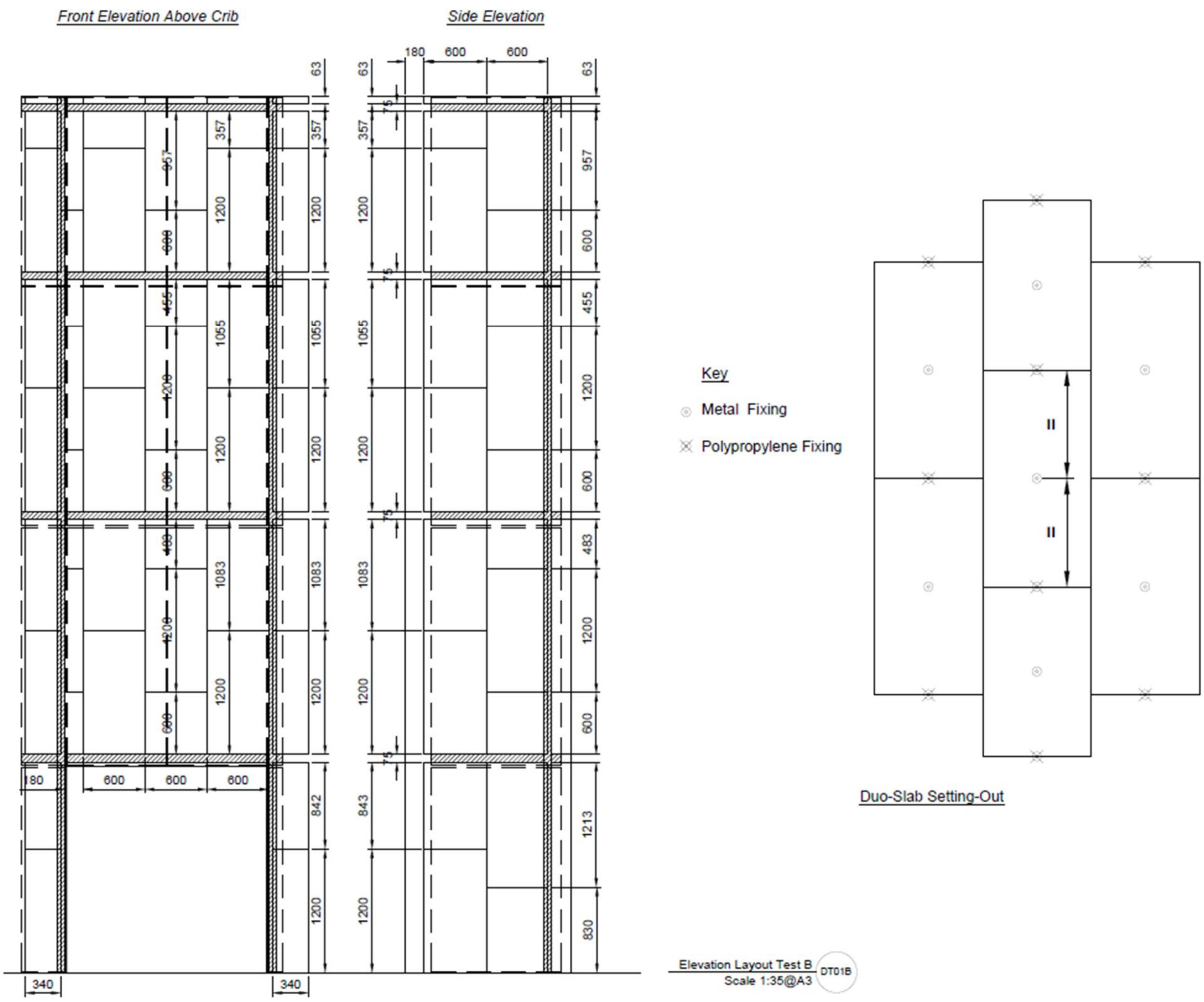

Figure 12. Front elevation, side elevation for the insulation panels installation (supplied by the Test Sponsor).

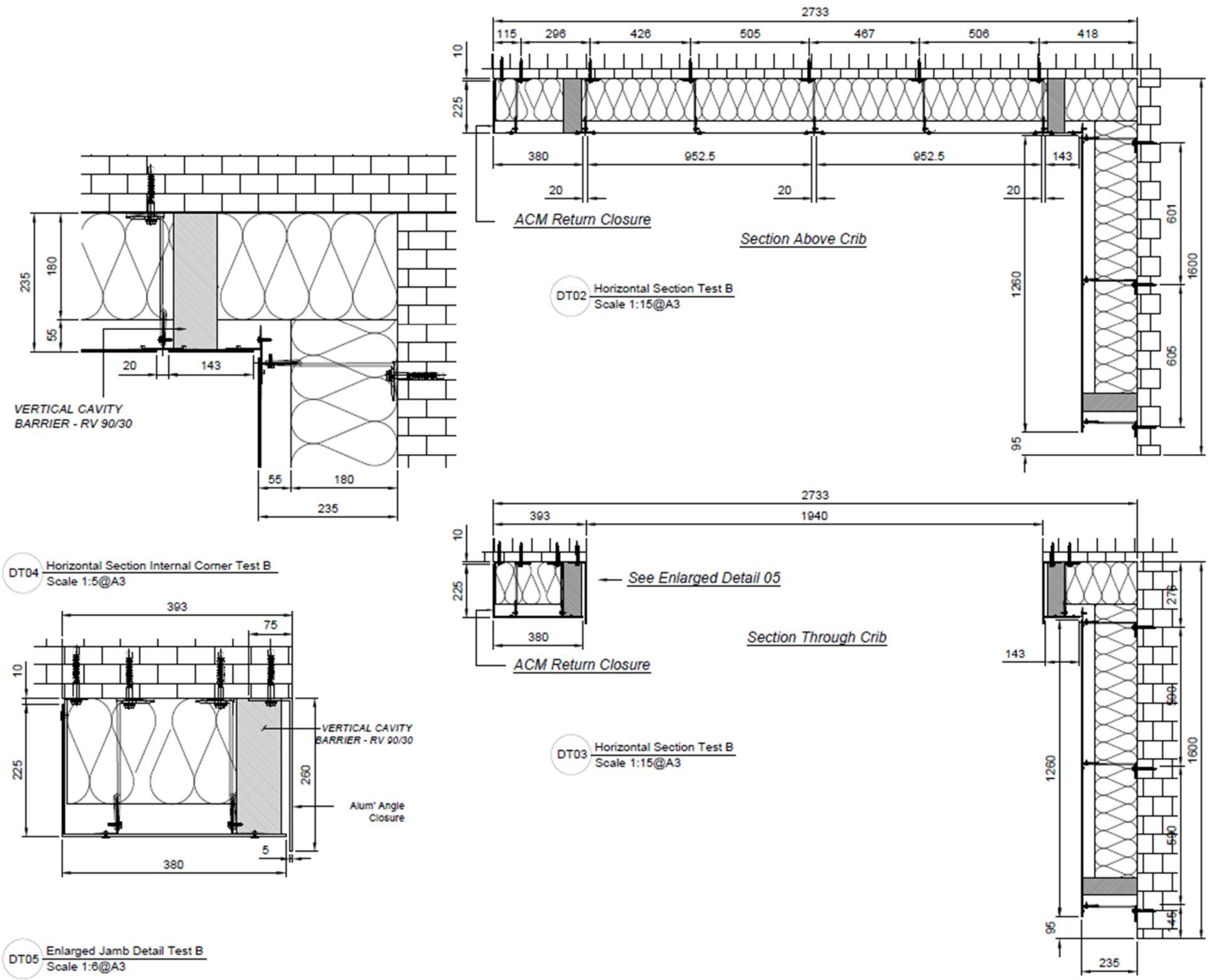

Figure 13. Horizontal section through and above the combustion chamber, and installation details for the system (supplied by the Test Sponsor).

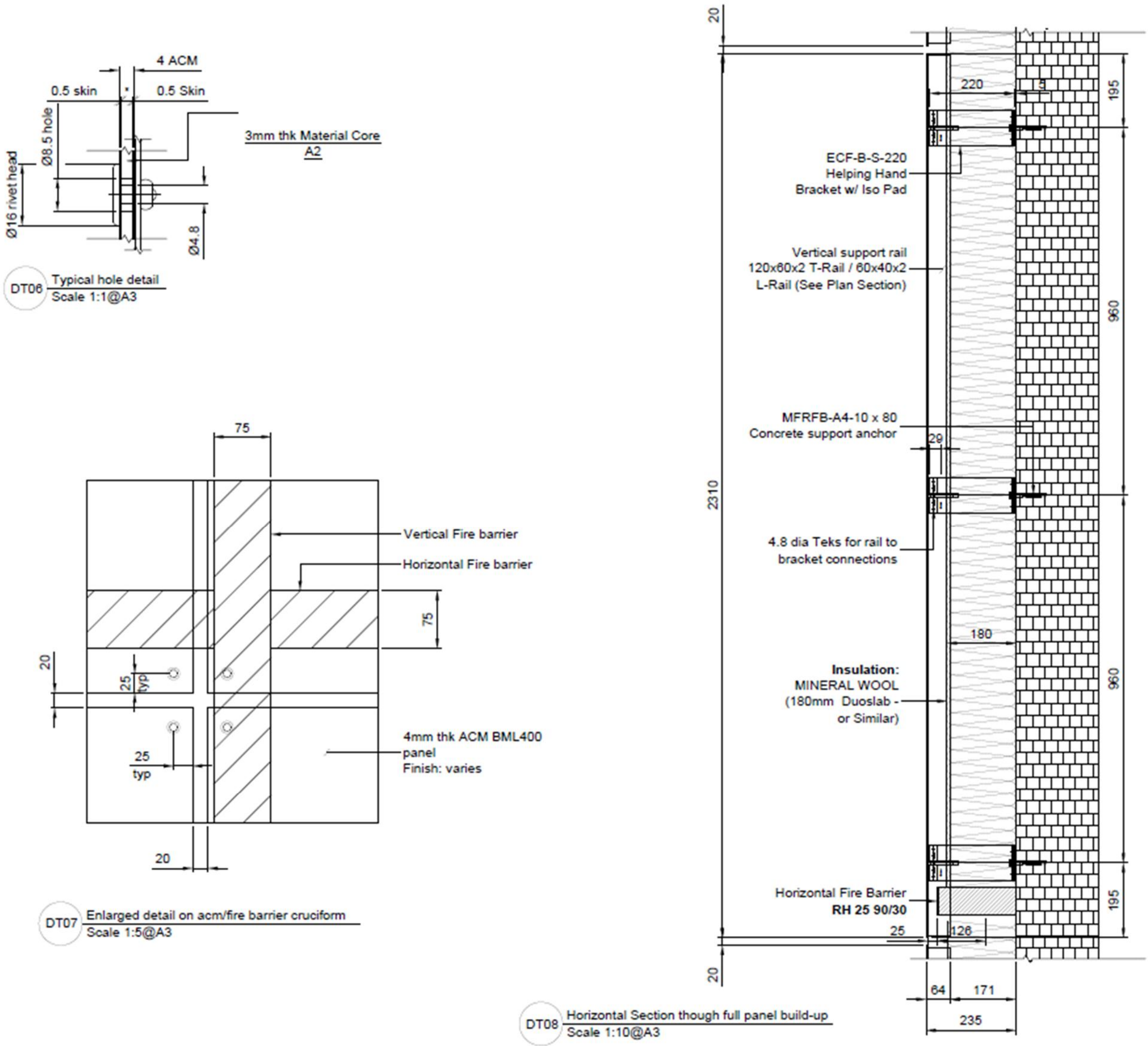

Figure 14. Vertical section through the cladding system, ACM panel detail and vertical and horizontal fire barriers intersection (supplied by the Test Sponsor).

9.4 Temperature data

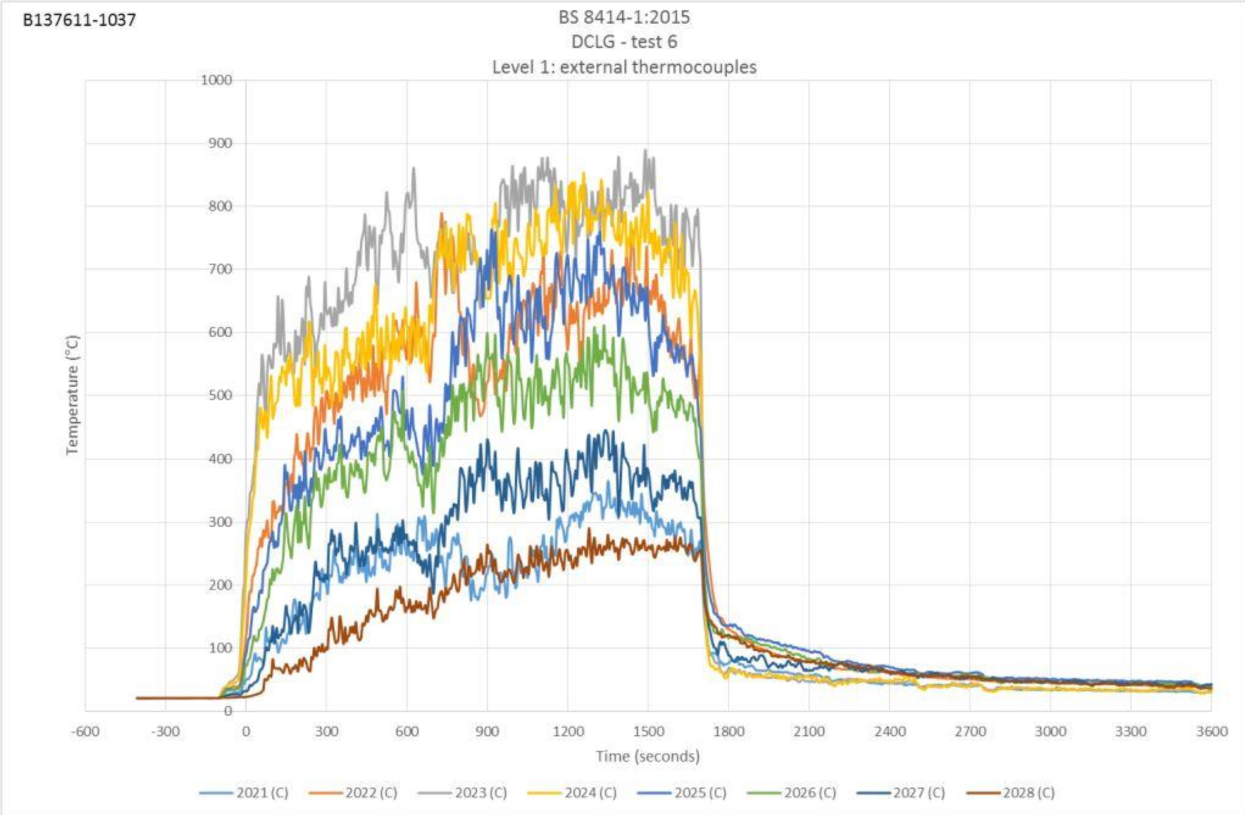

Figure 15. Level 1 external thermocouples.

t_s=105s after ignition of the crib.

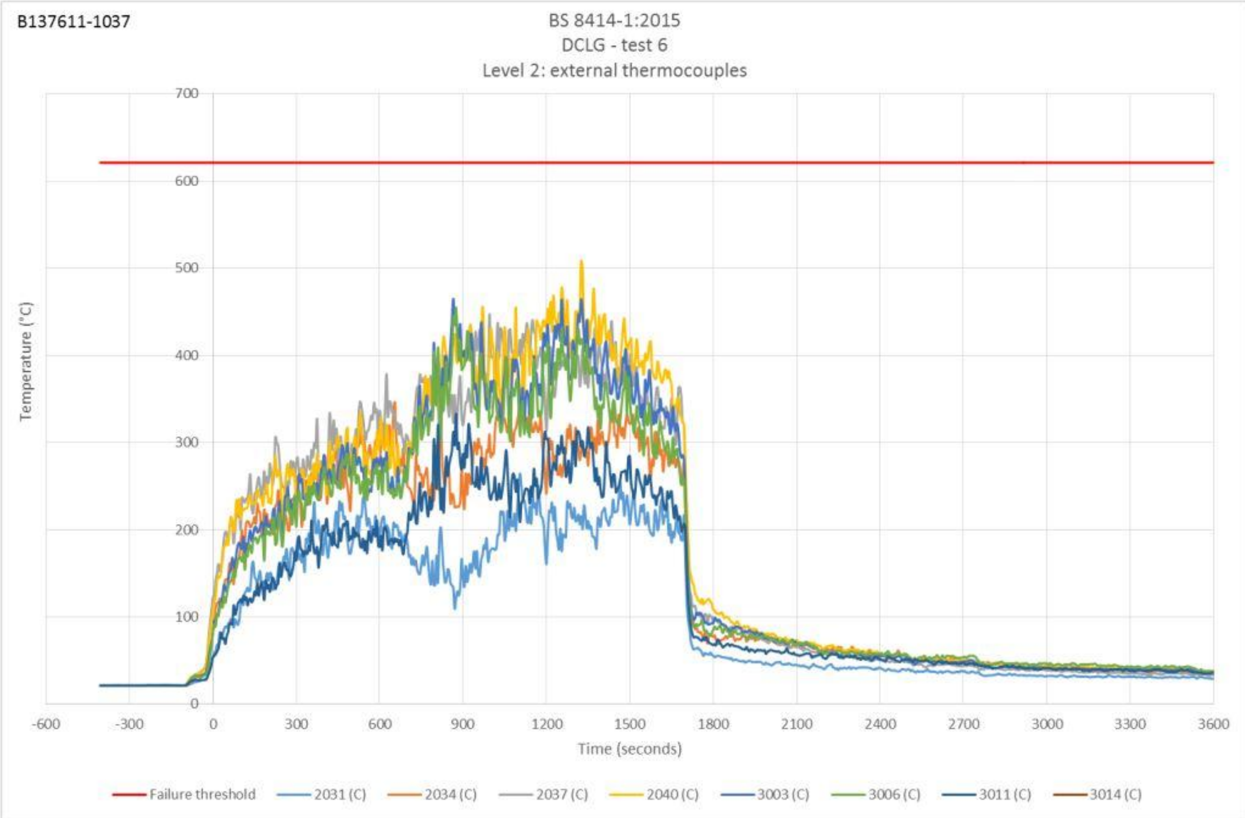

Figure 16. Level 2 external thermocouples.

t_s=105s after ignition of the crib.

Note: data from channel 3014 omitted due to failure of thermocouple during test.

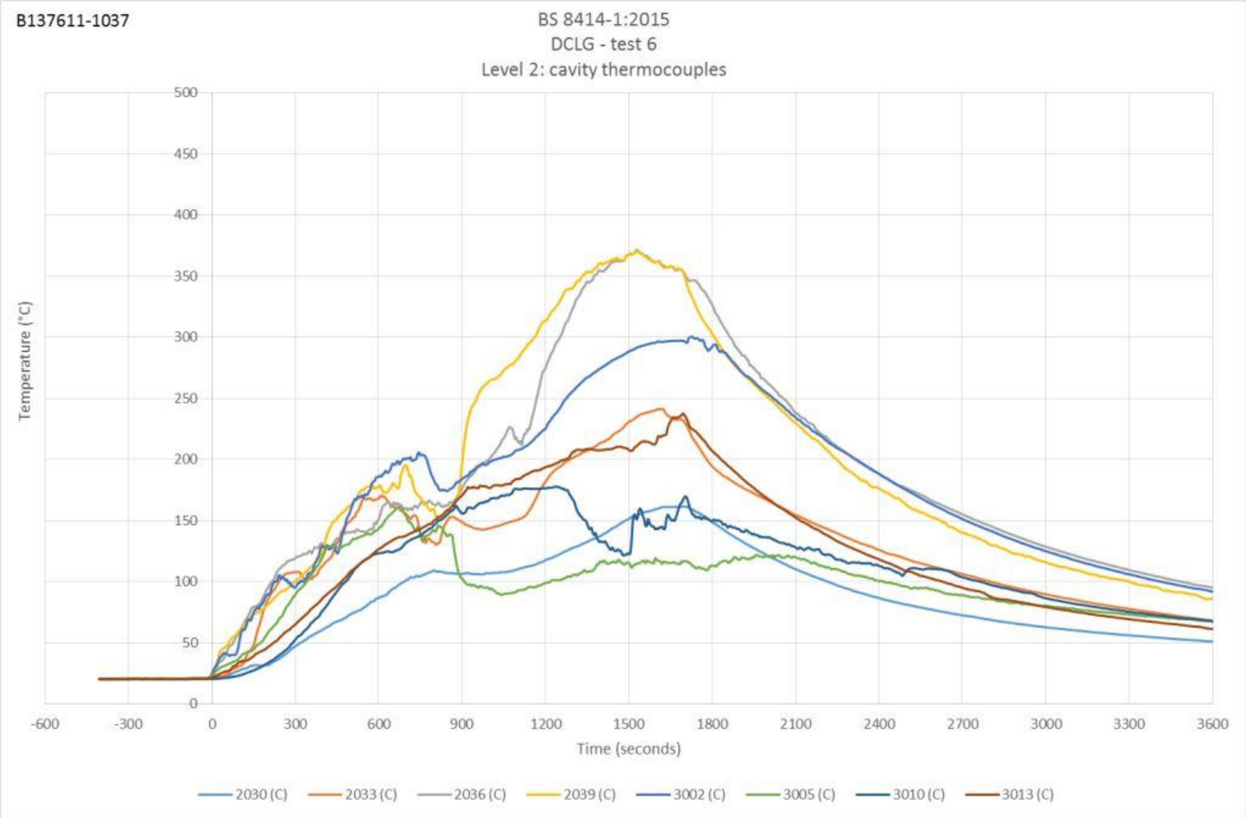

Figure 17. Level 2 cavity thermocouples.

t_s=105s after ignition of the crib.

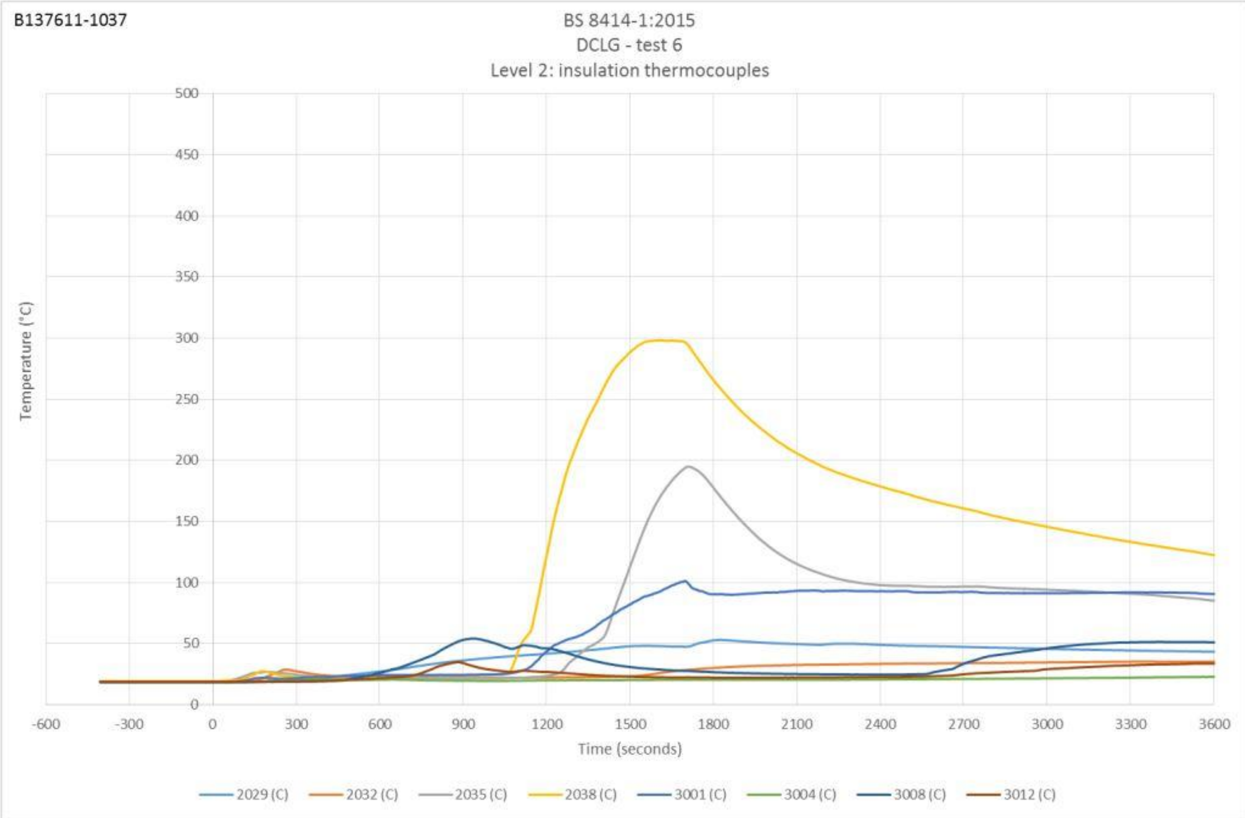

Figure 18. Level 2 insulation thermocouples.

t_s=115s after ignition of the crib.

9.5 Post-test photographs

Figure 19. Full height photograph of system post-test.

Figure 20. First row ACM panels (directly above combustion chamber).

Figure 21. Second row ACM panels (approximately 2300mm-4600mm above combustion chamber).

Figure 22. Third row ACM panels (approximately 4600mm-6500mm above combustion chamber).

Figure 23. Close up of melted window pod and collapsed horizontal cavity barrier directly above the combustion chamber.

Figure 24. Close up of charred section of stone wool insulation directly above the combustion chamber.

Figure 25. Full height photograph of cladding system following removal of ACM panels.

Appendix A – Material densities

Representative samples of the construction materials were taken during construction.

The free moisture content ($W_1 – W_2$) of the samples expressed as a percentage of the dried weights (W_2), and density (kg/m^3) are given in *Table 2.*

Table 2: Conditioning and material information.

Sample Material	Oven drying temperature	Moisture content by dry weight (%)	Density (kg/m^3)
Stone wool dual density insulation	105 ± 5ºC	0.5	48.9
Vertical cavity barrier	105 ± 5ºC	0.3	84.3
Horizontal cavity barrier	105 ± 5ºC	0.4	83.9

Appendix B – ACM panel screening test results

The screening test indicates whether the core or filler of the ACM panel used as part of the cladding system has properties which indicate flame retardant properties based on testing in BS EN ISO 1716:2010[3]. As the purpose of this testing was to quickly and reliably screen the core material, the full procedures set out in the BS EN ISO 1716:2010 (*"Reaction to fire tests for products. Determination of the gross heat of combustion (calorific value)"* test standard have not been followed as they are unnecessary to confirm which type of panel has been used. These results should therefore be considered to provide a high degree of certainty as to the type of panel screened.

The result indicates the performance achieved for the core in terms of a category

- **Category 1** means that the result is in line with the requirements for a material of limited combustibility (Calorific potential ≤3 MJ/kg)
- **Category 2** means that the result does not achieve the requirements of category 1 but that it does have some limited flame retardant properties (Calorific potential > 3MJ/kg and ≤35MJ/kg)
- **Category 3** means that the result does not achieve the requirements of Category 1 or 2 and that it has no flame retardant properties (Calorific potential >35MJ/kg)

DCLG Advice - ***The Department's view is that cladding material found to be in either Category 2 or Category 3 in the screening test would not meet the requirements for limited combustibility set out in Approved Document B guidance.***

The samples were taken from aluminium composite material panels that were part of the cladding system tested and they had the following characteristics:

Overall dimensions (H×W mm)	Total thickness including Al facings (mm)	Code
2310×953	4.0	CT006-01 CT006-02 CT006-03

The ambient conditions in the testing room, prior to the test, were:

Ambient temperature (°C)	Relative humidity of the air (%)
23.1	49.8

Test results:

Test No.	Calorific value (MJ/kg)	Category	Standard deviation (%)
1	2.2863	CAT 1	0.05
2	2.3554	CAT 1	
3	2.2563	CAT 1	

Report Ends