www.bre.co.uk

BRE Global Client Report

BS 8414-1:2015 + A1:2017 test referred to as DCLG test 4.

Prepared for: DCLG

Date: 9th August 2017 (Issue 1.0)

30th August 2017 (Issue 1.2)

Report Number: B137611-1037 (DCLG test 4) Issue: 1.2

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

bre

Version History

11/08/2017	Issue 1.1	Amendment to section 4.3.
30/08/2017	Issue 1.2	Amendments to Appendix A and Figure 14.

Table of Contents

bre

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.

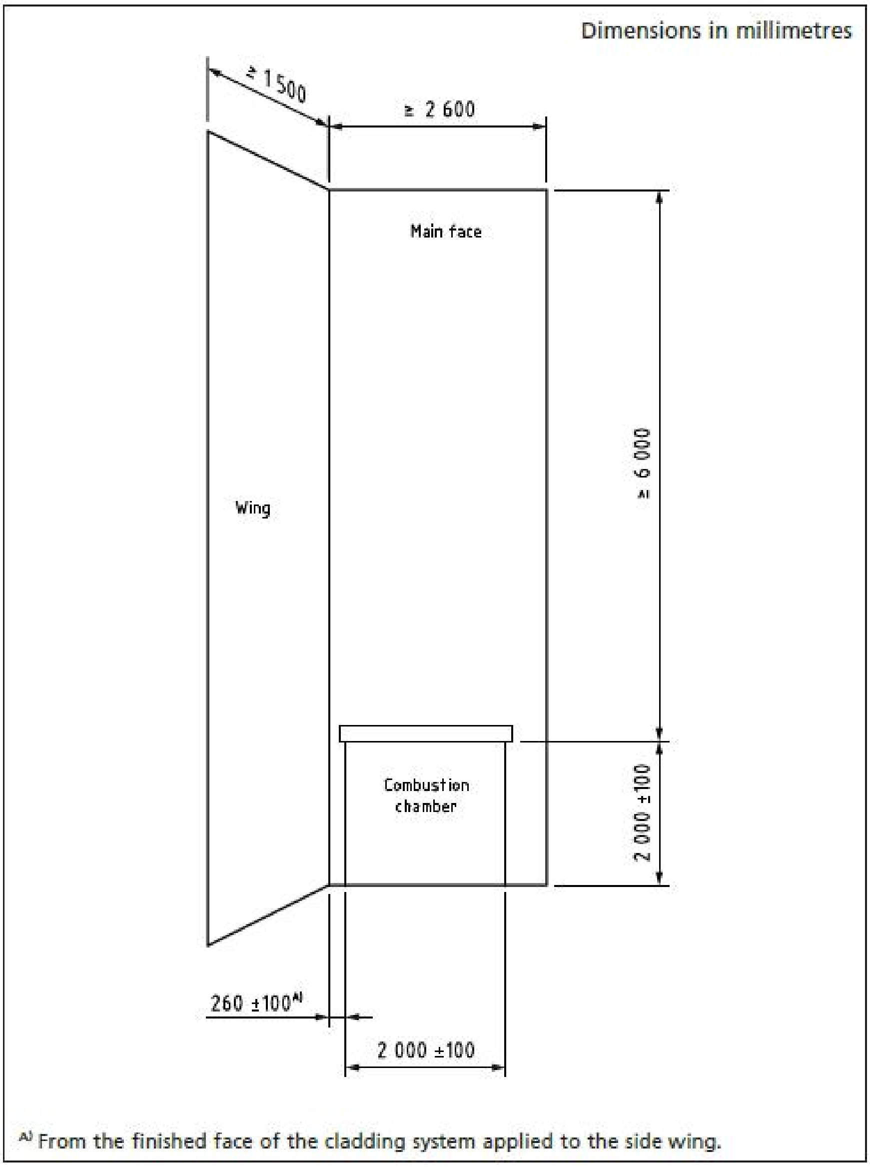
bre

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 4
Date of test:	06/08/2017
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 90° 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 12-16 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 *Figure 8;*
- 75mm-wide×240mm-deep stone wool vertical cavity barriers (stated integrity/insulation performance: 90/30mins), with 10mm compression – see *Figures 3&5*;
- 75mm-wide×205mm-deep stone wool with intumescent horizontal cavity barriers (stated integrity/insulation performance: 90/30mins) – see *Figure 4*;
- 4mm-thick front face Aluminum Composite Material (ACM) panels, with a white finish – see *Figure 11*.

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 fire retardant polyethylene 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 steel ‘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 3, 6&7*. On the main face the horizontal spacing between the brackets varied between 340mm and 500mm. 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 - see *Figure 3*.

The system included vertical and horizontal cavity barriers - see *Figure 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 *Figure 5*. 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 3*. The vertical cavity barriers were trimmed to fit - see *Figure 9*.

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. *Figure 3* demonstrates the installed 'L' brackets and vertical cavity barriers.

A pre-fabricated, welded window pod constructed from 5mm-thick aluminium 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 *Figures 8&10.*

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 8*. 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 10*. The measured gaps after installation varied between 20mm and 23mm. 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	2495mm
≥1200mm width across the wing wall	1260mm
260mm (±100mm) wing wall-combustion chamber opening	170mm
2000mm x 2000mm (±100mm) combustion chamber opening	2000mm × 1960mm

4.5 Test conditions

Test Date: 06/08/17

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.

bre

5 Test results

5.1 Temperature profiles

Figures 17-20 provide the temperature profiles recorded. *Figure 11* shows the system before the test.

Parameter	Result
T_s, Start Temperature	21˚C
t_s, Start time	85 seconds after ignition of crib.
Peak temperature / time at Level 2, External	810˚C at 1290 seconds after t_s.
Peak temperature / time at Level 2, Cavity	269˚C at 1725 seconds after t_s.
Peak temperature / time at Level 2, Insulation	88˚C at 775 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.
01:15		The flames from the combustion chamber are impinging on the cladding system.
01:25	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	25	Flame tips to mid-height of panels 1C&1D.
02:20	55	Flame tips to top of panels 1C&1D.
02:25	60	Flame tips to Level 1 thermocouples.
02:35	70	A small amount of distortion can be observed at the base of panels 1C&1D.

Time* (mins:secs)	t_s (seconds)	Description
03:00	95	Flame tips to mid-height of panels 2C&2D.
03:10	105	Discolouration at the vertical junction between panels 1C&1D from white to dark grey. A small amount of paint detachment can also be observed at this location.
03:20	115	Flame tips to mid-height of panels 2C&2D. Discoloration and paint detachment in a small area can be observed at the base of panels 2C&2D.
03:30	125	A small amount of distortion and discoloration is observed at the base of panel 1A on the wing wall.
04:10	165	Intermittent flaming to the top of panels 2C&2D.
04:40	195	Increased area of discoloration, distortion and paint detachment can be observed at the base of panels 2C&2D.
05:00	215	A small amount of burning droplets, with a duration of sustained flaming less than 5 seconds, from the cladding system.
06:00	275	Discoloration and distortion can be observed at the junction between wing wall panels 0A and 1A.
06:20	295	Sporadic burning droplets from cladding system. Flame movement towards wing wall panel 1A.
06:30	305	Increased rate of burning droplets (sustained flaming longer than 10 seconds).
06:40	315	Flickering flames on the surface of wing wall panel 1A (<5 seconds).
07:00	335	An increased rate of burning droplets is observed (sustained flaming longer than 20 seconds).
08:00	395	Increased discoloration and paint detachment to wing wall panel 1A.
08:30	425	Increased production of burning droplets and debris from above the combustion chamber opening. The stone wool insulation is visible through the flames where ACM panels 1C&1D have been consumed. At this point the flames are seen entering the cavity behind the remaining sections of panels 1C&1D. Discolouration and paint detachment to top of panel 1A and mid-height of panels 2C&2D.

Time* (mins:secs)	t_s (seconds)	Description
09:00	455	Flickering flames from the vertical junction between panels 1C&1D.
09:30	485	Increased production of burning droplets and debris. Sustained pool fire at the base of the cladding system.
09:45	500	Flickering flames observed at the horizontal junction above panels 1C&1D.
10:00	515	Discoloration and distortion can be observed at the base of panel 2A on the wing wall.
11:00	575	The central “T”-shaped aluminium rail on the main wall has been consumed up to the top of panels 1C&1D.
11:45	620	Increased consumption of panels 1C&1D has exposed a greater area of stone wool insulation directly above the combustion chamber. Discoloration and paint detachment can be observed on a small area at the top of wing wall panel 0A.
12:00	635	Increased discoloration and paint detachment can be observed on wing wall panel 2A.
12:50	685	Continued emission of burning droplets and debris resulting in increased size of pool fire at the base of the cladding system.
13:30	725	Flaming visible at the top of panel 1B.
14:00	755	Panel 1B has been partially consumed and a small part of the vertical cavity barrier can be observed through the flames.
14:50	805	Sporadic flaming to the base of panels 3C&3D.
15:00	815	Sustained flames can be observed on the damaged vertical edge of panel 1B.
15:30	845	Flickering flames are observed at the bottom of panels 2C&2D.
16:00	875	Consumption of the base of panels 2C&2D to expose the horizontal cavity barrier.
16:10	885	At the base of panel 2C the stone wool above the horizontal cavity barrier is visible. Flames entering the cavity behind panel 2C.

bre

Time* (mins:secs)	t_s (seconds)	Description
17:00	935	The majority of panels 1C&1D have been consumed. The length of intermittent flames is relatively constant at the base of panels 3C&3D.
17:30	965	Flickering flames from the vertical junction between panels 2C&2D.
18:00	995	Discoloration can be observed to the base of panel 3C.
19:00	1055	Intermittent flaming visible at the horizontal junction above panels 2C&2D.
19:30	1085	Intermittent flaming from the damaged sections of panel 2C and the vertical junction with panel 2D.
21:00	1175	Increased consumption of panel 2C&2D, increasing exposed area of stone wool insulation.
21:10	1185	Intermittent flaming from the vertical junction between panels 2B&2C.
21:20	1195	Sustained flaming at the vertical junction between panels 2B&2C and on the surface of panel 1B.
22:00	1235	Flaming from the horizontal junction above panels 2C&2D. Detachment of small sections of aluminium from panel 2C.
22:30	1265	Reduced flaming from the horizontal junction at the top of panels 2C&2D.
23:20	1315	Flame spread on the surface of panels 1B&2B. Intermittent flaming at the main-wing wall junction to the top of the cladding system.
23:45	1340	Frequent flaming along main-wing wall junction to the top of the cladding system.
24:00	1355	Consumption of the base of panel 1A.
24:20	1375	Reduced flaming from panels 1B&2B. Sustained flaming on the surface of wing wall panel 1A, at the horizontal junction with wing wall panel 2A and on the damaged, vertical edge of panel 2B.
25:00	1415	Intermittent flaming at the horizontal junction between panels 2D&3D. Sustained flaming up to mid-height of panel 2B.
26:00	1475	Significant reduction in general flaming from all panels.
26:30	1505	Flickering flaming on panels 2A&2B are the only locations of visible flaming from row 2 panels.

Time* (mins:secs)	t_s (seconds)	Description
27:00	1535	Discoloration and distortion can be observed up to mid-height of panels: 3A, 3B&3C. Flaming from row 2 panels has ceased.
27:50	1585	Flaming has subsided between wing wall panels 1A&2A.
28:30	1625	Intermittent flaming from the horizontal junction between panels 2A&3A.
28:50	1645	Sustained flaming from the horizontal junction between panels 2A&3A up to mid-height of panel 3A.
29:20	1675	Reduced flaming from the horizontal junction between panels 2A&3A.
30:00	1715	Fuel load extinguished. The monitoring procedure continued for an additional 30 minutes.
31:00	1775	Small amount of flaming from the base of wing wall panel 1A.
33:00	1895	Flaming from wing wall panel 1A has reduced.
34:40	1995	All visible flaming has ceased.
60:00	3515	No significant visual changes since the last observation. 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 21-35*. 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 3600mm – see *Figures 21-35*. The wing wall was less severely damaged than the main wall with small areas of panel consumption (total area <0.6m^2) up to the height of the first cavity barrier and significant ACM panel discolouration up to the height of the third cavity barrier, which reduced in severity towards the top of the cladding system – see *Figures 21-27*. 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 and, with the exception of the area between the second and third horizontal cavity barriers, on the main wall side of the central ‘L’ rail – see *Figures 31-35.*

7.1.1 ACM panels

On the main wall, approximately 65% of the ACM panels directly above the combustion chamber, up to the height of the third cavity barrier, were consumed – see *Figures 21, 23&24*. With reference to *Figure 1*:

- 100% consumption of panel 1C.
- 85% consumption of 1D.
- 60% consumption of 2C.
- 20% consumption of panel 2D.

Smaller areas of panel consumption on the main wall were sustained by panel 1B (40%) – see *Figure 23.*

Significant discolouration and distortion was sustained by panels: 2B (100%), 3B (80%), 3C (40% - tapering towards wing wall), 3D (10% - lower right corner) and the majority of the remaining sections of partially consumed ACM panels (1B, 1D, 2C: 100% of remaining panel. 2D: 75% of remaining panel) – see *Figures 21-25.*

On the wing wall, smaller, roughly oval areas of panel consumption (approximately 450mm-wide×1200mm-high (0.5m^2)), (200mm-wide×300mm-high (<0.1m^2)) and a rectangular section 200mm×200mm were visible directly adjacent to the main wall towards the base of panel 1A, spanning the junction between panels 1A and 2A, and at the base of panel 0A respectively – see *Figures 21-24*. At the outside edge of panels 0A-2A melting of the ACM core filler material is evident –see *Figure 26*.

Significant discolouration and distortion was sustained by panels: 0A (90%), 1A (90%), 2A (70%) and 3A (30%) – see *Figures 21-25*. The damaged area tapered, in the direction of the main wall, from the outer edge of the wing wall (approximately 1.2m above the height of the combustion chamber) to the wing-main wall junction at the top of the cladding system – see *Figure 22*.

7.1.2 ‘T’ and ‘L’ rail substructure

Damage to the rail substructure was most severe on the main wall with four of the five sections spaced evenly across the combustion chamber opening sustaining significant consumption – see *Figures 29-30*. At 500mm intervals from the edge of the combustion chamber adjacent to the wing wall the following damage occurred:

- ‘T’-section: significant distortion up to the height of the second cavity barrier.

- ‘L’-section: complete consumption of rail from the combustion chamber opening up to the height of the second cavity barrier. Areas of dark discolouration and distortion between the second and third cavity barriers.
- ‘T’-section: complete consumption of rail from the combustion chamber opening to a height approximately 1000mm above the second cavity barrier. The remaining sections of ‘T’ rail between the second and third cavity barrier were significantly damaged and distorted.
- ‘L’-section: complete consumption from the combustion chamber opening to a height approximately 650mm above the second cavity barrier. A 100mm-long section of partially consumed rail remained immediately above the second cavity barrier. The remaining sections of ‘L’ rail between the second and third cavity barrier were significantly damaged and distorted.
- ‘T’-section: complete consumption of rail from the combustion chamber opening to a height approximately 500mm below the second cavity barrier. Partial consumption of rail to a height approximately 650mm above the second cavity barrier. The remaining sections of ‘T’ rail between the second and third cavity barriers were significantly damaged and distorted.

Damage to the rail substructure on the wing wall was far less severe – see *Figure 29.* Between the first and the third cavity barrier, two of the ‘L’-rail sections (one immediately adjacent to the main wall, and the other at mid-width) sustained localised areas of discolouration and distortion – see *Figure 29.* The rail substructure above this, and at the outside edge (full-height) of the vertical cavity barrier appeared undamaged *Figure 29.*

7.1.3 Stone wool insulation

The stone wool insulation appeared pale and bleached of its original colour between the first and second horizontal cavity barriers: this extended from the outside edge of the combustion chamber to the central ‘L’-rail on the wing wall – see *Figures 31-33*. Between the central ‘L’-rail and the outside edge of the wing wall the stone wool was partially affected by areas of darker discolouration. A bell-shaped area with a yellow hue spanned the full width of the combustion chamber peaking 500mm below the base of the second horizontal cavity barrier – see *Figures 31&33.* A section of stone wool insulation, approximately 250mm×250mm had collapsed from the cladding system directly above the centre line of the combustion chamber – see *Figures 27-30.*

Between the second and third horizontal cavity barriers, the pale/bleached appearance of the stone wool insulation spanned the region, approximately 1500mm-wide, between the ‘L’-rail (500mm from the outside edge of the combustion chamber opening) and the ‘T’-rail (in line with the inside edge of the combustion chamber opening) – see *Figures 31&34*. Dark discolouration was observed on the remaining area in line with the combustion chamber opening and, on the wing wall, between the main wall and the central ‘L’-rail – see *Figures 32&34.*

Between the third and fourth horizontal cavity barriers the central 1000mm-width above the combustion chamber opening, which was contained by consecutive sections of ‘L’-rail, sustained minor discolouration – see *Figures 31&35.*

At ground level, dark discolouration was observed on the wing wall between the main wall junction and the central ‘L’-rail – see *Figures 32.*

No discolouration was observed outside the outer main wall vertical cavity barrier. Minimal discolouration was observed, with the exception of the area between the second and third horizontal cavity barriers, beyond the central ‘L’-rail on the wing wall – see *Figures 31-35.*

7.1.4 Horizontal (intumescent) cavity barriers

The first row of horizontal intumescent cavity barrier had collapsed across the central 1200mm of the combustion chamber opening where the supporting window pod had been consumed – see *Figure 27*.

Full-width activation of the intumescent strip occurred on the wing wall with detachment of the expanded material observed between the main wall and the central 'L'-rail – see *Figures 31-33.*

There is evidence to suggest activation of the second row of horizontal intumescent cavity barriers across the full width of the combustion chamber opening and the wing wall, however; most of the intumescent material was no longer present except for the outer section of the wing wall – see *Figures 31-34*. Initial signs of activation were visible from the section of cavity barrier located at the outer edge of the main wall.

Activation of the third row of horizontal intumescent cavity barriers occurred across the full width of the combustion chamber opening and the wing wall – see *Figures 31, 32, 34&35*. Detachment of the intumescent material was observed in line with the central 500mm of the combustion chamber opening and in a section 150mm-long approximately 100mm from the main wall. Partial activation occurred in the section of cavity barrier located at the outer edge of the main wall.

Partial activation of the fourth row of horizontal intumescent cavity barriers occurred across the full width of the combustion chamber opening and the wing wall. The section of cavity barrier located at the outer edge of the main wall appeared unaffected – see *Figure 35*.

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 discoloured and significantly distorted – see *Figures 31&35*.

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 discoloured and slightly distorted – see *Figures 31&33*.

The vertical cavity barrier on the outside edge of the wing wall appeared to be undamaged – see *Figure 32.*

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

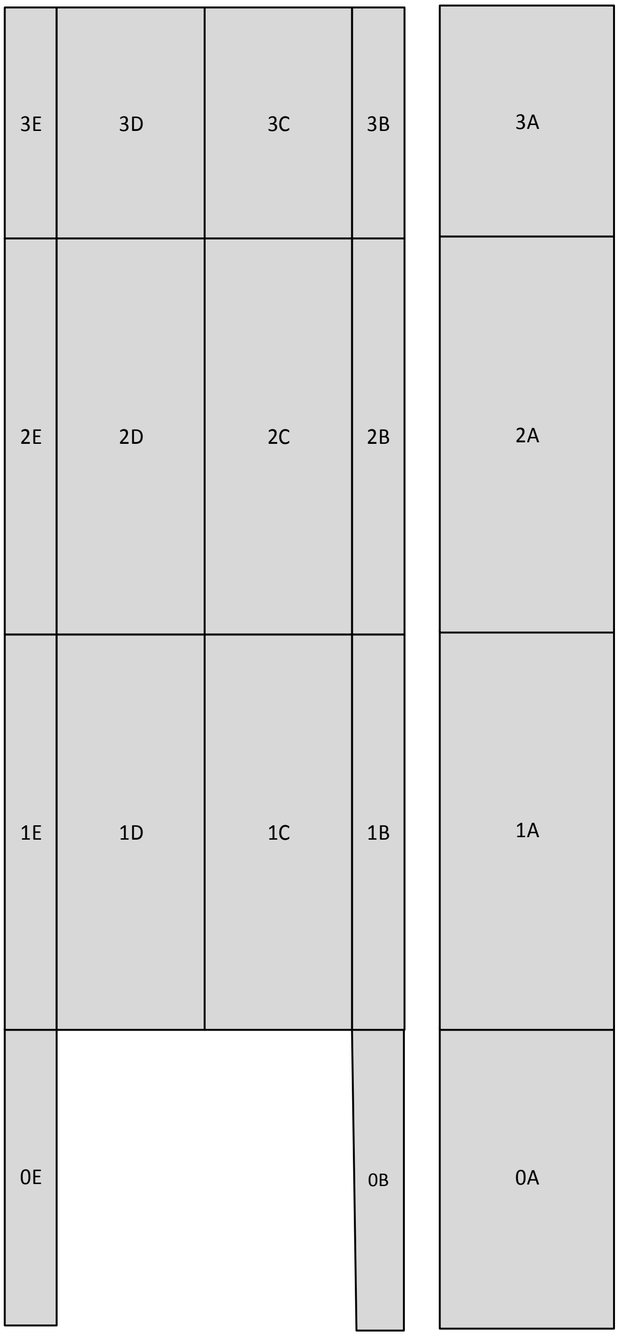


Figure 1. Layout of panels and labelling system used for reporting purposes. Not to scale.

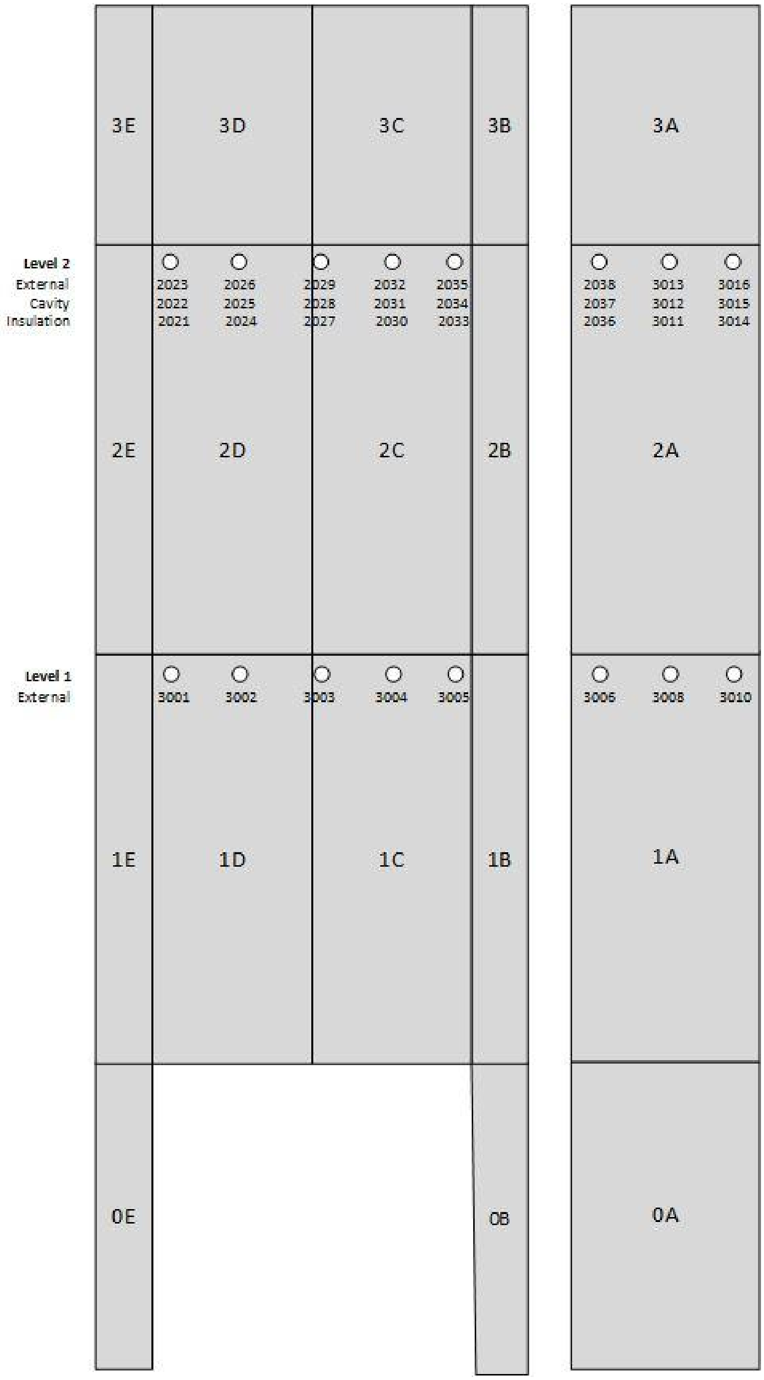


Figure 2. TC positions and panel labelling system (0A – 3E). Not to scale.

9.2 Installation photographs

Figure 3. Location of 'L' brackets and vertical cavity barriers.

Figure 4. Horizontal intumescent cavity barrier fixed through the entire depth on face turned steel brackets, fitted between vertical cavity barriers.

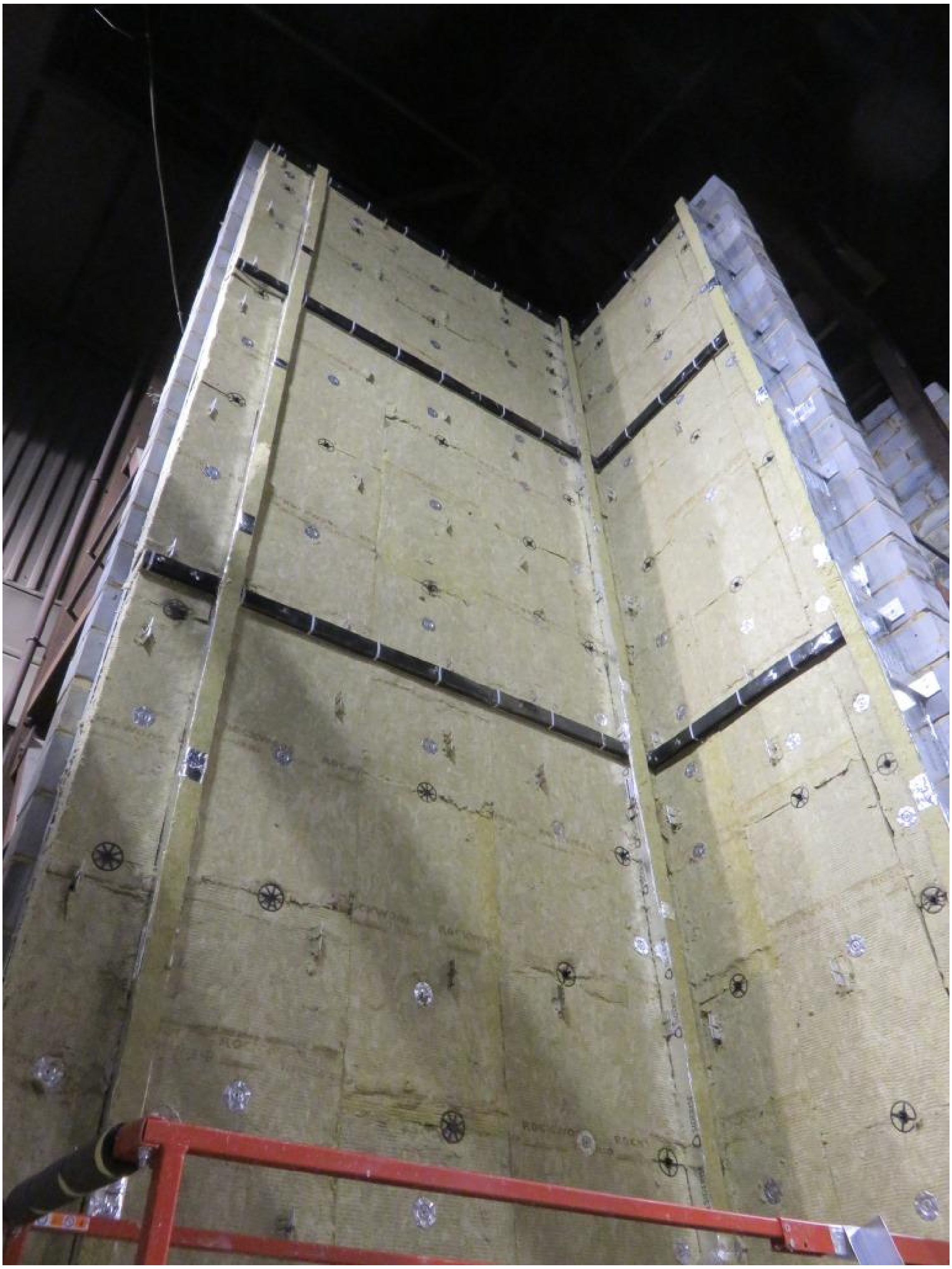


Figure 5. Installed cavity barriers and stone wool insulation.

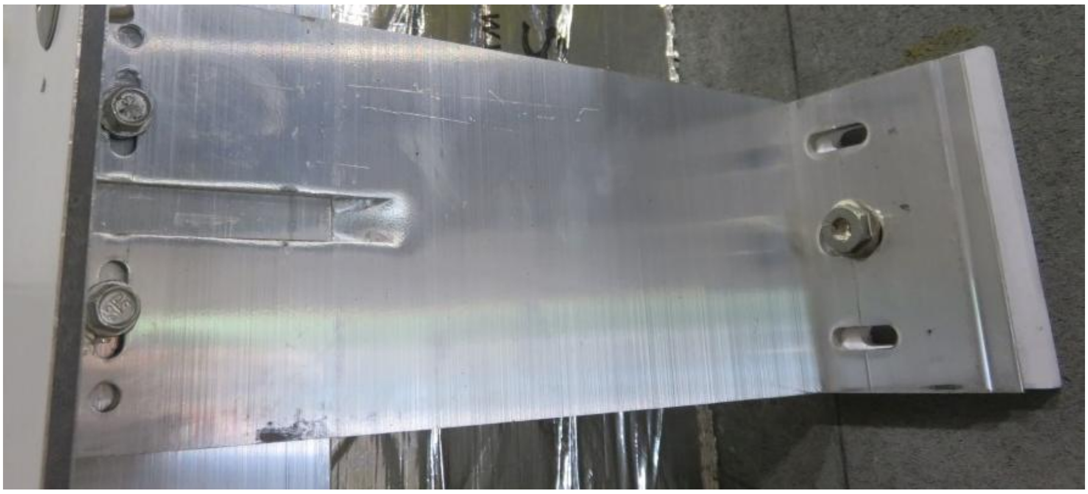


Figure 6. Example of aluminium rail fixed to ‘L’ bracket through movement holes.

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

Figure 8. Installation of railing substructure visible on main wall.

Figure 9. Vertical cavity barrier cut to fit under 'T'-rail.

Figure 10. Detail at corner of combustion chamber opening. Panels riveted in place and nominal 20mm vertical gap left for ventilation purposes.

Figure 11. Completed installation prior to test.

9.3 System drawings

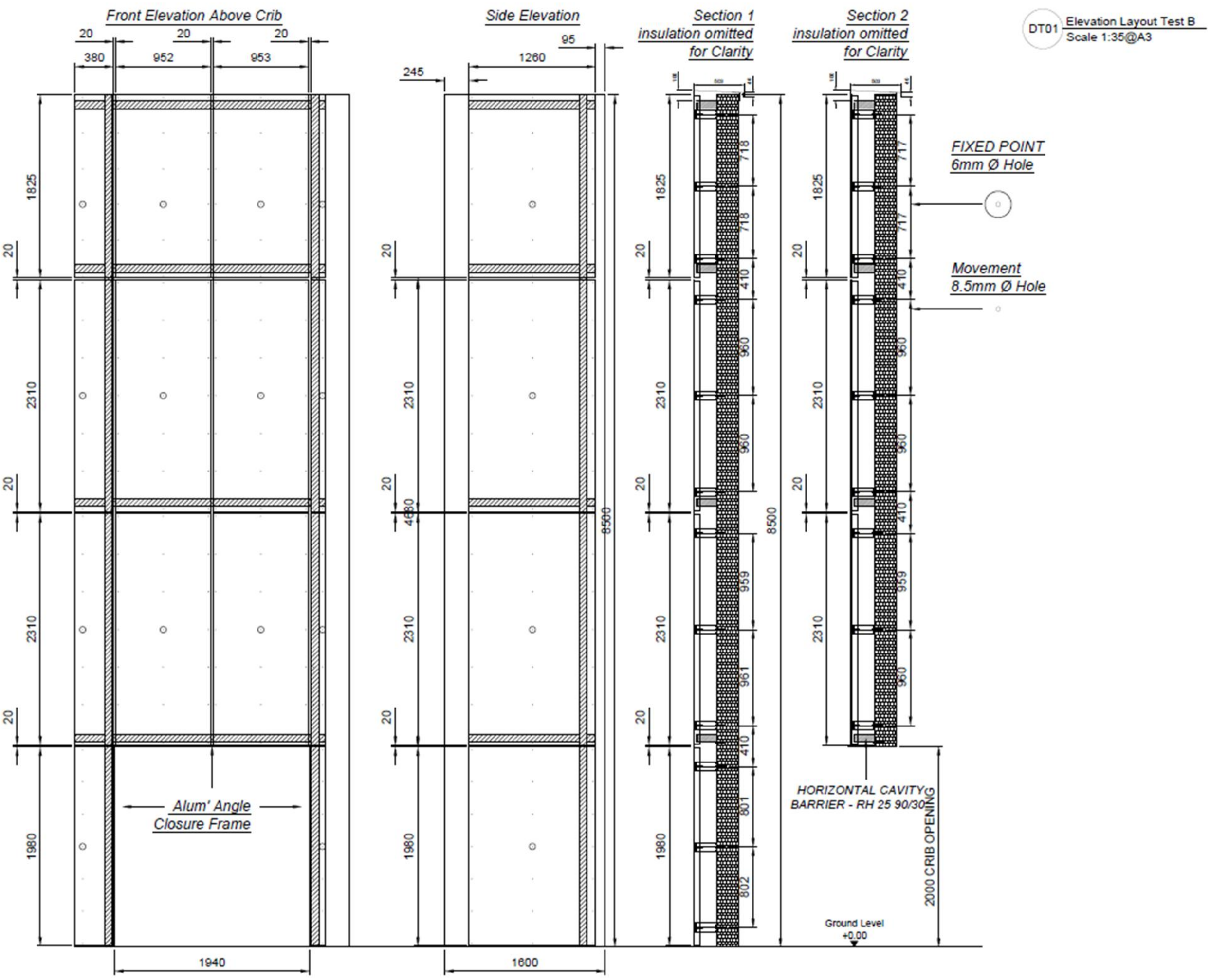


Figure 12. Front elevation, side elevation and vertical sections for the system (supplied by the Test Sponsor).

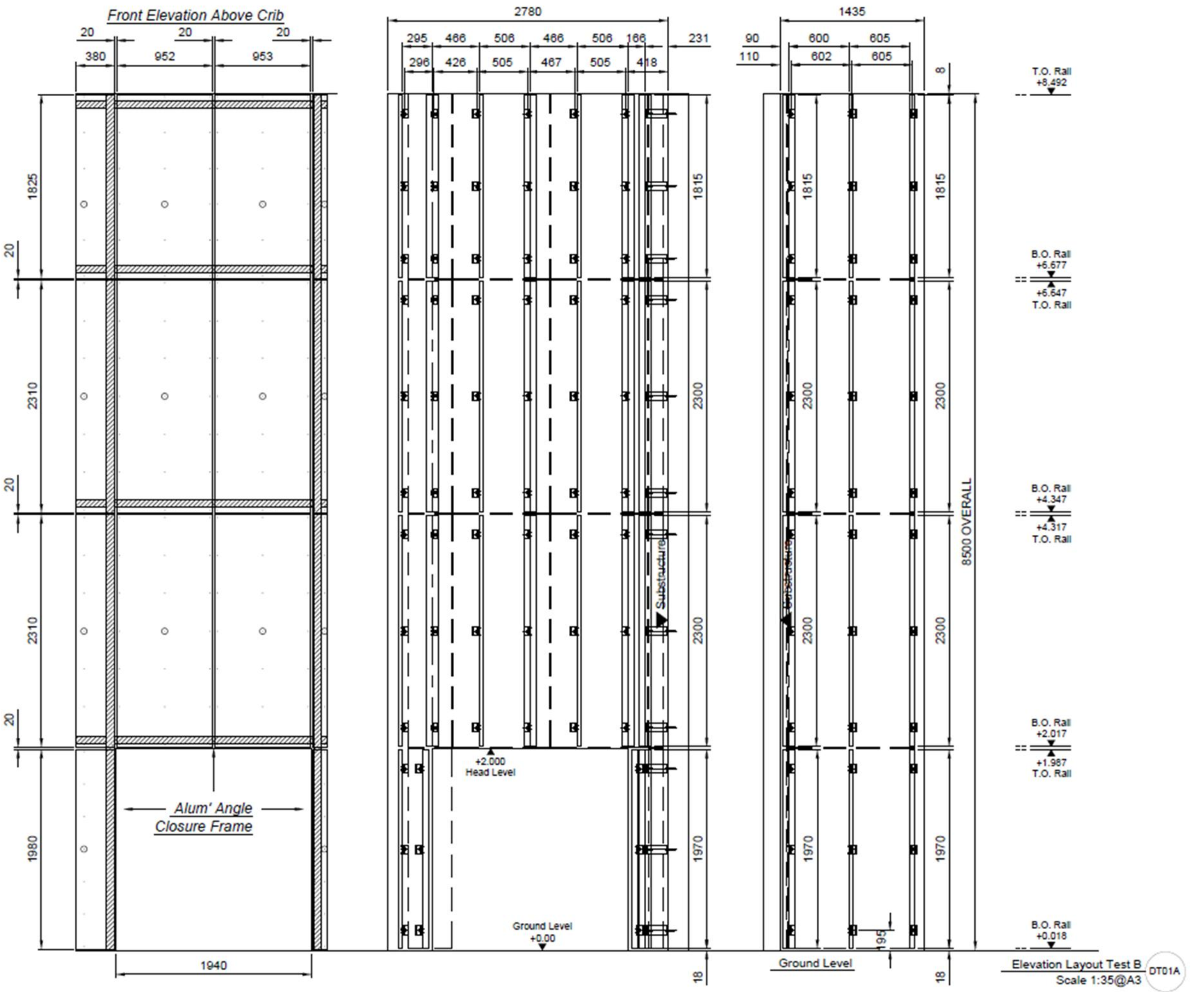


Figure 13. Front elevation, side elevation and vertical sections for the substructure system (supplied by the Test Sponsor).

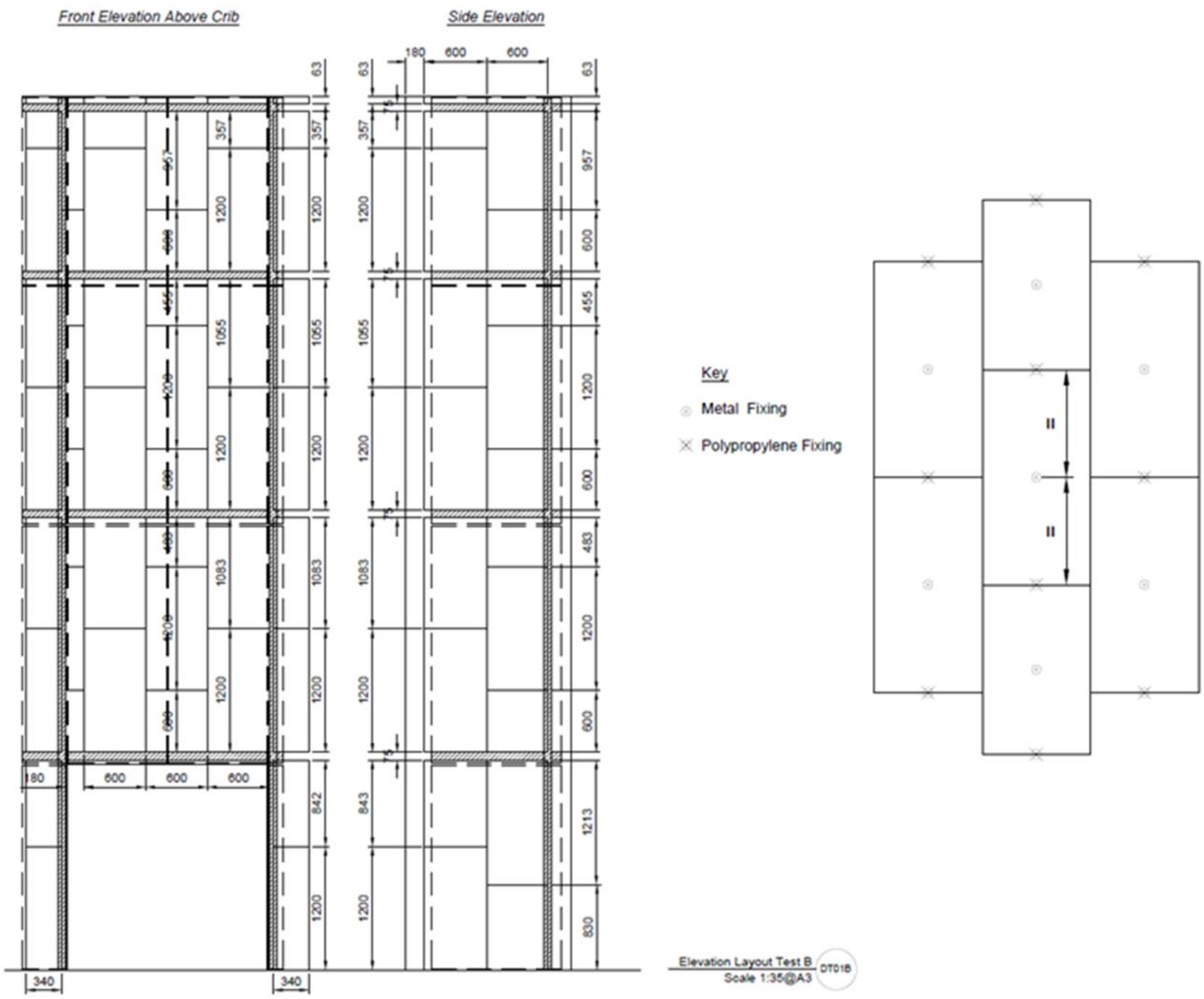


Figure 14. Front elevation, side elevation for the insulation panels installation (supplied by the Test Sponsor).

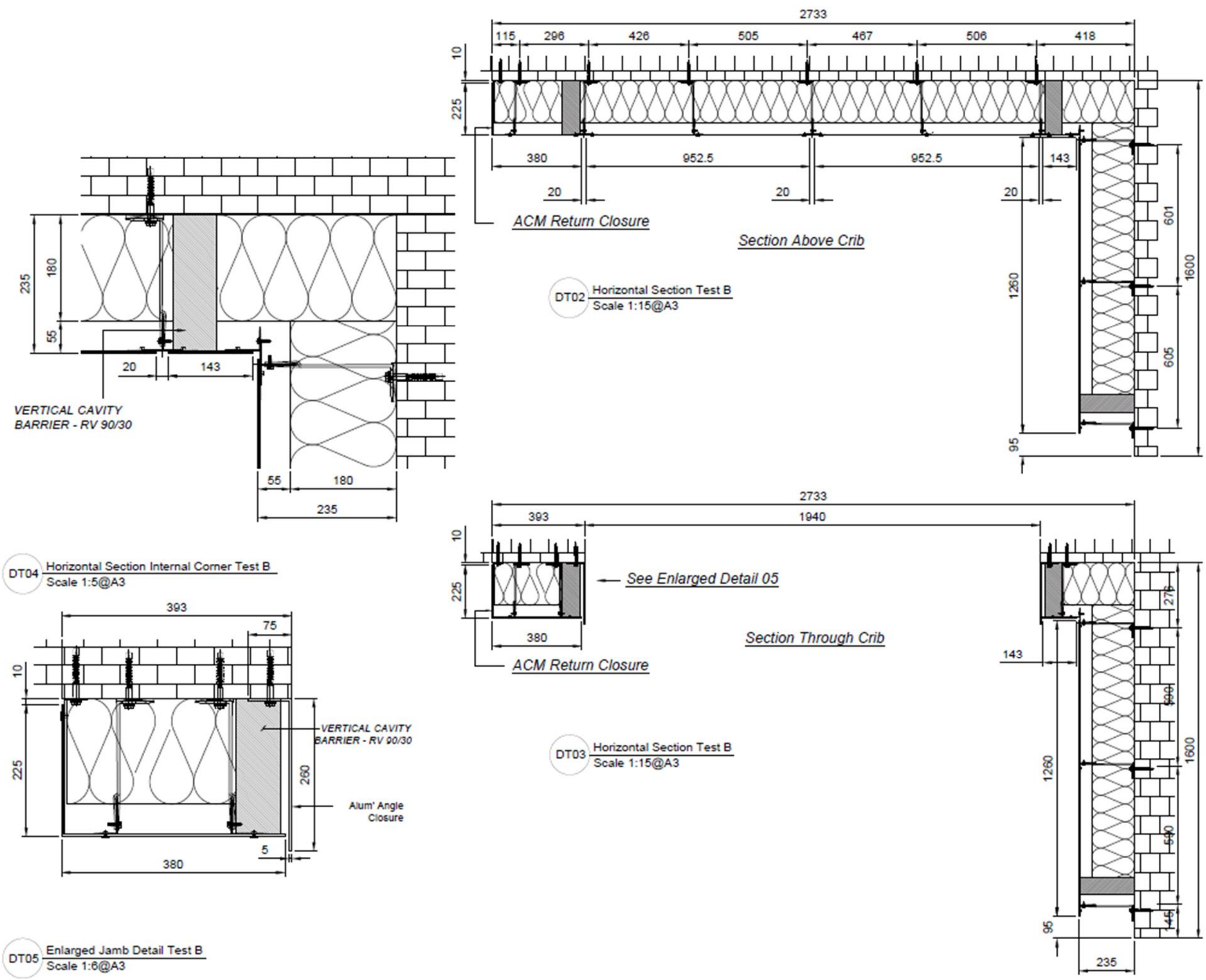


Figure 15. Horizontal section through and above the combustion chamber, and installation details for the system (supplied by the Test Sponsor).

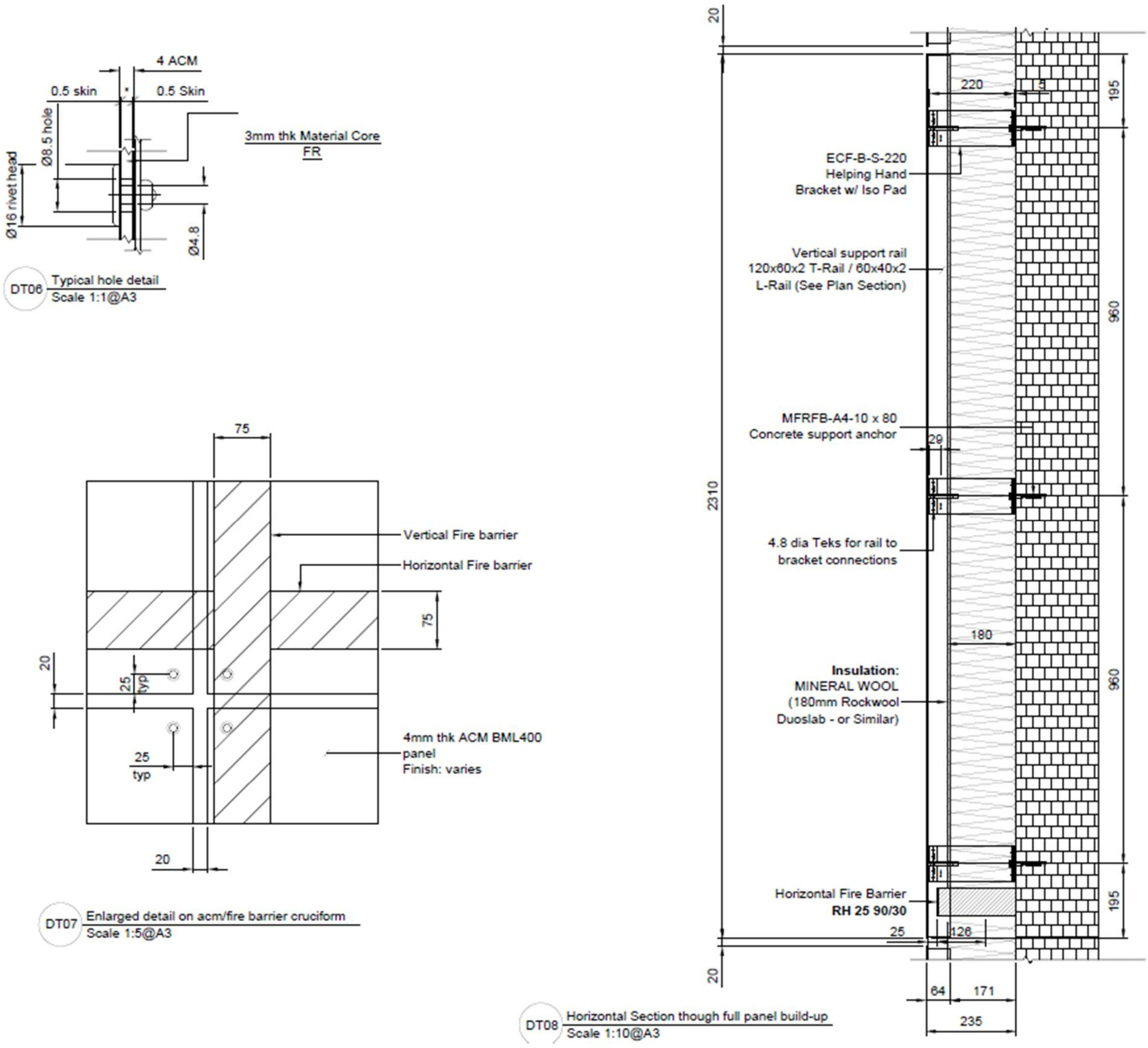


Figure 16. Vertical section through the cladding system, ACM panel detail and vertical and horizontal fire barriers intersection (supplied by the Test Sponsor).

9.4 Temperature data

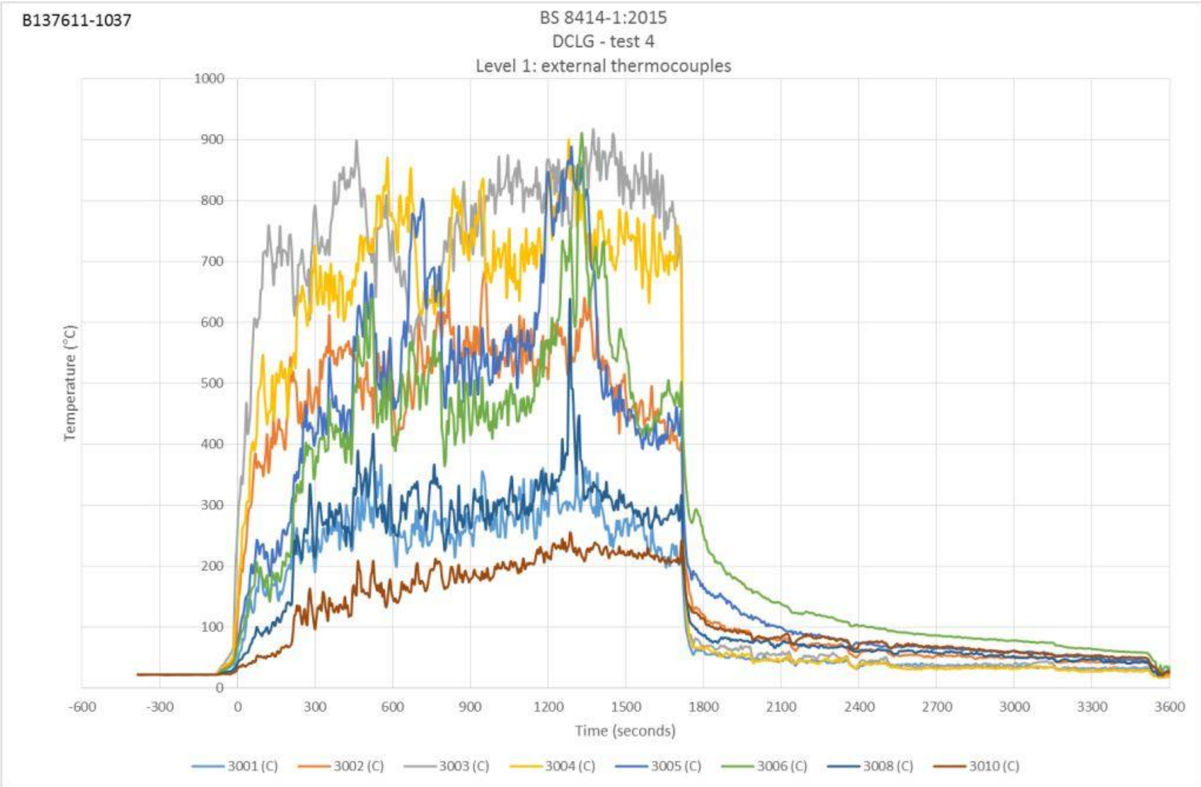


Figure 17. Level 1 external thermocouples.

t_s=85s after ignition of the crib.

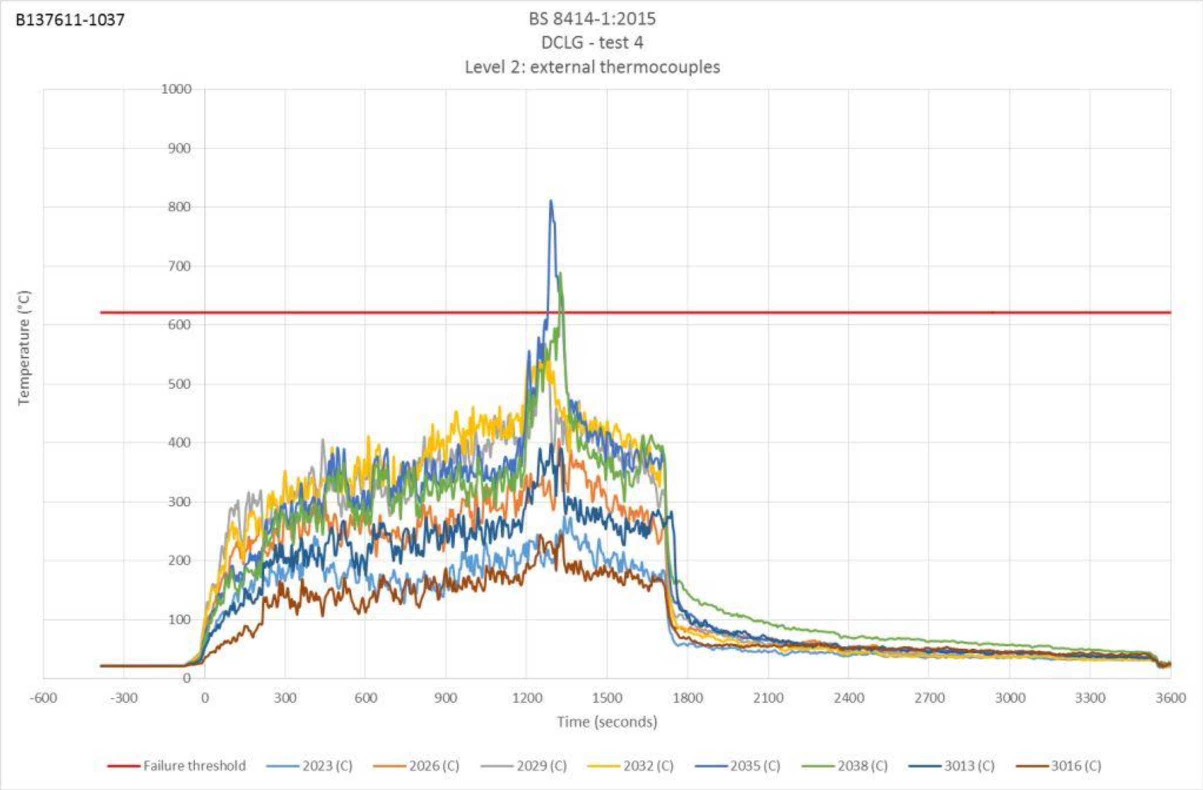


Figure 18. Level 2 external thermocouples.

t_s=85s after ignition of the crib.

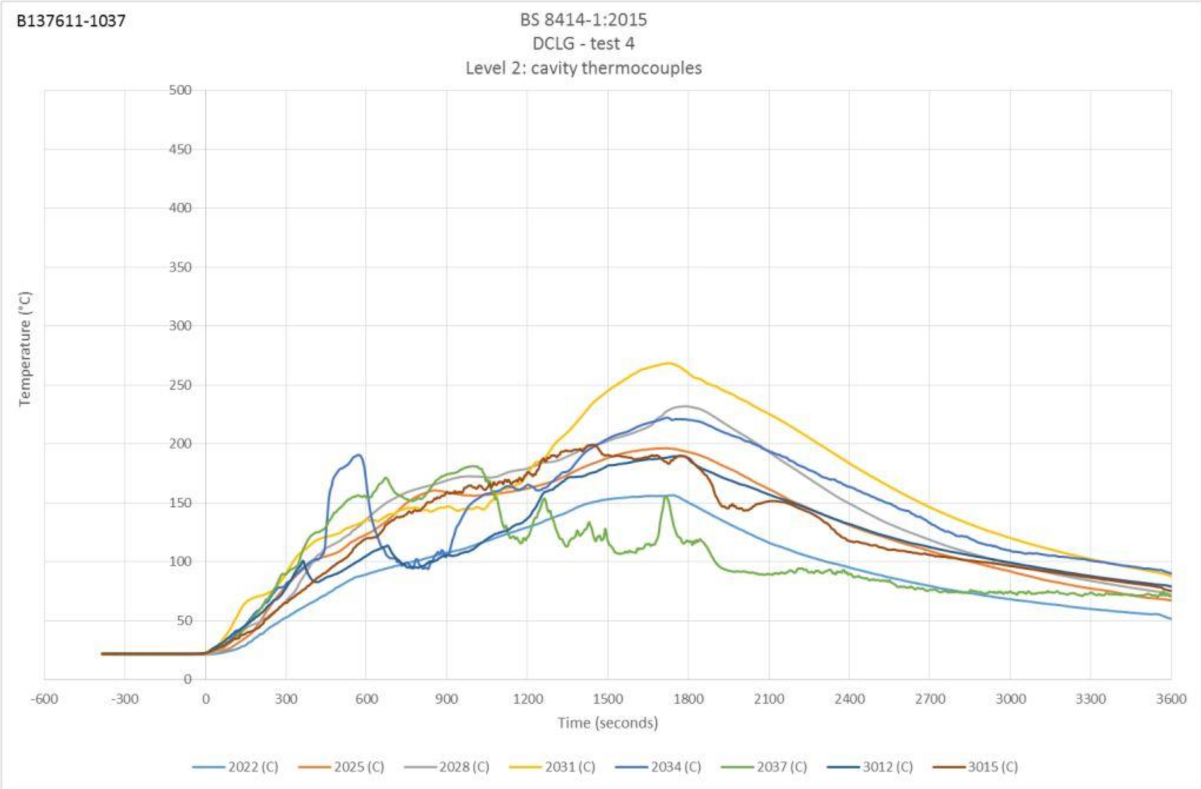


Figure 19. Level 2 cavity thermocouples.

t_s=85s after ignition of the crib.

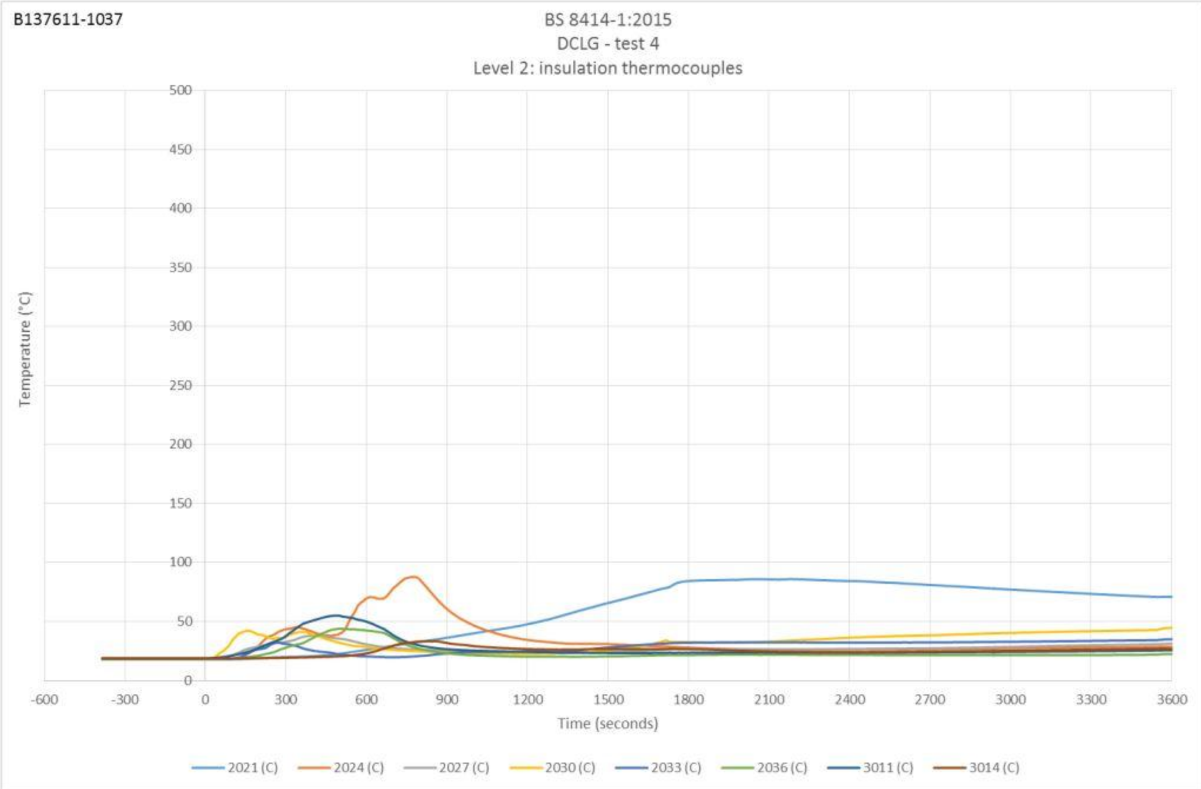


Figure 20. Level 2 insulation thermocouples.

t_s=85s after ignition of the crib.

9.5 Post-test photographs

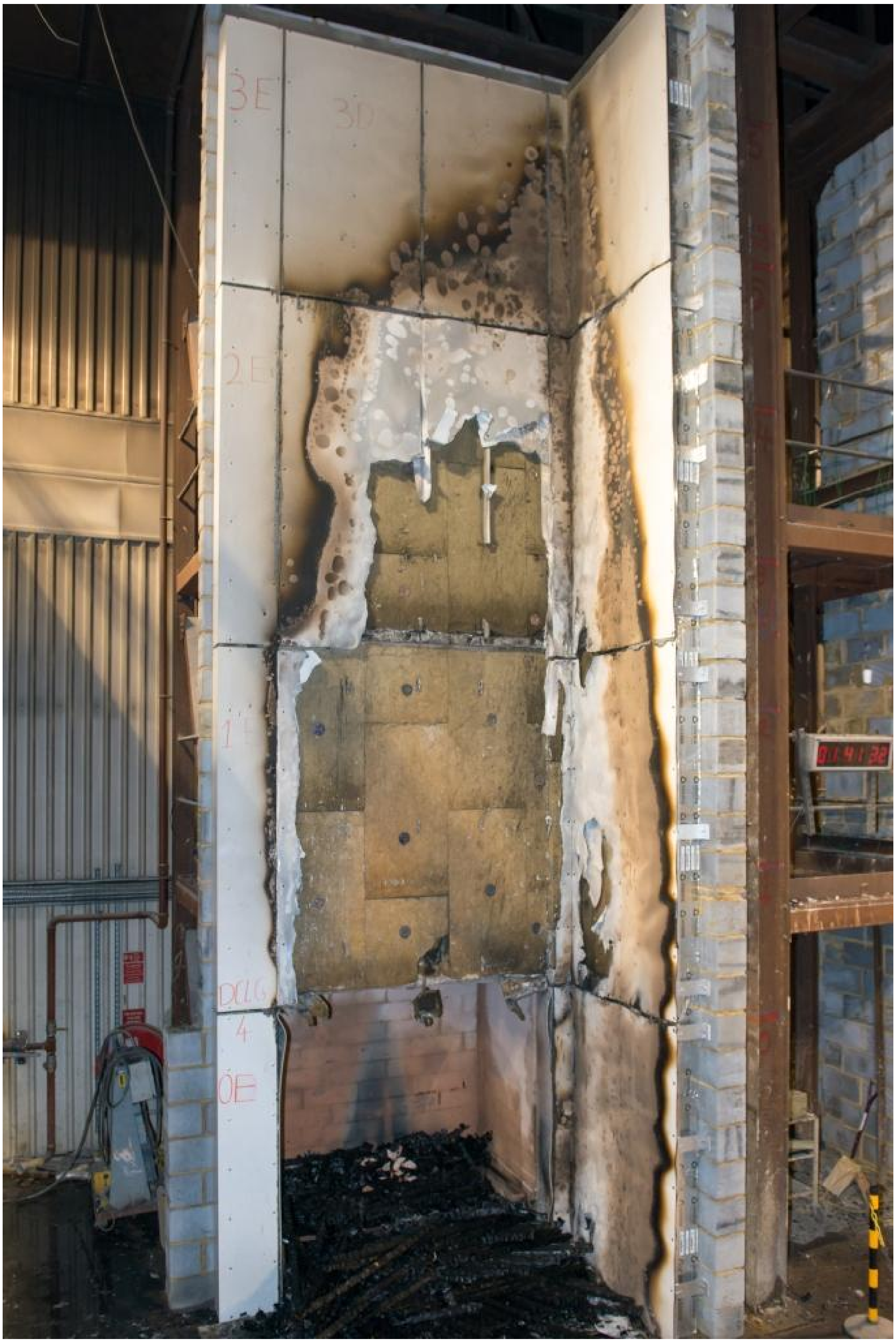


Figure 21. Full height photograph of system post-test.

Figure 22. Full height photograph of wing wall post-test.

Figure 23. First row ACM panels (directly above combustion chamber).

Figure 24. Second row ACM panels (approximately 2300mm-4600mm above combustion chamber).

Figure 25. Third row ACM panels (approximately 4600mm-6500mm above combustion chamber).

Figure 26. Close up of ACM panel edges showing melted core filler material.

Figure 27. Close up of melted window pod and collapsed horizontal cavity barrier directly above the combustion chamber.

Figure 28. Close up of detached section of stone wool insulation directly above the combustion chamber.

Figure 29. Full height photograph of cladding system following removal of ACM panels.

Figure 30. Damage to cladding system beneath ACM panels directly above the combustion chamber.

Figure 31. Full height photograph of cladding system following removal of ACM panels and rail substructure.

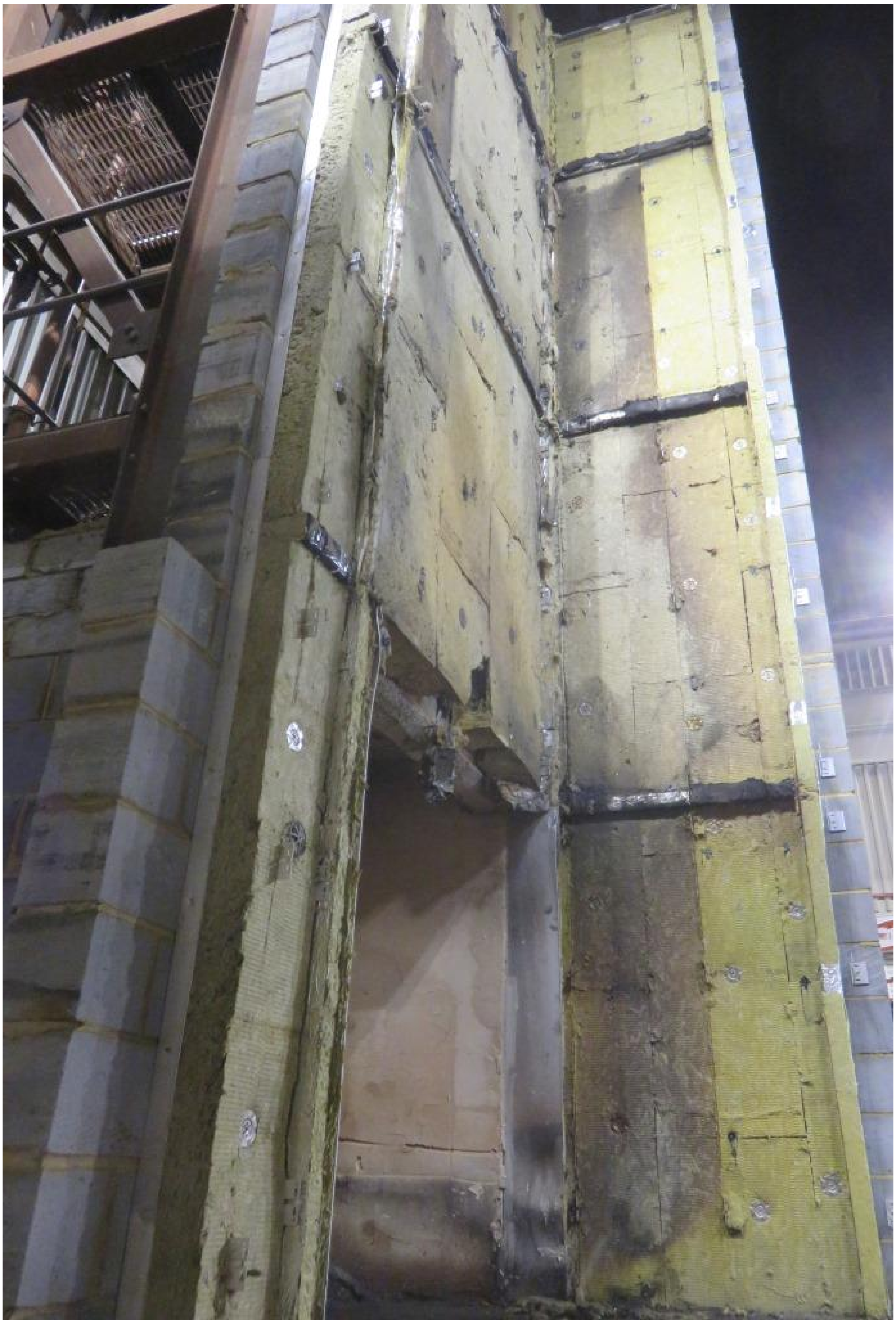


Figure 32. Full height photograph of wing wall following removal of ACM panels and rail substructure.

Figure 33. Cladding system beneath ACM panels and rail substructure between the first and second horizontal cavity barrier (approximately 0-2400mm above combustion chamber).

Figure 34. Cladding system beneath ACM panels between the second and third horizontal cavity barrier (approximately 2400-4700mm above combustion chamber).

Figure 35. Cladding system beneath ACM panels between the third and fourth horizontal cavity barrier (approximately 4700-6400mm above the combustion chamber).

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 board	105 ± 5ºC	0.5	46.6
Vertical cavity barrier	105 ± 5ºC	0.4	79.1
Horizontal cavity barrier	105 ± 5ºC	0.4	86.0

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	CT004-01 CT004-02 CT004-03

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

Ambient temperature (°C)	Relative humidity of the air (%)
23.7	48.6

Test results:

Test No.	Calorific value (MJ/kg)	Category	Standard deviation (%)
1	13.6601	CAT 2	0.06
2	13.5834	CAT 2	
3	13.5405	CAT 2	

Report Ends