

BRE Global Client Report

BS 8414-1:2015 + A1:2017 Test referred to as DCLG test 7.

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Version History

22/08/2017	Issue 2.0	Amendment to front cover.
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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 originally included 6 combinations of cladding systems. This report specifically refers to a seventh test added to the work programme by DCLG. The detailed design of each test specimen was carried out by a cladding company appointed by DCLG. The design of the cladding systems were reviewed by the Independent Expert Advisory Panel and other industry bodies to ensure that they were representative of the systems that are in common use on buildings, including the way they are fixed. The cladding systems were installed by a Company appointed by DCLG and each one was independently assessed during the installation to ensure that it met the design specification.

The original six test specimens incorporated 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 original testing were rigid polyisocyanurate foam (PIR) or stone wool. This seventh test was carried out on an ACM panel with core filler of fire retardant polyethylene with an insulation material of rigid phenolic foam.

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.



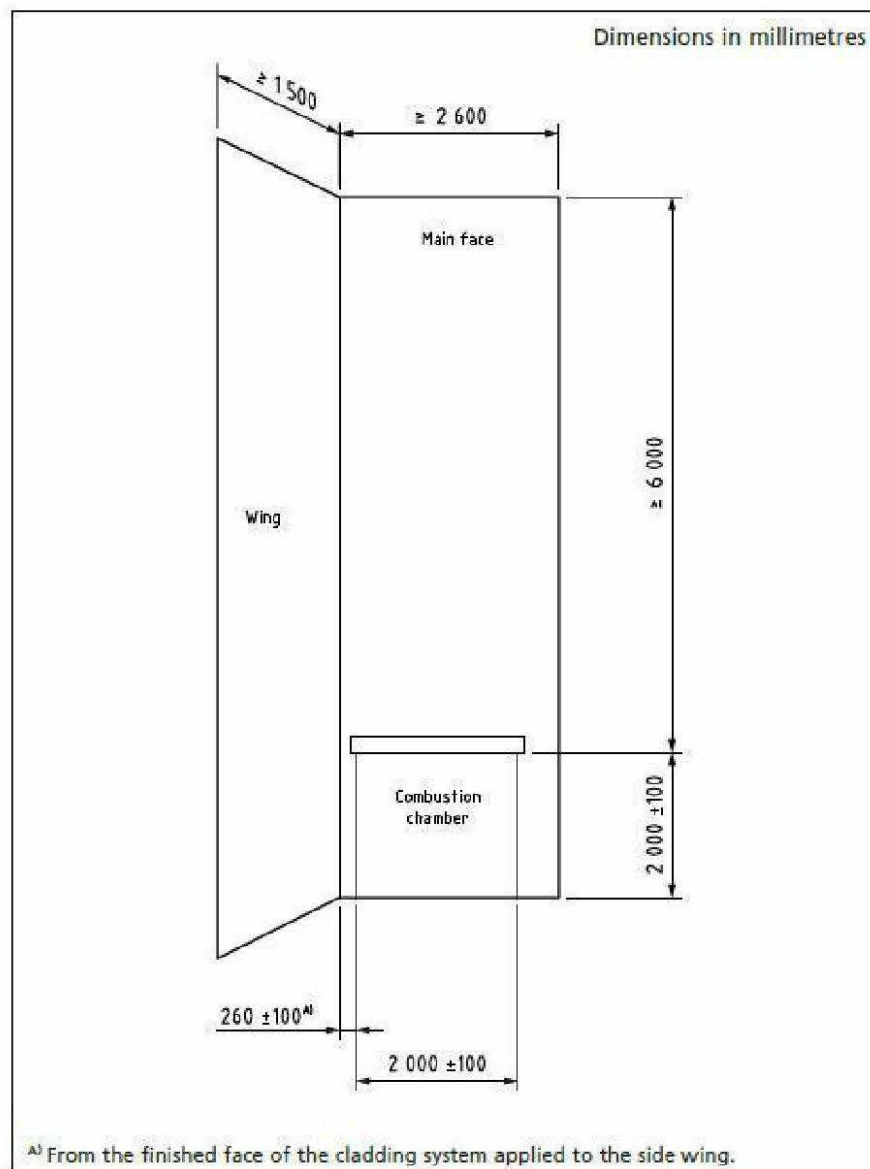
2 Details of test carried out

Name of Laboratory:	BRE Global Ltd.
Laboratory Address:	Bucknalls Lane, Garston, Watford, Hertfordshire, WD25 9XX.
Test reference:	DCLG test 7
Date of test:	13/08/2017
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 1 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 1 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 13-17 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 × 113mm-deep × 4mm-thick aluminum 'L'-shaped brackets fixed with a single 90mm-long × ϕ 8mm stainless steel screw anchor and plastic plug – see Figures 8&9;
- 100mm-thick phenolic insulation boards (supplied 2400mm × 1200mm and cut to size) with aluminium foil facings on both sides – see Figure 7;
- 120mm-wide × 60mm-deep × 2mm-thick aluminum 'T'-section framing and 40mm-wide × 60mm-deep × 2mm-thick aluminum 'L'-section framing – see Figure 10;
- 75mm-wide × 160mm-deep stone wool vertical cavity barriers (stated integrity/insulation performance: 90/30mins), with 10mm compression – see Figure 3;
- 75mm-wide × 125mm-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 12.

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 × 113mm-deep × 4mm-thick aluminium 'L'-shaped brackets were fixed in position on low density polyethylene isolation pads (5mm-thick), with a single 90mm-long × ϕ 8mm stainless steel screw anchor and plastic plug – see Figures 8&9. On the main face the horizontal spacing between the brackets varied between 340mm and 500mm – Figure 3. On the wing wall the horizontal spacing between the brackets was 645mm 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&4.



The system included vertical and horizontal cavity barriers – see *Figure 4*. On the main face, two 75mm-wide×160mm-deep stone wool vertical cavity barriers, with 10mm compression, were fixed in position with a clear distance of 1950mm between them. The vertical cavity barriers were skewered to $\frac{3}{4}$ -depth on steel brackets fixed into the masonry wall with one 70mm-long× ϕ 4mm anchor. Two steel brackets were used for each length of 1200mm of stone wool cavity barrier. The vertical cavity barriers were trimmed to fit - see *Figure 6*.

On the wing wall, one 75mm-wide×160mm-deep stone wool vertical cavity barrier, with 10mm compression, was fixed in position at the edge of the system, approximately 1350mm from the external face of the main wall – see *Figure 3*. 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× ϕ 8mm stainless steel screw anchor and plastic plugs – see *Figure 5*.

A set of four 75mm-wide×125mm-deep intumescent horizontal cavity barriers were butted up to the continuous vertical barriers (see *Figures 4-7*) 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 5*. Two steel brackets were used per length of 1200mm of stone wool cavity barrier, each fixed into the masonry wall with one 70mm-long× ϕ 4mm 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 100mm-thick foil-faced phenolic insulation panels (supplied in 2400mm×1200mm panels and cut to fit) were installed in position through the substructure bracket fixing systems and fixed to the support structure (masonry wall) with five 125mm-long× ϕ 8mm plastic anchors and four 140mm-long× ϕ 8mm stainless steel anchors per full size panel - see *Figure 7*. The insulation panels were installed with the long edge orientated vertically. All the gaps between the insulation panels and at the intersection with the cavity barriers or aluminium brackets were sealed with aluminium tape as recommended by the manufacturer - see *Figure 10*.

After the insulation was fixed in position, the 120mm-wide×60mm-deep×2mm-thick aluminium 'T'-section and 40mm-wide×60mm-deep×2mm-thick 'L'-section framing were installed at horizontal spacings of 480mm – see *Figure 10*. The horizontal spacing between successive sections of aluminium 'T'-section or 'L'-section framing was 970mm. The aluminum vertical rails, with a typical length of 2300mm, were positioned 10mm inside the thermal insulation 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 – see *Figure 6*. 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 8&9*.

The external ACM panels of the system were installed on to the rail substructure with one fixed point (ϕ 6mm hole) in the middle and twenty (per full size panel) oversize (ϕ 8.5mm 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 11*. The measured gaps after installation varied between 17mm and 27mm. 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	2570mm
≥1200mm width across the wing wall	1335mm
260mm (±100mm) wing wall-combustion chamber opening	240mm
2000mm x 2000mm (±100mm) combustion chamber opening	2000mm x 1960mm

4.5 Test conditions

Test Date: 13/08/17

Ambient Temperature: 19°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 18-21 provide the temperature profiles recorded. Figure 12 shows the system before the test.

Parameter	Result
T _s , Start Temperature	19°C
t _s , Start time	115 seconds after ignition of crib.
Peak temperature / time at Level 2, External	939°C at 1570 seconds after t _s .
Peak temperature / time at Level 2, Cavity	319°C at 995 seconds after t _s .
Peak temperature / time at Level 2, Insulation	142°C at 1300 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
0:00		Ignition of crib.
1:33		Flames impinge on the base of panels 1C & 1D.
1:55	0	Start time (t_s) criteria achieved: External temperature 2.5m above the top of the combustion chamber in excess of 219°C (=200°C+ T_s).
2:18	0:23	Flame tips reach the horizontal junction between panels 1C and 2C.
2:49	0:54	Distortion of panels 1C and 1D observed.
3:03	1:08	Detachment of the surface coating from panels 1C and 1D.
4:01	2:06	Flame tips reach the base of panels 2C/2D.
6:32	4:37	Flaming debris from systems falls in front of hearth.
6:55	5:00	Flaming debris falls from system but extinguishes.
7:36	5:41	Distortion of panel 1A observed.
8:04	6:09	Possible burn through of panel 1C exposing insulation.
8:25	6:30	Steady stream of flaming debris from the system.
9:00	7:05	Hole observed in panel 1D.
9:50	7:55	Discolouration of panel 1A.
10:20	8:25	Hole observed in panel 1C.
10:54	8:59	Internal flaming, bottom right hand side of panel 3D.
11.15	9:20	Flaming debris from panels 1C and 1D.



Time* (mins:secs)	t _s (seconds)	Description
12:06	10:11	Flaming material in front of hearth.
13:13	11:18	Flaming material drops in front of crib.
16:00	14:05	Panels 1C and 1D largely destroyed.
17:00	15:05	Burning observed behind panels 2C and 2D.
18:00	16:05	Panels 2C and 2D beginning to melt. Panels detach from frame at base of panels.
19:22	17:27	Hole through to the insulation observed on panels 2C and 2D.
22:02	20:07	Burning timber falls from crib.
23:00	21:05	More timber falls from crib.
23:12	21:17	Panels 2C and 2D 50% destroyed.
24:20	22:25	Fire growing on wing wall
25:20	23:25	Hole visible in wing wall in line with hearth
26:06	24:11	Flaming from panel joint 2500mm above hearth
26:17	24:22	Hole in wing wall 2000mm above hearth
28:01	26:06	Flaming at junction of wing and main walls to height of test apparatus
28:14	26:19	Test terminated, crib and flaming on the sample extinguished.

*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. The minimum test duration is 40 minutes. 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.

In accordance with BS 8414-1^[1] (and reported above in *Section 5*), the test of this cladding system was terminated after 28 minutes and 14 seconds from ignition of the fire load (timber crib) due to flame spread above the test apparatus. Therefore this cladding system failed to meet the minimum test duration as detailed in BS 8414-1^[1]. A classification to BR 135^[2] is therefore not possible for this cladding system.

The Level 2 thermocouples reached 600°C above T_s at 1500 s. Although the Level 2 thermocouple recordings did not exceed a 600°C temperature rise above T_s for a minimum of 30s, within 15mins from test start time (t_s), failure to achieve the minimum test duration, due to flame spread off the top of the cladding system, prevents classification to BR135^[2].



7 Post-test damage report

7.1 Summary

The cladding system was significantly damaged up to the height of the third horizontal cavity barrier – see *Figures 22-34*. The extent of the damage increased from discolouration of the ACM panels at the edges of the flame damage zone to complete consumption of panels, rail substructure, substantial charring and detachment of the insulation across the full width of the combustion chamber opening up to a height of approximately 5000mm – see *Figures 22-34*.

The wing wall was less severely damaged than the main wall with insulation charring adjacent to the main wall up to a height of approximately 4500mm above the combustion chamber (second fire break). Above the second fire break there was an area of damage where the foil was no longer present and there was surface charring of the insulation (approx 700mm high x 300mm wide at the base) consisting of one, and significant panel discolouration and distortion below the height of the third cavity barrier which reduced in severity towards the top of the cladding system – see *Figures 24-35*.

7.1.1 ACM panels

On the main wall, the damage to the ACM panels was (See *Figures 22 to 28* and with reference to *Figure 1*):

- Panel 0B. Distorted and surface discolouration of panel
- Panel OE. Largely undamaged.
- Panels 1C and 1D. 100% consumption of panels
- Panel 1B. 60% consumption of panel 1B. Panel 2B approximately 30% of the panel consumed
- Panel 2C. 90% consumption of panel.
- Panel 2D. 50% consumption of panel.
- Panel 2E. Surface discolouration extending for approximately 1m vertically from the base of the panel at the vertical joint between panels 2D & 2E
- Panel 3B. Panel in place. Discoloration across the full face of the panel. The panel was distorted.
- Panel 3C. Panel in place. Delamination of bottom edge of panels observed. Discolouration across 90% of the panel.
- Panel 3D. Panel in place. Some surface damage to the panels in the bottom left hand corner of the panel and heat distortion of the panel was observed.
- Panel 3E. Panel in place and largely undamaged.

On the wing wall, the damage to the ACM panels was;

- Panel OA. Panel in place. Distortion and heat damage to the panel. A section of panel adjacent to panel OB approximately 700mm high and 150mm wide was consumed.
- Panel 1A. 30% of the panel consumed in a vertical strip adjacent to panel 1B exposing the insulation beneath. A small section of panel remained in place at the base of this panel. The remaining panel was in place.
- Panel 2A. A section of panel adjacent to panel 2B, approximately 300mm wide x 1000mm high was completely consumed exposing the insulation beneath. The outer aluminium above this for approximately 300mm was consumed leaving the inner layer of aluminium in place. The remaining panel was in place.



- Panel 3A. Distortion and discolouration of the panel extending the full height of the panel. The area of damage was approximately 1000mm wide at the base and 200mm wide at the top. The panel was in place.

7.1.2 'T' and 'L' rail substructure

Damage to the rail substructure was:

Wing wall.

- 'L' section framing between ground level and first level cavity barrier was intact and in place with no sign of damage.
- 'T' section framing between ground level and first level cavity barrier (adjacent to main wall was intact and in place).
- 'L' section framing between first and second level cavity barrier was intact and in place. The sectioned showed heat discolouration
- 'T' section framing between first and second level cavity barriers, adjacent to main wall was intact and in place.
- 'L' section framing between second and third level cavity barrier was intact and in place.
- 'T' section framing between second and third level cavity barriers, adjacent to main wall was intact and in place
- 'L' section framing between third and fourth level cavity barrier was intact and in place.
- 'T' section framing between third and fourth level cavity barriers, adjacent to main wall was intact and in place.

Main wall.

Aluminium framing system located between the first and second level cavity barriers and above the hearth between the vertical cavity barriers was almost completely destroyed. All of the rail system was no longer in place. Some 'L' shaped brackets remained attached to the substrate, although all were melted to some degree. The vertical rails section at the junction of panels 1E and 1F was in place but distorted.

Aluminium framing system located between the second and third level cavity barriers.

- 'T' section adjacent to main wall. Sections of the rail were melted and the rail was distorted.
- 'L' section to the right of the above rail. A small section of rail was in place beneath the cavity barrier (approximately 200mm). The remaining rail was no longer in place. The brackets were still attached to the wall and these were melted.
- 'T' Section bisecting the main wall. Completely destroyed beneath the third level cavity barrier. Remains of brackets used to mount the rail on the wall could be seen.
- 'L' section to the right of the above 'T' section. 800mm (approx.) section of rail remained located below the 3rd level cavity barrier.

Aluminium Framing system above the third level fire break was intact.



7.1.3 Phenolic Insulation

On the main wall face, at the location of panel/s (refer to *Figure 1*):

- 1C&1D, Approximately 50% of the insulation detached or consumed exposing the blockwork behind. Remaining insulation heavily charred. Some remains of foil facing.
- 1E. Insulation largely undamaged. Foil facing of insulation intact.
- 2C, charring of the insulation occurred in decreasing severity between the second and third cavity barrier. No foil facing was visible upon removal of the ACM panels.
- 2D, charring of the insulation occurred in decreasing severity between the second and third cavity barriers mirroring the damage to the ACM panel above.
- 2E Insulation largely undamaged with the foil facing intact.
- 3B Discolouration of the foil facing.
- 3C Discolouration of the foil facing
- 3D Discolouration of 50% of the foil facing.
- 3E Insulation undamaged.

On the wing wall face, beneath panel (refer to *Figure 1*):

- 0A. The foil facing on the insulation remained intact.
- 1A. Insulation charred to the full height between the fire breaks on approximately 50% of the insulation adjacent to panel 1B. The foil facing on the remaining insulation was intact.
- 2A, A small section of the insulation was charred (approx. 300mm wide at the base and 800mm high). The foil facing remained intact on the rest of the insulation.
- 3A, minor discolouration to the foil facing – see *Figure 34*.

7.1.4 Horizontal (intumescent) cavity barriers

The cavity barrier behind Panel 1A (in line with the top of the combustion chamber) had activated and was still in place when the ACM panels were removed.

The cavity barrier beneath panel 1B In line with combustion chamber had activated and was still in place.

There is evidence of activation of the first row horizontal intumescent cavity barrier directly above the combustion chamber (behind panels 1C and 1D). However, significant destruction and detachment occurred during the test – see *Figure 30*. The metal straps attaching the cavity barrier to the wall remained with small sections of stone wool attached to these.

The section of cavity barrier at the outside edge, beneath panel 1E, showed initial signs of activation on the left hand side.

The second row horizontal cavity barrier on the wing wall at the junction of panels 1A and 2A, had activated and was still in place when the ACM panels were removed.

The cavity barrier behind panels 1B and 2B, 1C and 2C, 1D and 2D had activated. The cavity barrier was in place when the ACM panels were removed, but a section of cavity barrier had become detached from the substrate - see *Figure 31*.

The cavity barrier behind panel 2E showed signs of surface heating but not full activation.

The third row horizontal cavity barrier has activated behind panels 2A/3A, 2B/3B, 2C/3C and 2D/3D. The section of cavity barrier at the junction of panels 2E/3E had not activated. This cavity barrier showed evidence of heating on the bottom right hand edge.

The fourth row horizontal cavity barrier showed early signs of activation except for the section behind panels 3E.



7.1.5 Vertical (compression) cavity barriers

From the height of the combustion chamber opening to the height of the second horizontal cavity barrier, the vertical cavity barrier on the inside edge of the main wall (adjacent to the wing wall), was significantly discoloured – see *Figure 34*. Between the second and third cavity barrier discolouration of the vertical barrier reduced and was minimal beyond this point – see *Figure 31*.

The vertical cavity barrier on the outside edge of the combustion chamber opening was discoloured along the inside edge but remained intact and prevented fire spread to the outside edge of the main wall.

Fire spread within the cavity did not reach the vertical cavity barrier at the outside edge of the wing wall.



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

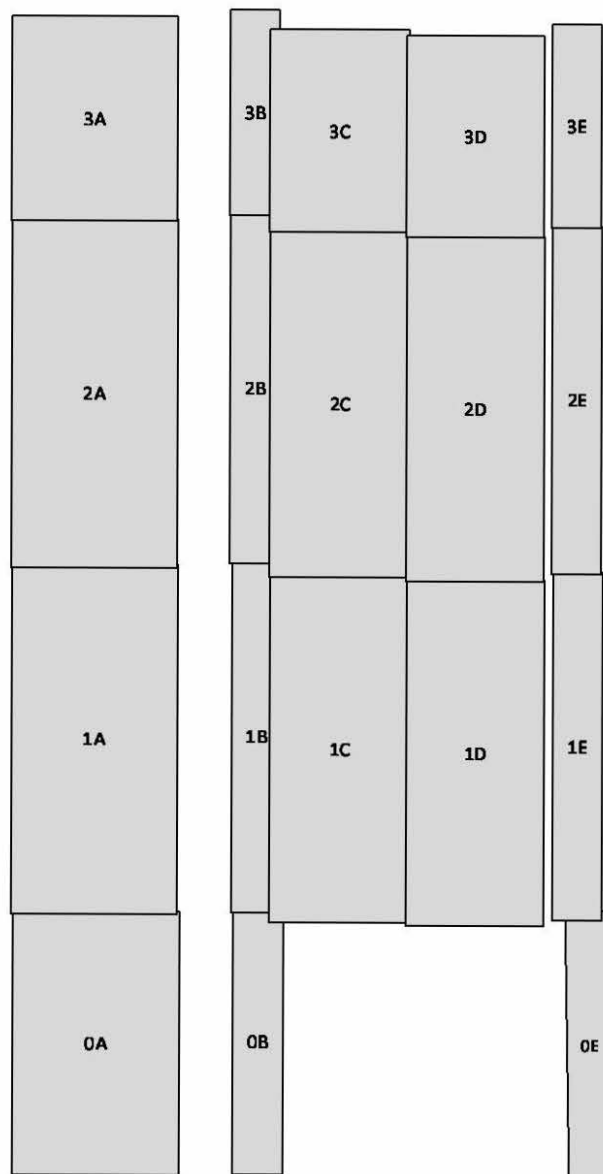


Figure 1. Layout of panels and labelling system used for reporting purposes. Not to scale.

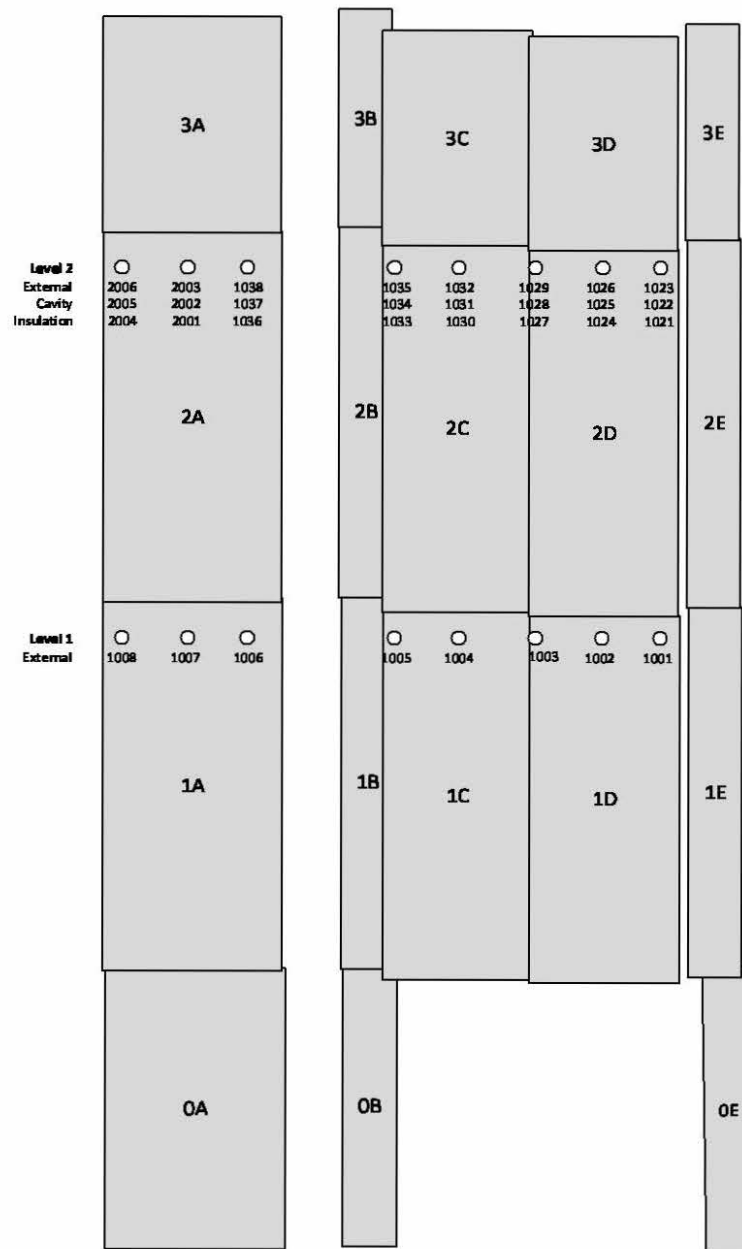


Figure 2. TC positions and panel numbering (0A – 3E). Not to scale



9.1 Installation photographs

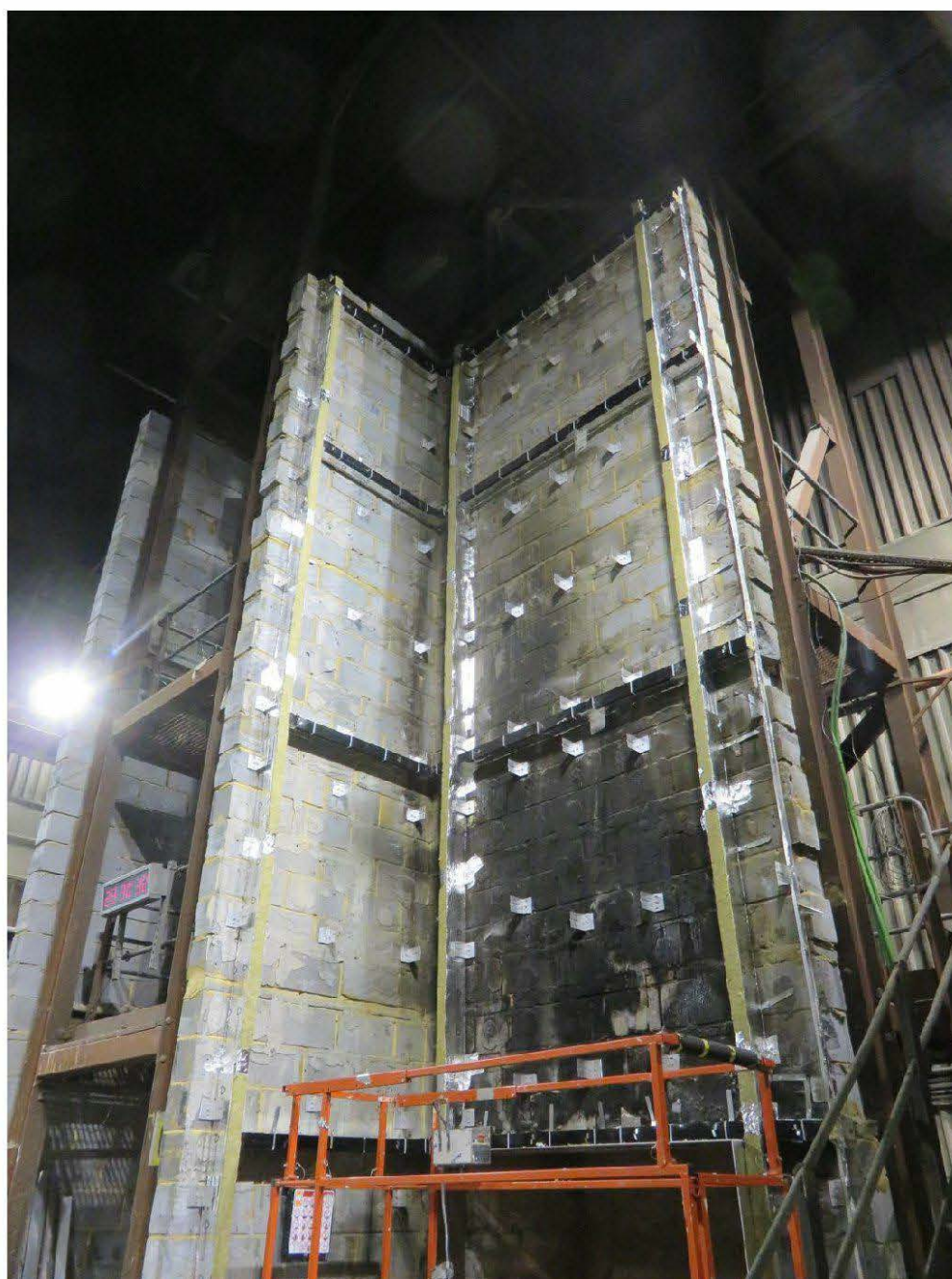


Figure 3. Location of 'L' brackets (partially visible) vertical and horizontal cavity barriers.



Figure 4. Horizontal intumescent cavity barriers fitted between vertical cavity barriers.



Figure 5. Horizontal intumescent cavity barriers fixed through the entire depth on face turned steel brackets, fitted above window pod.

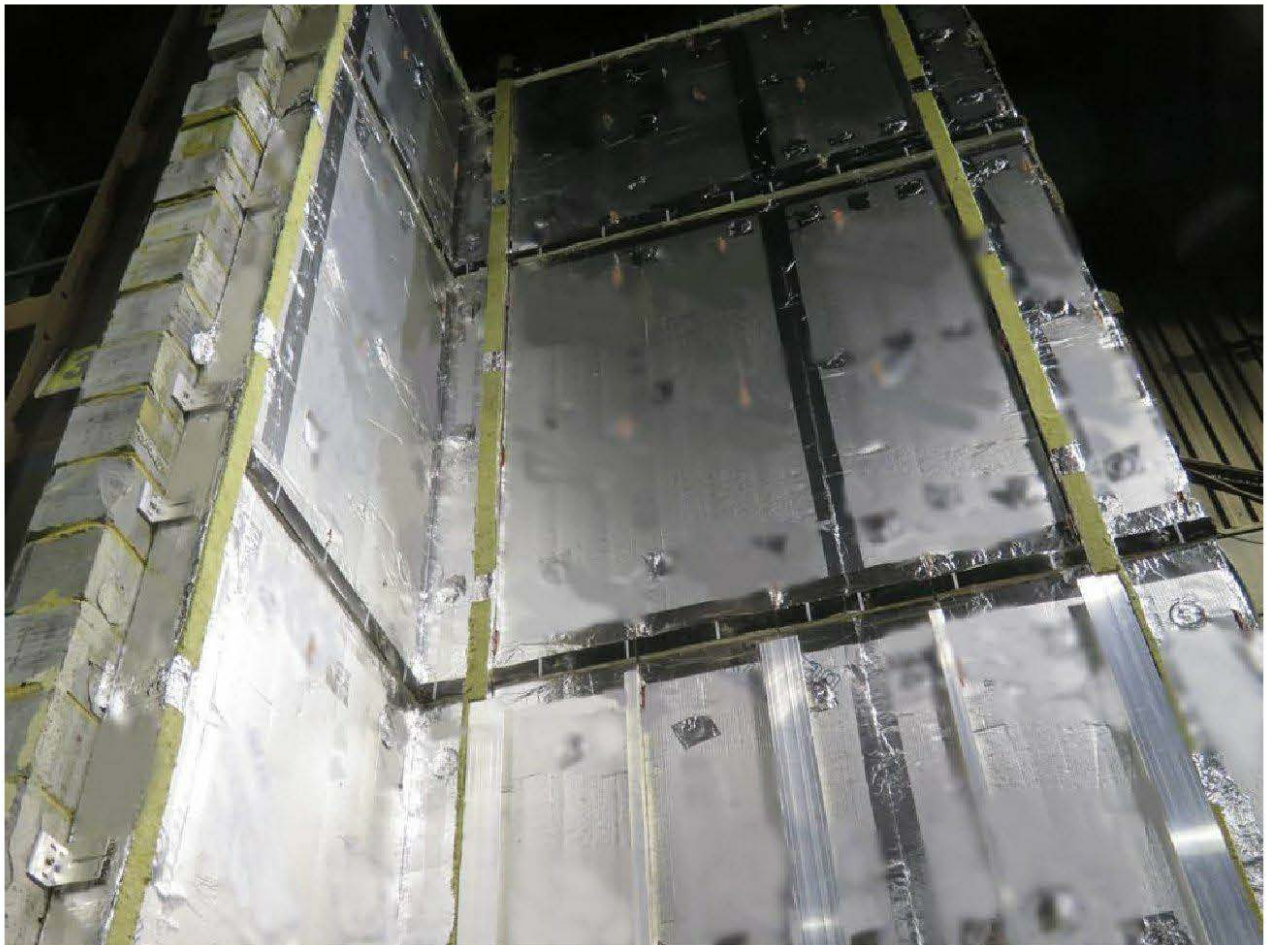


Figure 6. Vertical cavity barrier installed under 'T'-rail.

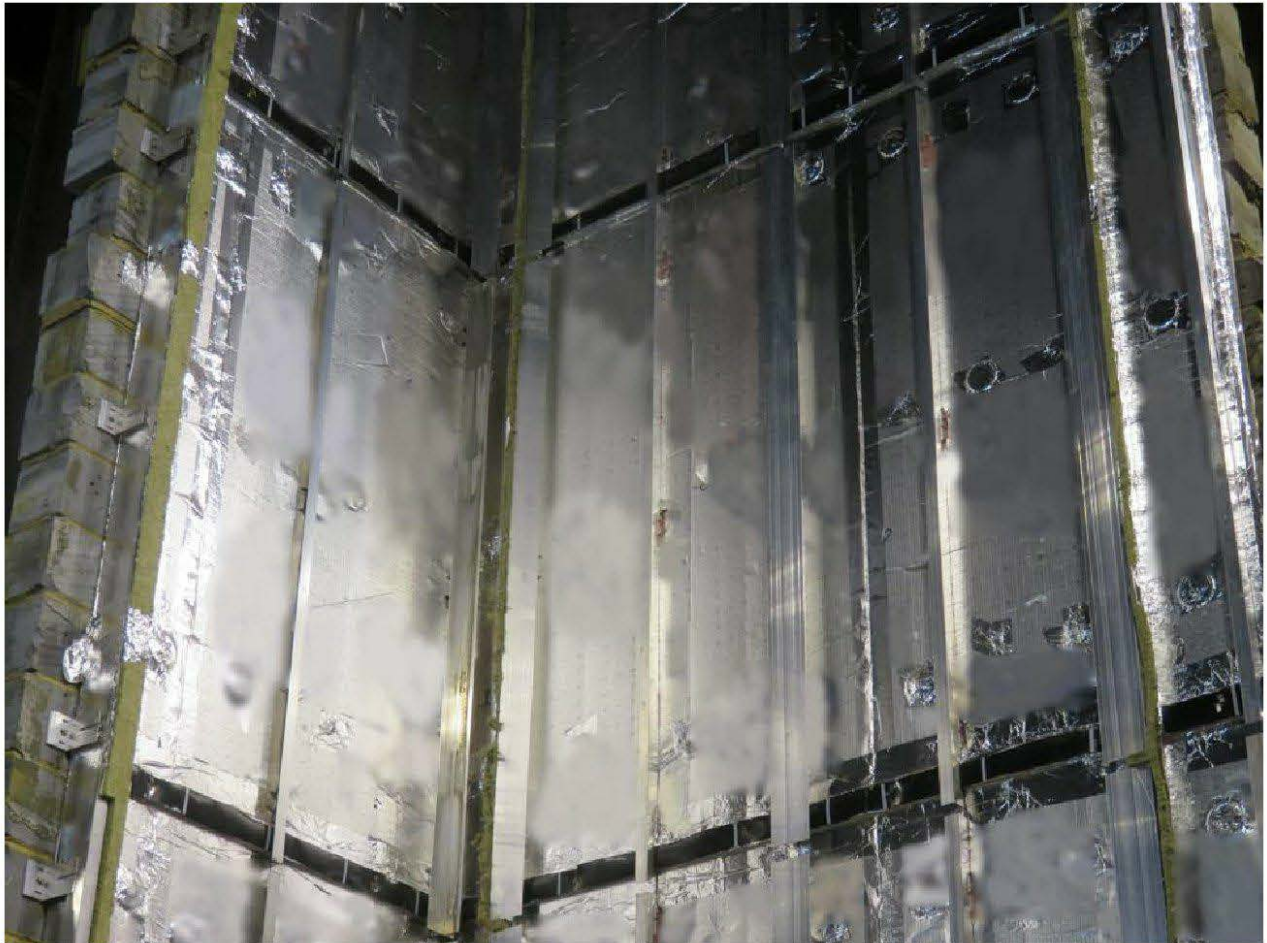


Figure 7. Installed cavity barriers and Phenolic insulation panels.



Figure 8. Example of aluminium rail fixed to 'L' bracket through movement holes.



Figure 9. Example of aluminium rail fixed to 'L' bracket through fixed holes.



Figure 10. Completed installation of railing substructure visible on main wall.



Figure 11. Detail at corner of combustion chamber opening. Panels riveted in place with nominal 20mm vertical gap for ventilation purposes.



Figure 12. Completed installation prior to test.



9.2 System drawings

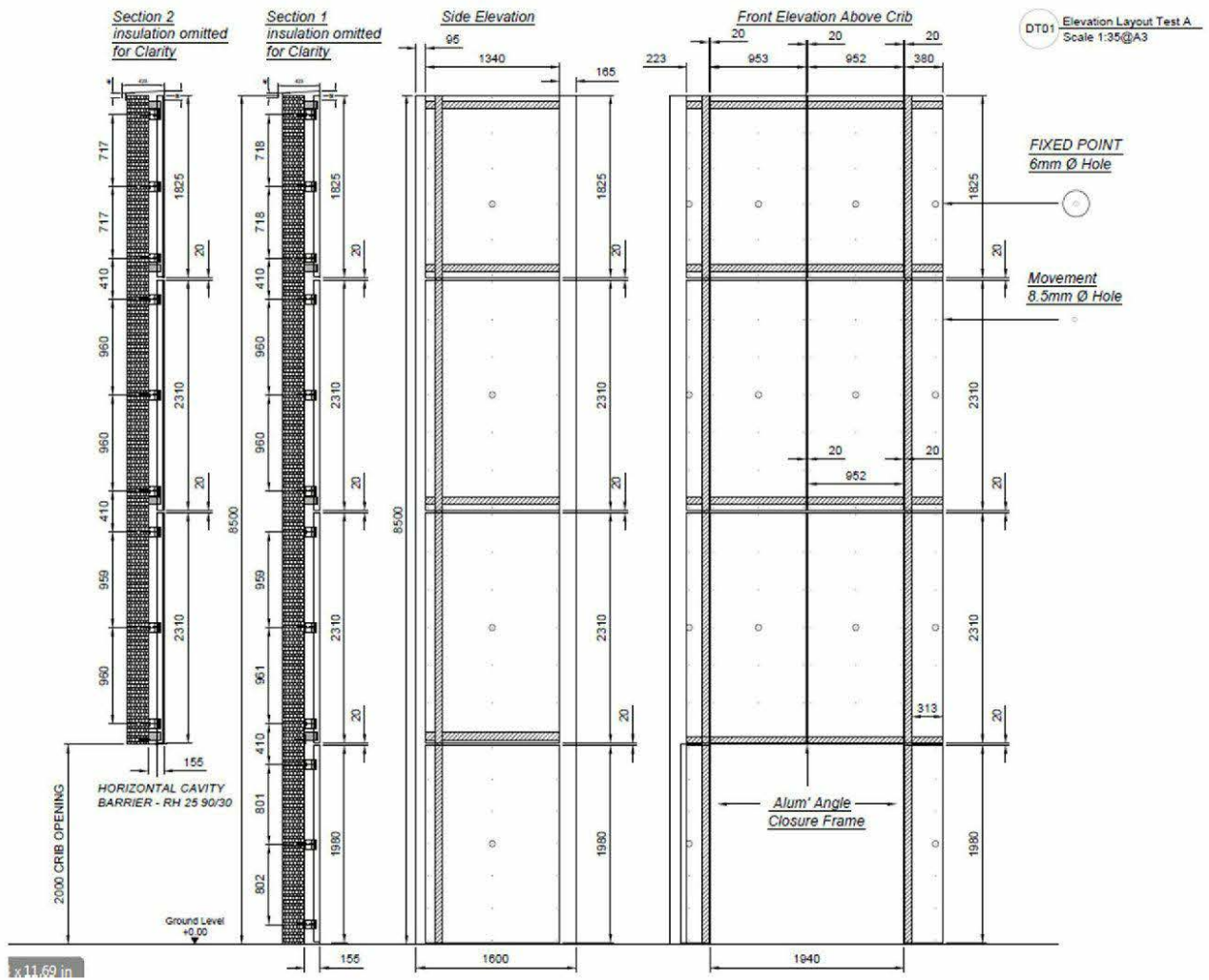


Figure 13. Front elevation, side elevation and vertical sections for the system (supplied by the Test Sponsor)

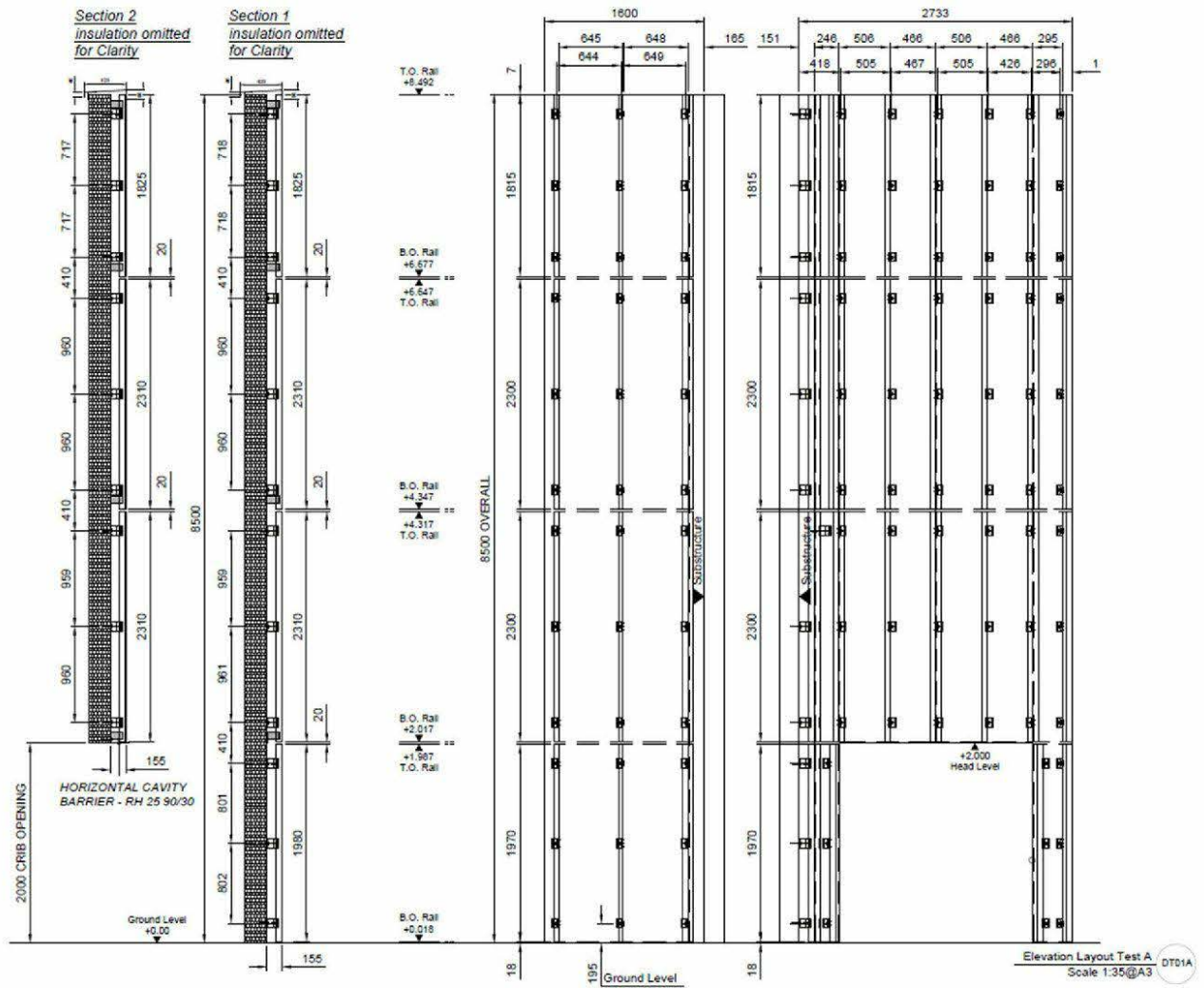


Figure 14. Front elevation, side elevation and vertical sections for the substructure system (supplied by the Test Sponsor).

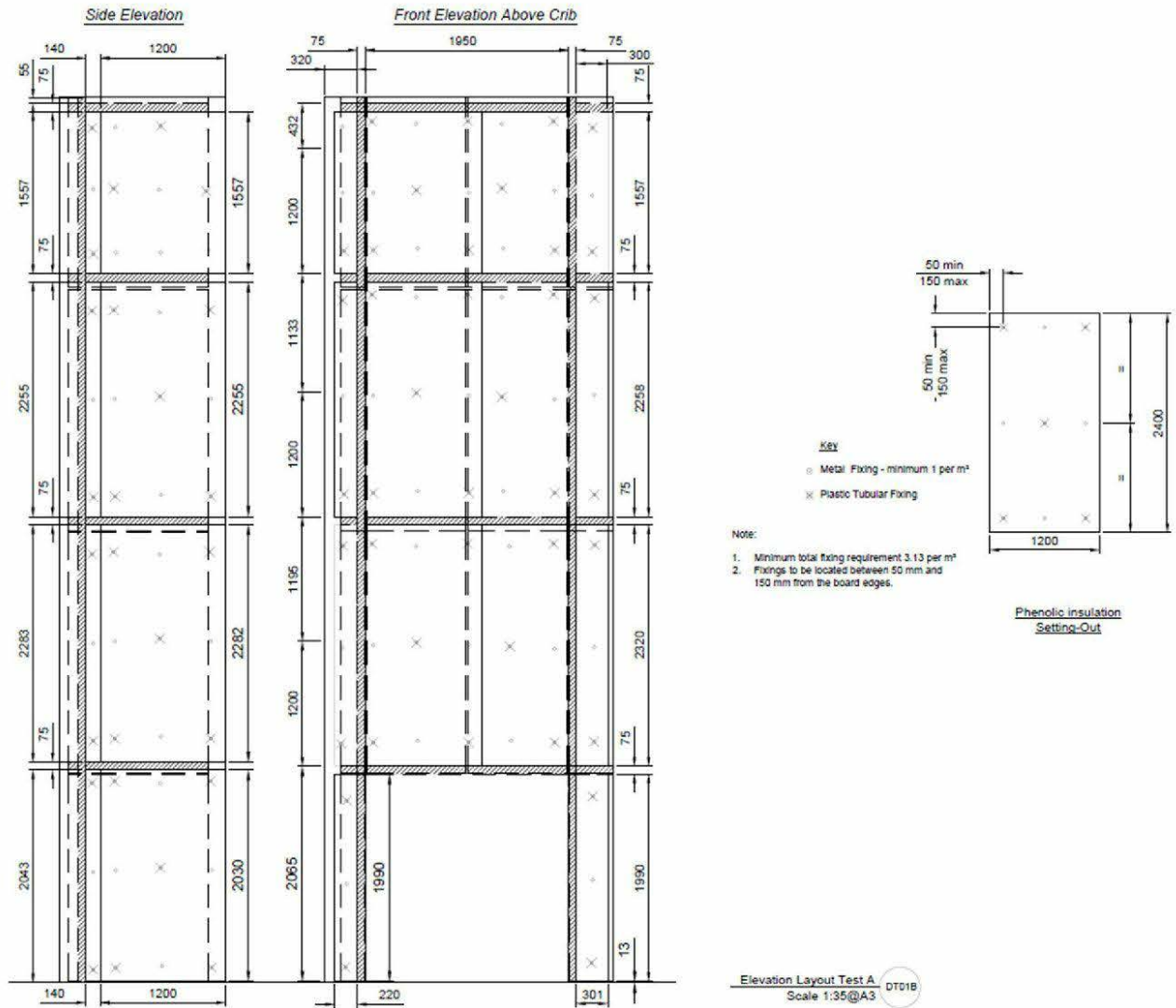


Figure 15. Front elevation, side elevation for the insulation panels installation (supplied by the Test Sponsor).

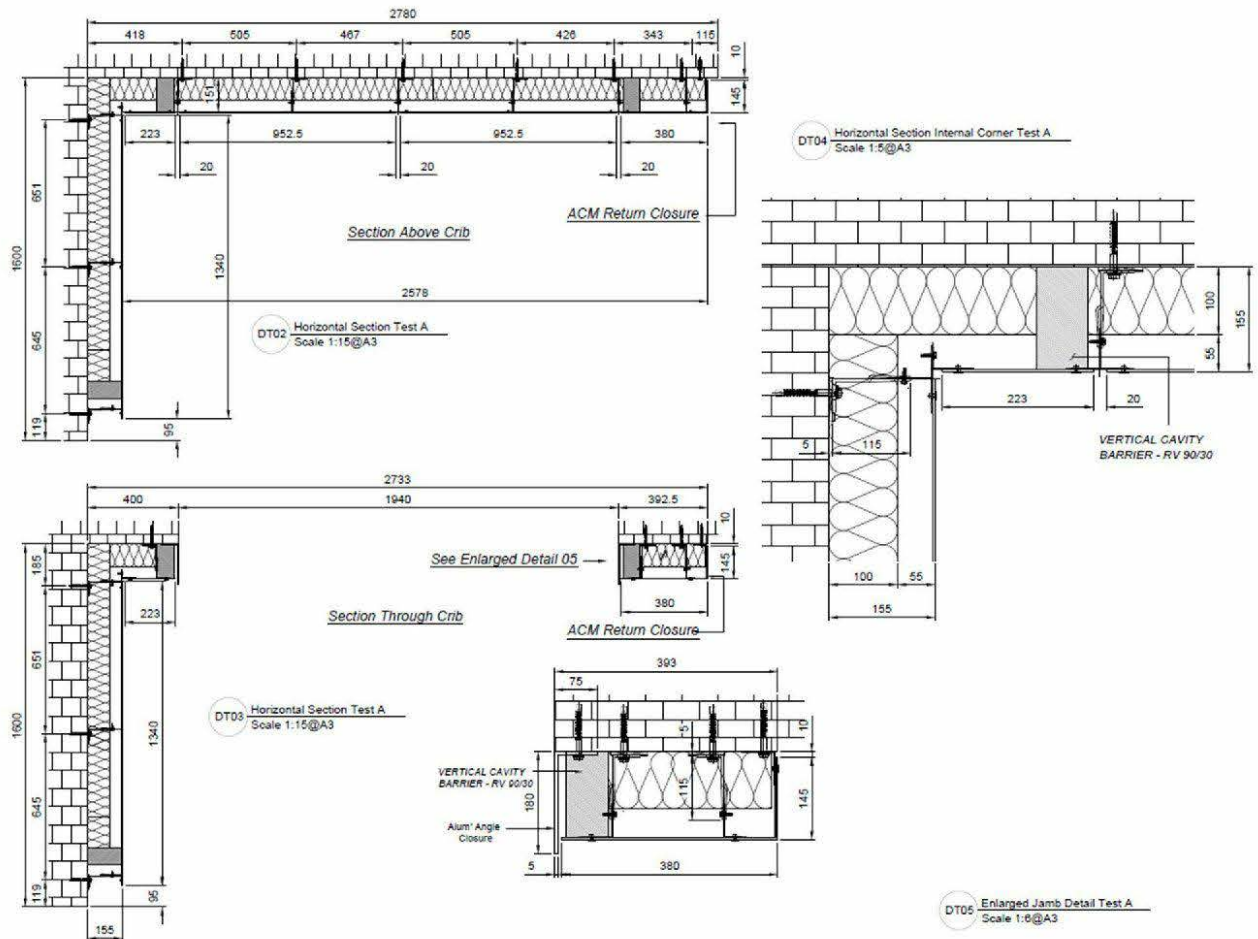


Figure 16. Horizontal section through and above the combustion chamber, and installation details for the system (supplied by the Test Sponsor).

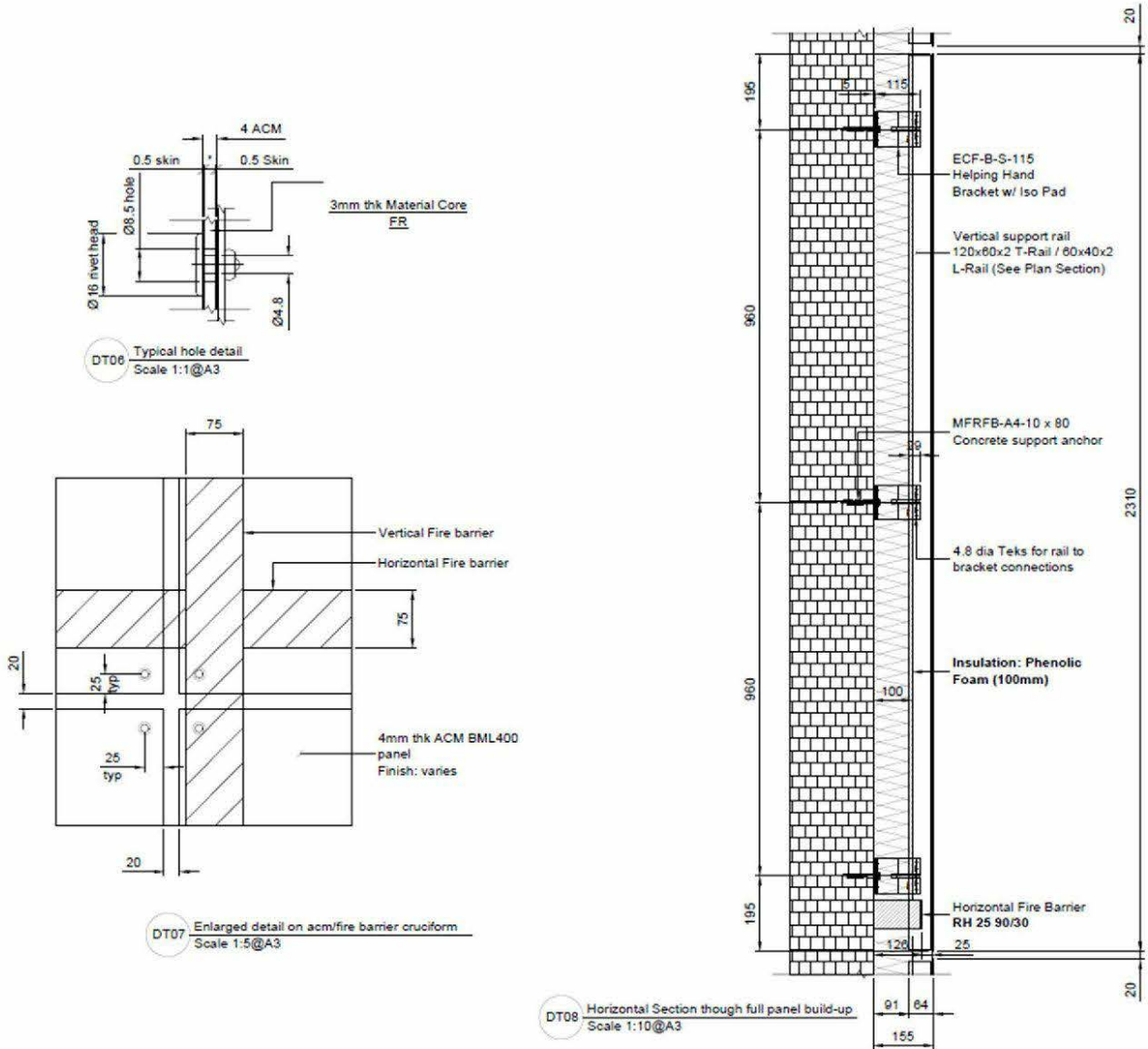


Figure 17. Vertical section through the cladding system, ACM panel detail and vertical and horizontal cavity barriers intersection (supplied by the Test Sponsor).



9.3 Temperature data

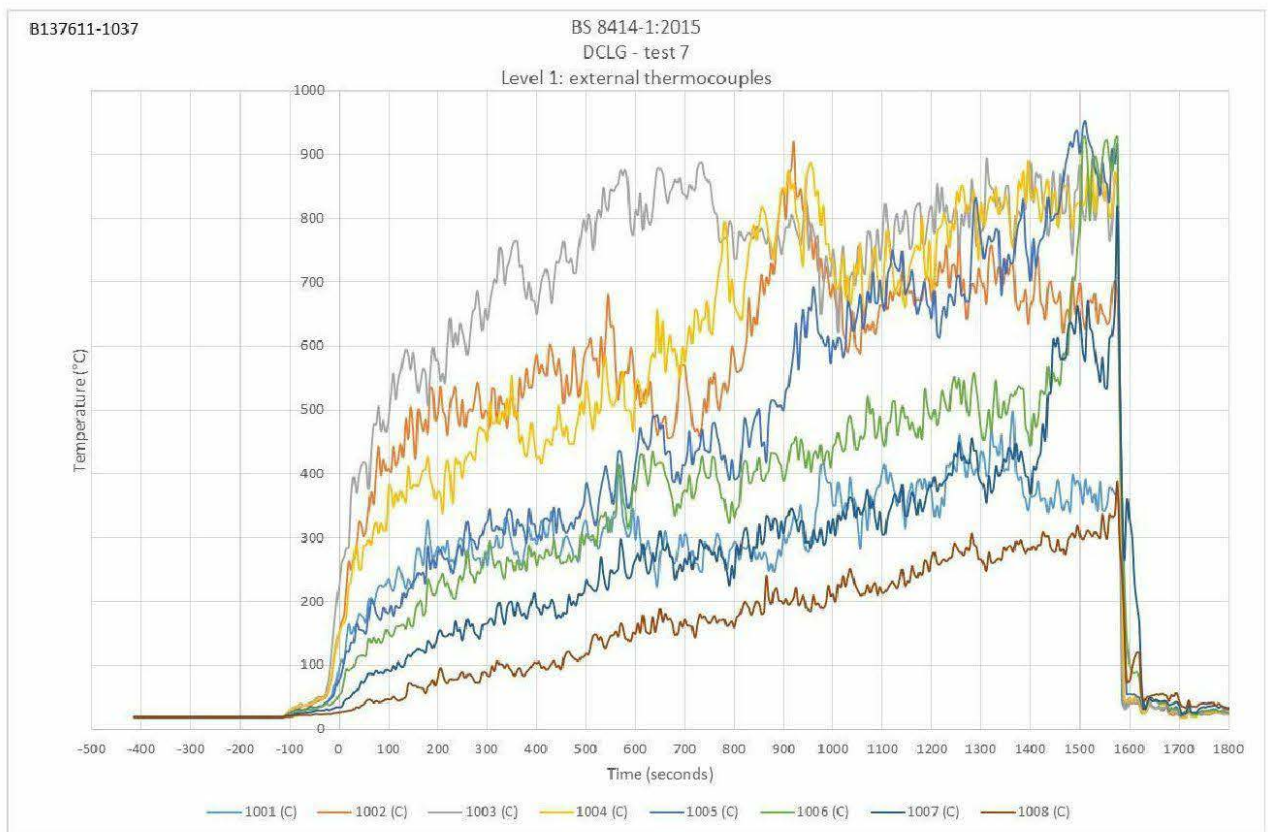


Figure 18. Level 1 external thermocouples.

$t_0=115s$ after ignition of the crib.

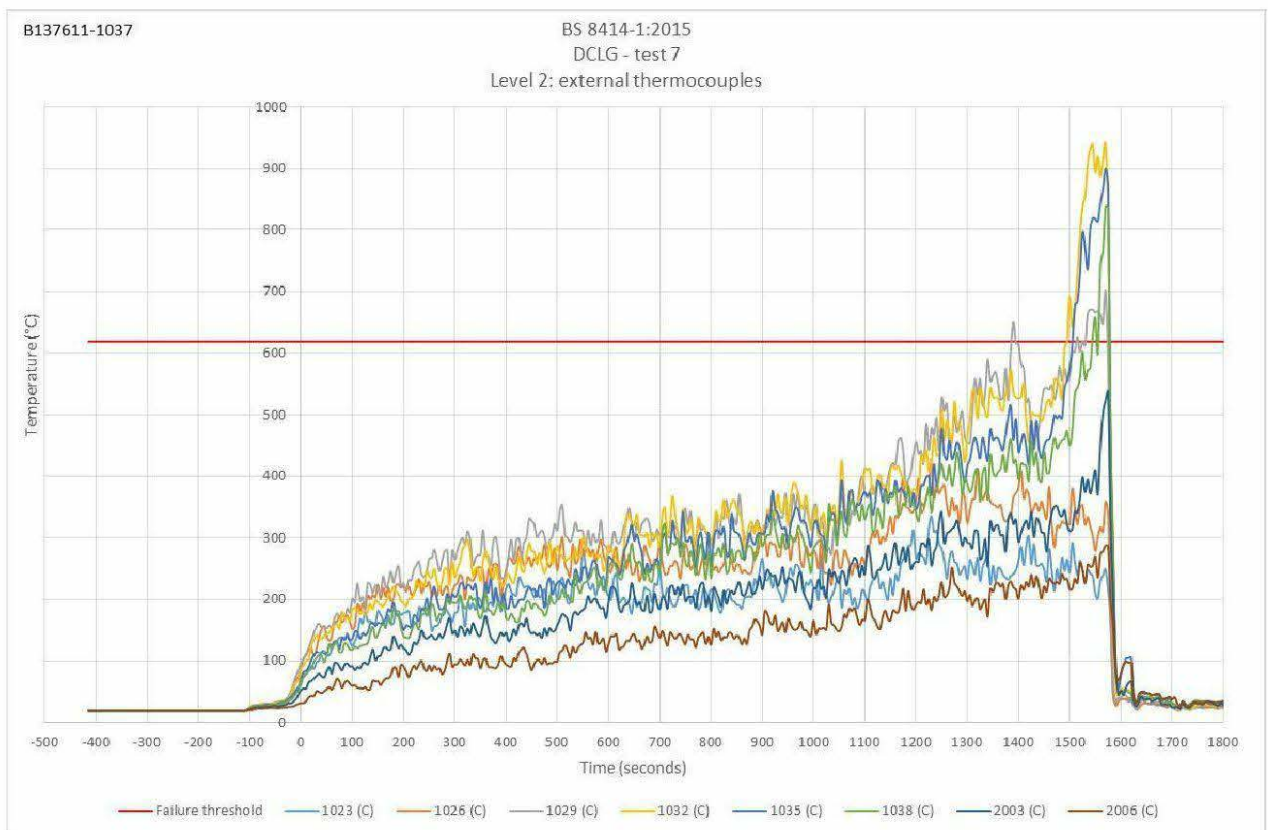


Figure 19. Level 2 external thermocouples.
 $t_s=115s$ after ignition of the crib.

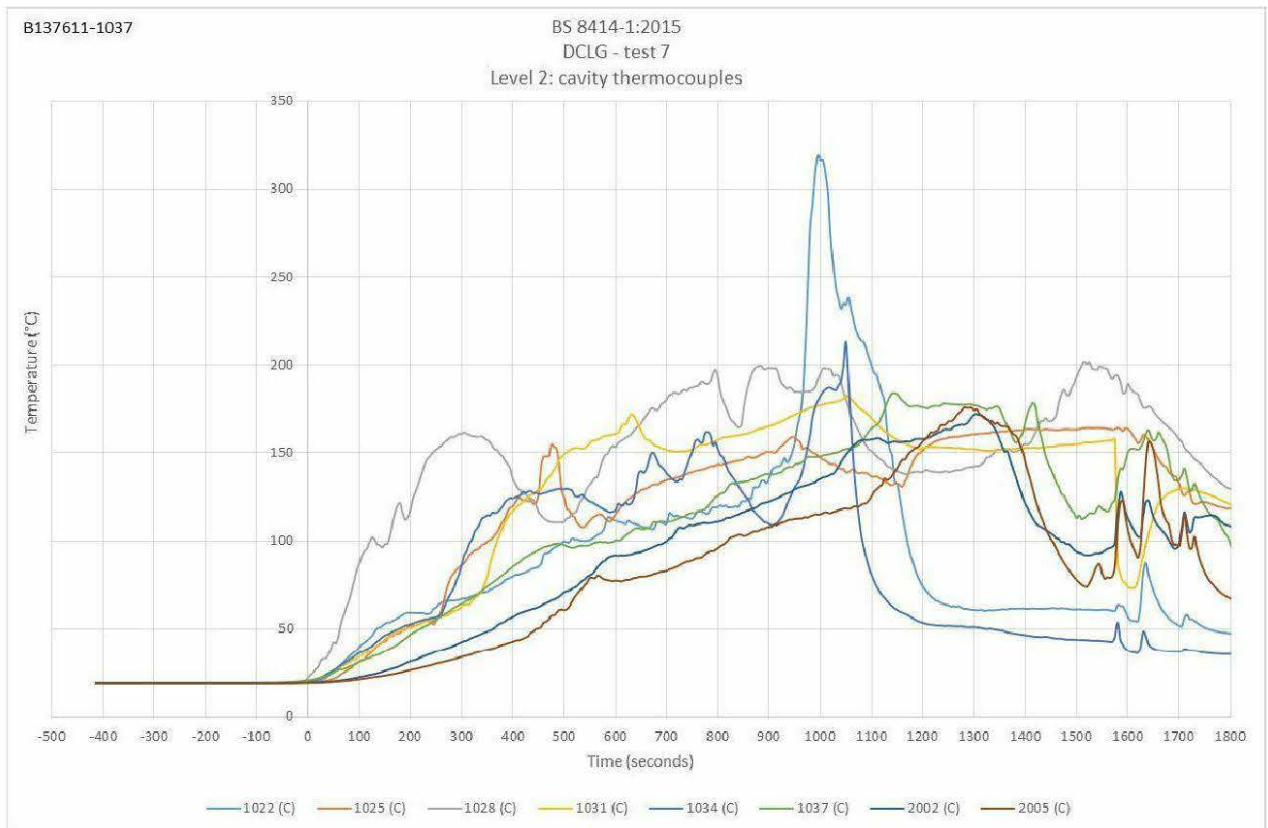


Figure 20. Level 2 cavity thermocouples.
t_s=115s after ignition of the crib.

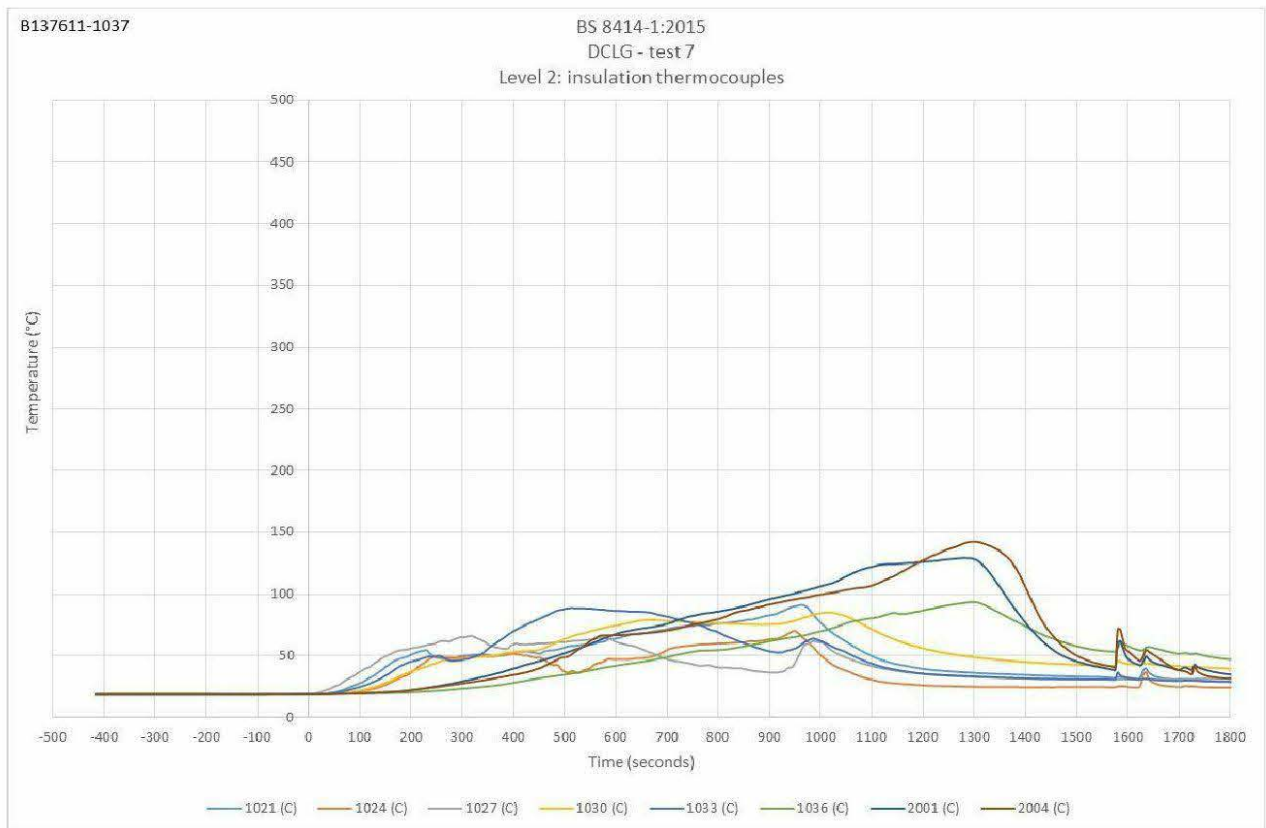


Figure 21. Level 2 insulation thermocouples.

$t_b=115s$ after ignition of the crib.



9.4 Post test photographs



Figure 22. Full height photograph of system post-test – general.

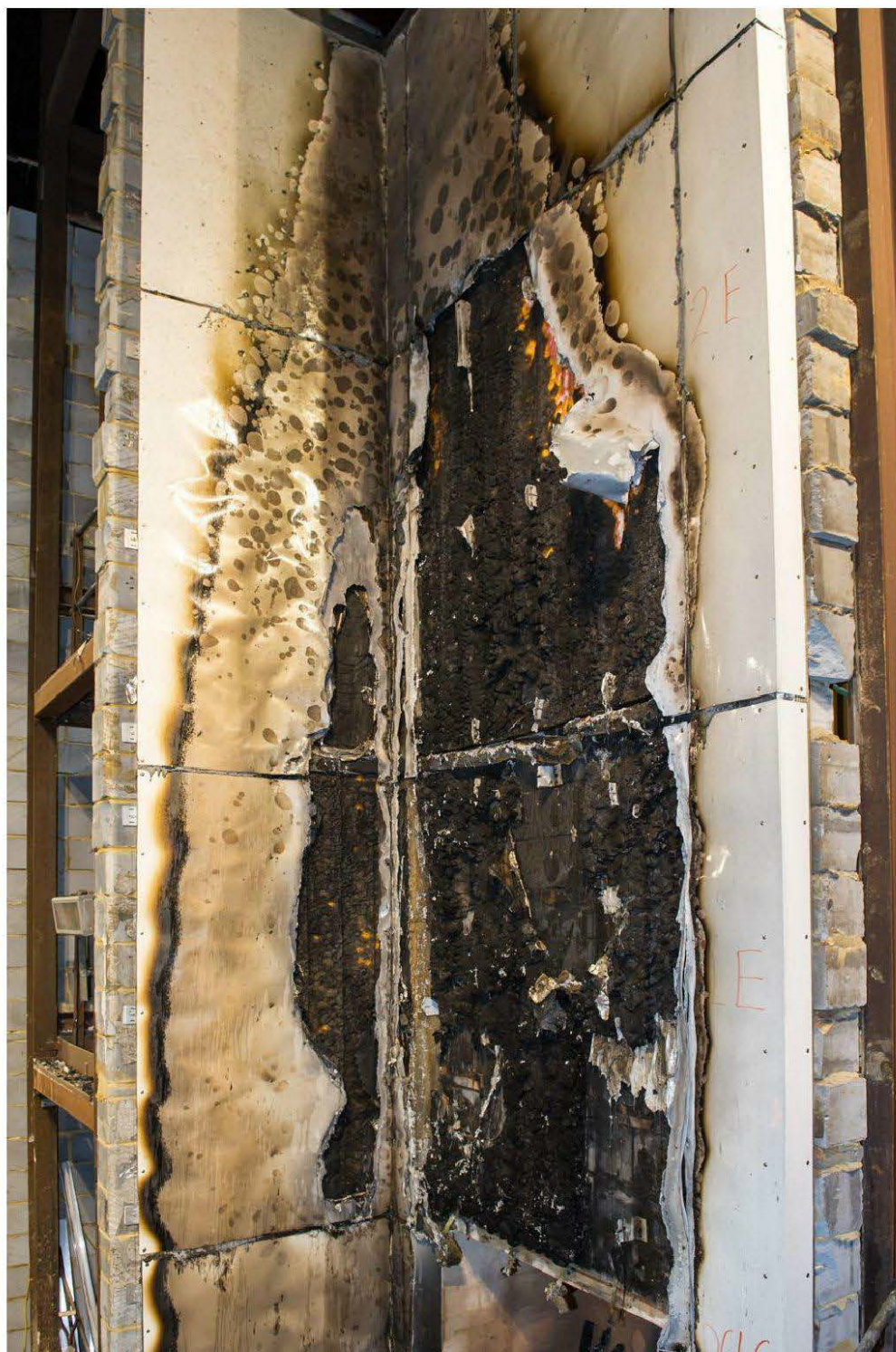


Figure 23. Photograph of system post-test – wing wall.

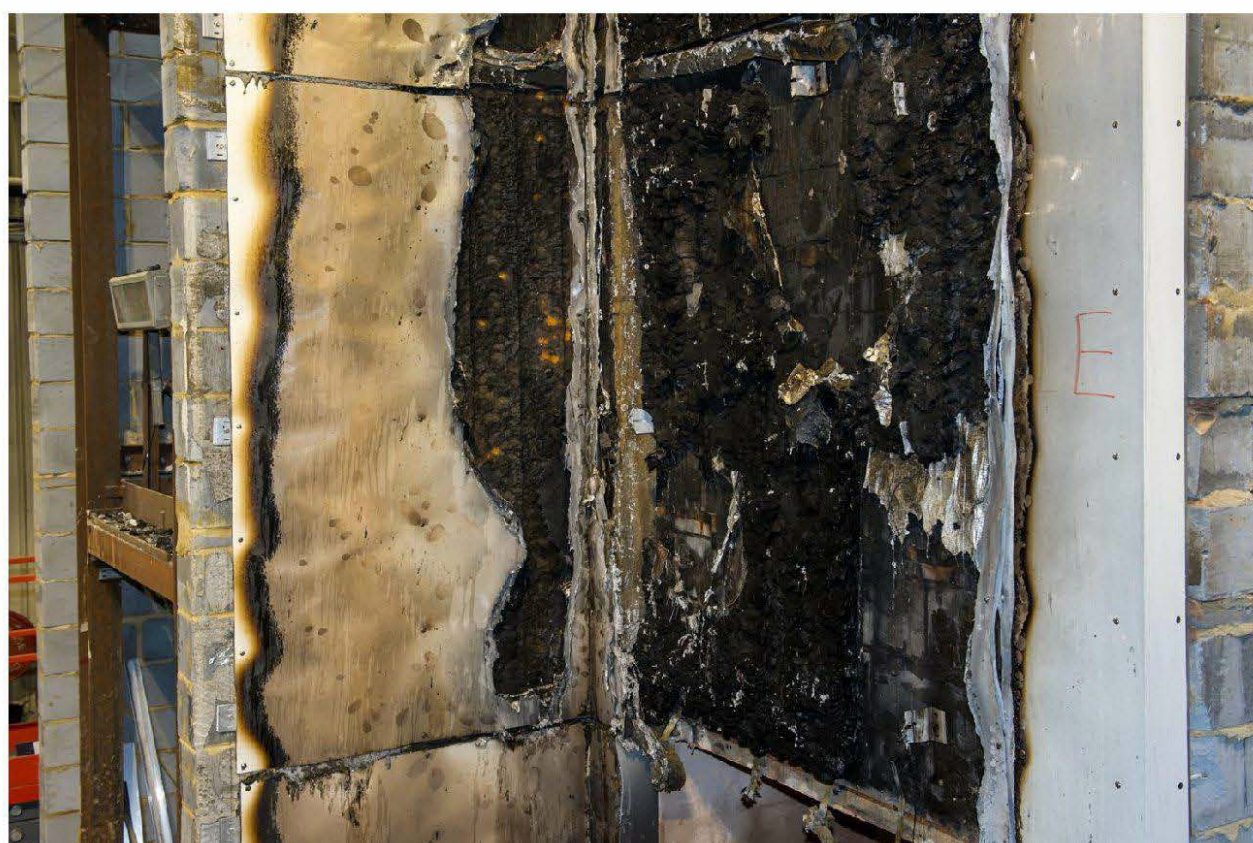


Figure 24. First row ACM panels (directly above combustion chamber).

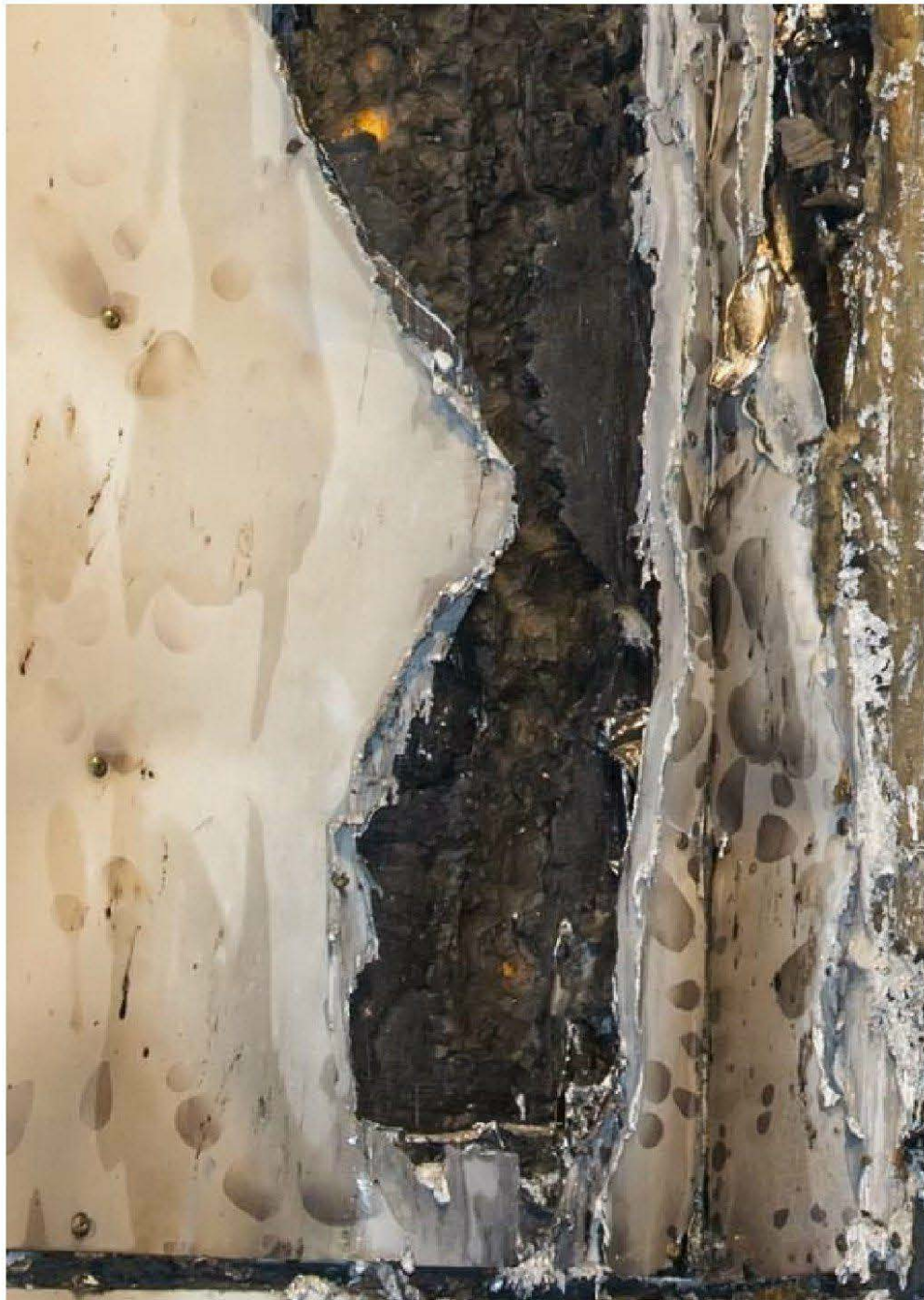


Figure 25. Close up view of partial panel consumption on the wing wall.



Figure 26. Second row ACM panels



Figure 27. Third row ACM panels (approximately 4600mm-6500mm above combustion chamber).

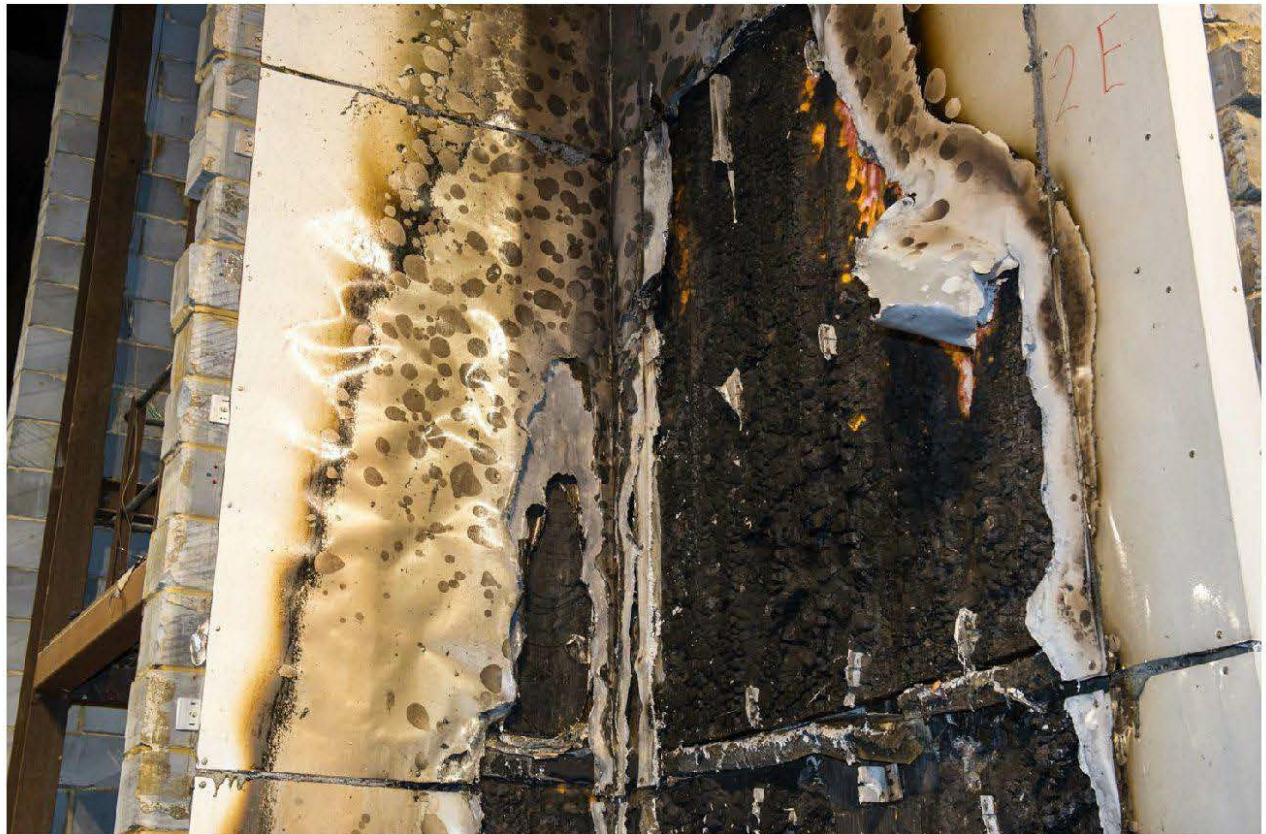


Figure 28. Distortion and damage to panel 2A– note delamination of the panel.

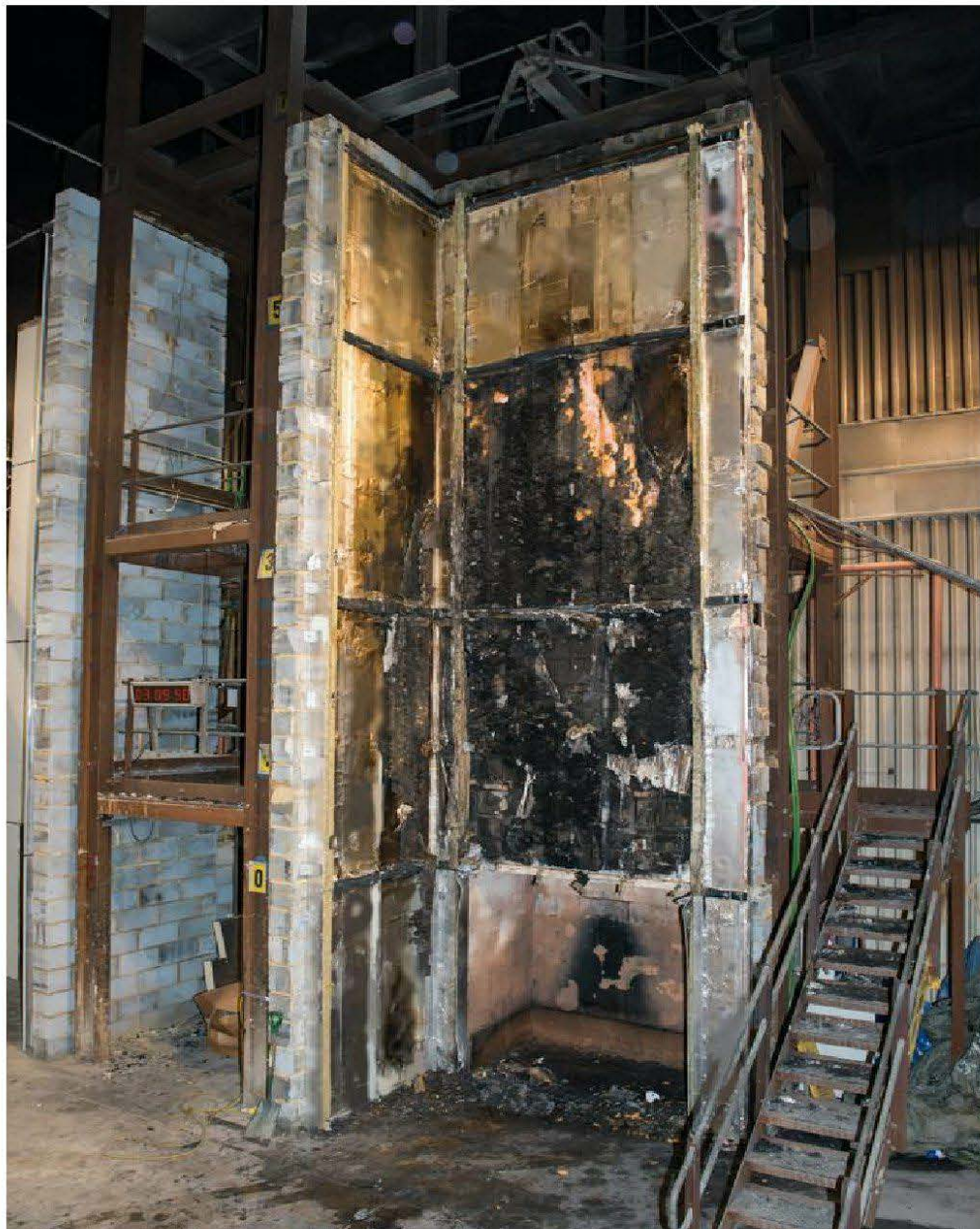


Figure 29. Full height photograph of system following removal of ACM panels.

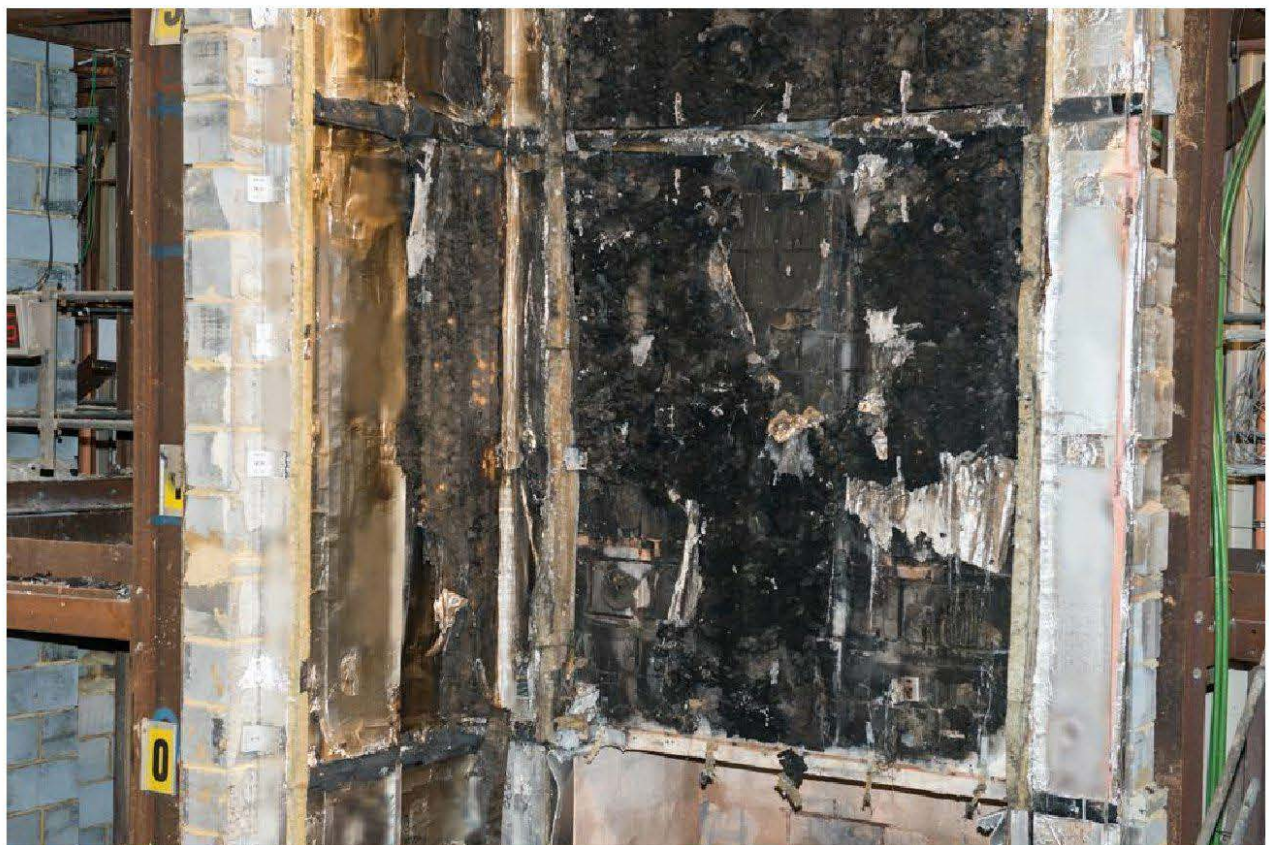


Figure 30. Damage to cladding system beneath ACM panels directly above combustion chamber.

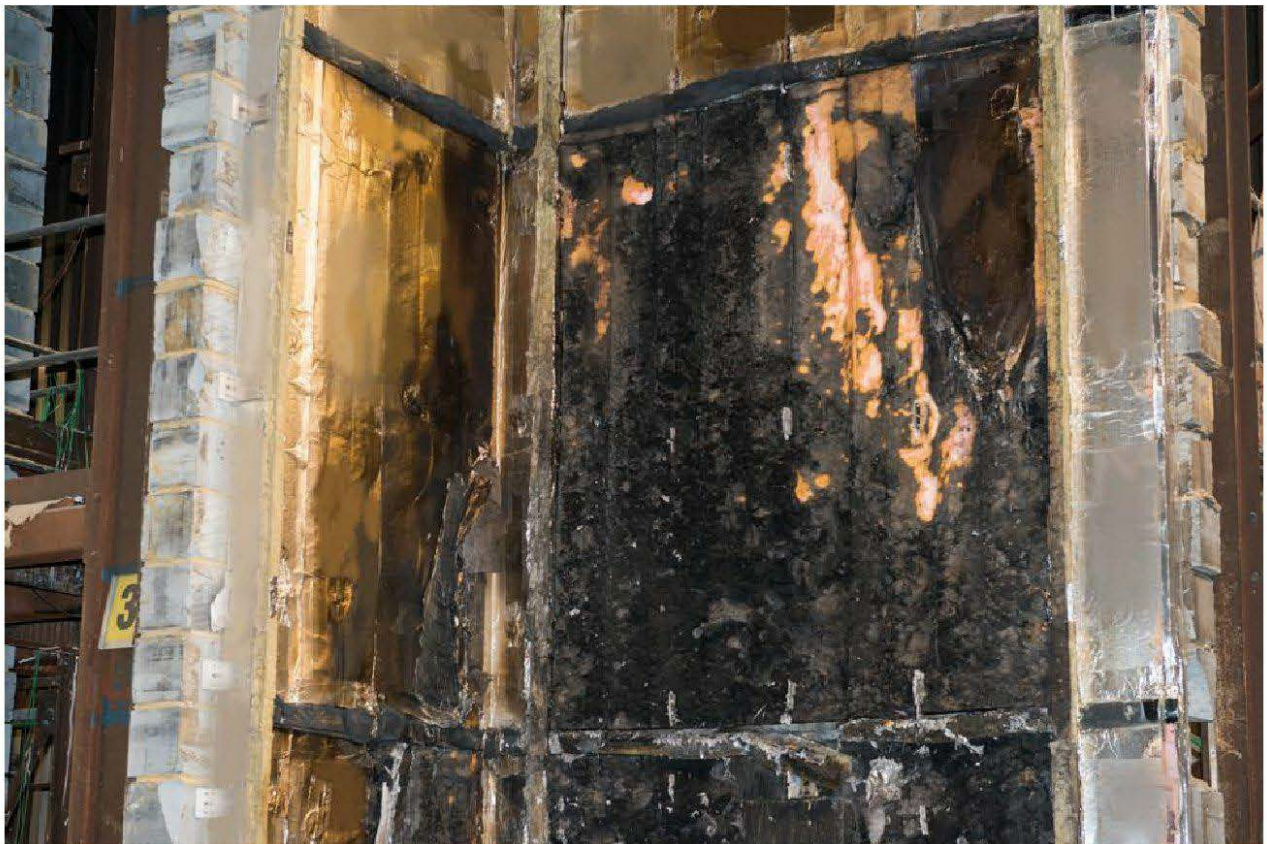


Figure 31. Damage to cladding system beneath ACM panels between the second and third horizontal cavity barrier .



Figure 32. Damage to cladding system beneath ACM panels between the third and fourth horizontal cavity barrier



Figure 33. Close up of second cavity barrier in line with the combustion chamber opening.

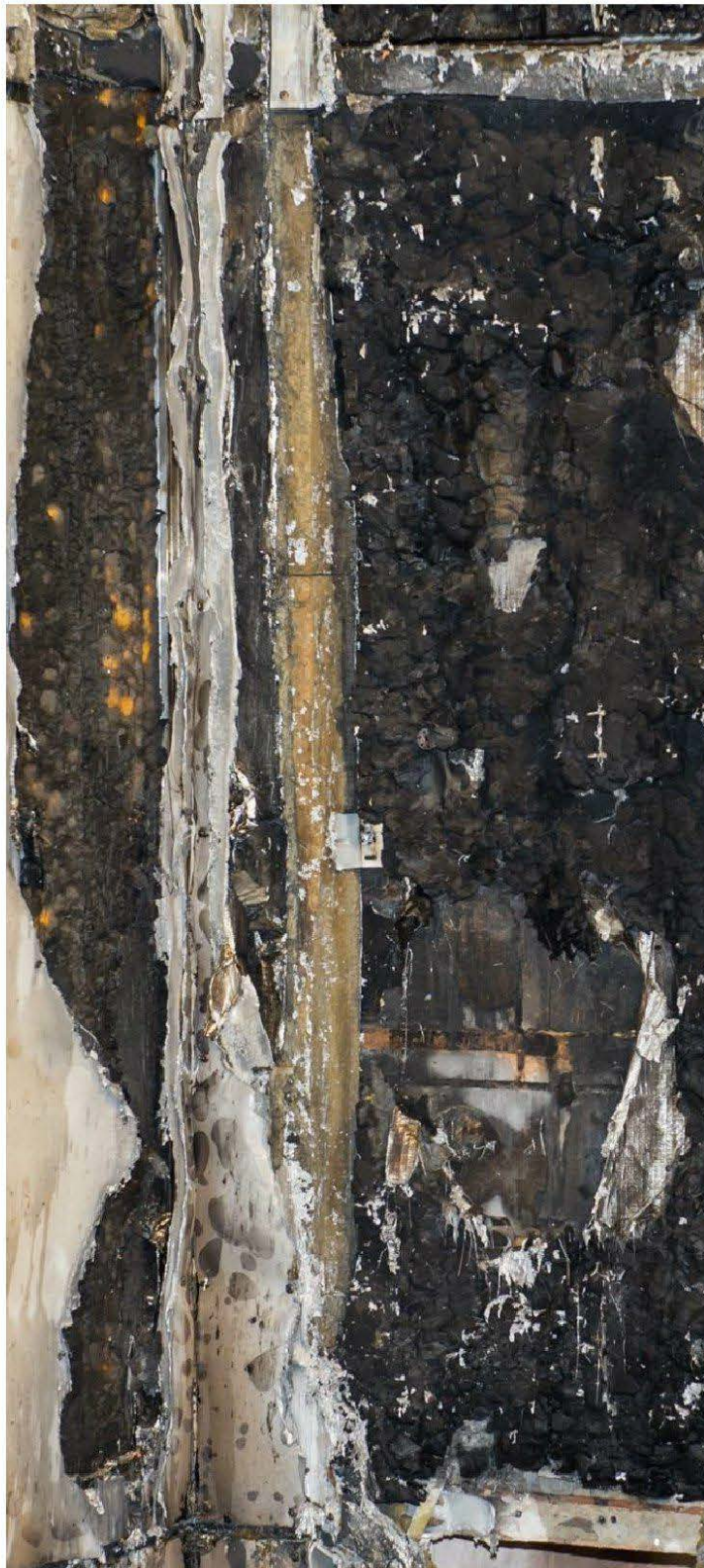


Figure 34. Close up of vertical cavity barrier adjacent to the wing wall directly above the combustion chamber –post test.



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)
Phenolic insulation	$105 \pm 5^\circ\text{C}$	8.5	32.0
Vertical cavity barrier	$105 \pm 5^\circ\text{C}$	0.4	82.9
Horizontal cavity barrier	$105 \pm 5^\circ\text{C}$	0.3	84.5



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 > 3 MJ/kg and ≤ 35 MJ/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 > 35 MJ/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	CT007-01 CT007-02 CT007-03

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

Ambient temperature (°C)	Relative humidity of the air (%)
23.2	49.8

Test results:

Test No.	Calorific value (MJ/kg)	Category	Standard deviation (%)
1	13.7430	CAT 2	0.04
2	13.7725	CAT 2	
3	13.6824	CAT 2	