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Rendered expanded polystyrene clad wall system AS 5113 external wall fire spread test

Fire test witness and review report

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Executive summary

This report is the *Fire test witness and review report* for the Rendered expanded polystyrene clad wall system AS 5113 external wall fire spread test sponsored by the Victorian Building Authority (VBA). The test was conducted on 4 June 2020.

Warringtonfire Australia (Warringtonfire) was the registered testing authority providing the test. Warringtonfire has provided formal test reports in accordance with the relevant standards and these should be referred to for exact details of the test specimen and test results.

The VBA have undertaken an AS 5113 Exterior wall fire spread test applying BS 8414-2:2015+A1:2017 to provide clear evidence on the fire spread performance of rendered EPS cladding installed as is typical for this type of cladding in Australia. VBA decided to undertake this testing following a literature review on Fire Safety of Exterior Insulation Finish Systems (EIFS) and Insulated Sandwich Panel (ISP) undertaken and reported on by CSIRO.

The tested system was selected to be reasonably representative of typical Australian rendered EPS construction. The rendered EPS wall system tested included:

- 5 mm thick polymer modified render
- 100 mm thick EPS Board
- sarking
- direct screw fixing to Timber framed wall cavity
- 10 mm thick standard grade plasterboard to non-fire exposed (internal) side, and
- a vertical and horizontal control joint as recommended by AS 5113 and BS 8414.

The rendered EPS wall system tested **failed** to meet the external wall (EW) classification acceptance criteria stated in AS 5113:2016 Amendment 1 and failed to meet BR 135 classification acceptance criteria.

This test provides clear test-based evidence to support the following conclusions:

- a typical Australian rendered EPS wall system has a propensity for rapid vertical fire spread and pool fires when exposed to large fire sources
- although rendered EPS and ACP-PE wall systems are constructed of significantly different products/materials, the propensity of a rendered EPS wall system for rapid vertical fire spread and pool fires when exposed to large fire sources is similar to that of ACP-PE wall systems when exposed to large fire sources, and
- it is reasonable that rendered EPS wall systems and ACP-PE wall systems should be given the same risk ranking in the Risk Assessment Tool used for the Statewide Cladding Audit when undertaking preliminary building risk assessments.

The following key limitations should be noted:

- the test applies a large crib fire source. Fire sources that could potentially result in similar fire exposure are post flashover apartment fires with flames emerging from windows or large external fire sources, and

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- the test does not simulate a medium sized balcony fire of the order of 100 kW-300 kW, or Building to Building (BB) fire spread. No AS 5113:2016 AS 5113:2016 Amendment 1 BB classification test was undertaken.

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1 Introduction

1.1 Background

The Victorian Building Authority (VBA) previously commissioned CSIRO to undertake a literature review and report on the fire safety of Exterior Insulation Finishing Systems (EIFS) and Insulated Sandwich Panels (ISP) applied to external walls of Class 2-9 buildings. The report focused primarily on expanded polystyrene (EPS) systems as the main type of system in Australia, but did also cover other types of core materials used. The research was commissioned by the VBA because it had identified a need for clear, independent and authoritative advice due to differing views in the industry.

The key findings of the literature review were:

- EIFS and ISP are not permitted by the National Construction Code (NCC) 2019 Deemed-to-Satisfy (DTS) provisions for use on external walls of buildings of Type A and B construction. DTS provisions generally require external walls for Type A and B construction to be non-combustible and this has been the case for more than 20 years of previous National Construction Code / Building Code of Australia versions.
- EIFS and ISP, particularly having EPS insulation, appear to have been installed on external walls of buildings of Type A and B construction in numerous cases without adequate certification or approval via a Performance Solution assessment process.
- There is currently insufficient test (or other) evidence publicly available regarding façade fire spread performance of EPS cored EIFS and ISP systems as typically installed in Australia. The limited evidence that is available indicates that they are very unlikely to perform suitably in terms of façade fire spread performance if presented with a large ignition source.

Based on these findings, CSIRO recommended that EIFS and ISP should not be applied to any new Type A and B construction buildings without suitable demonstration of NCC compliance via full-scale façade testing and performance-based assessment. CSIRO made suggestions on a broad range of further research opportunities to address identified knowledge gaps. One of the recommendations was for full-scale façade fire spread testing of EIFS.

1.2 Full-scale façade test

In June 2020, the VBA procured a full-scale façade test of EIFS, more specifically rendered EPS, as an external wall system.

The test result and this report are intended to establish the safety of rendered EPS on Victorian buildings of Type A and B construction beyond the typical pass/fail evaluation of fire spread testing in that it would assess aspects of the performance of rendered EPS as an external wall system, such as specific points of failure and common areas of failure in EIFS that could be applicable to 'as installed' EIFS on NCC Type A and B construction buildings.

The test result and this report are intended to assist the VBA to better understand fire behaviour on rendered EPS as an external façade on buildings of Type A and B construction, and verify if the product

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performs as expected (as identified in the literature review). Additionally, these reports can inform the VBA's consideration of rectification requirements for those buildings that it has been delegated the functions of municipal building surveyor due to the presence of combustible cladding on external walls, and the rectification requirements and prioritisation of rectification work for higher risk buildings with EPS.

To achieve the test purpose, a rendered EPS system that was considered to represent good installation/workmanship but is reasonably representative of typical Australian installation was tested.

The test specifications were determined by the VBA, taking into account advice provided by CSIRO.

The test specimen was constructed and tested by Warringtonfire at their test facility in Dandenong at the request of the VBA.

The test was conducted in accordance with *AS 5113:2016: Classification of external walls of buildings based on reaction-to-fire performance*, external wall (EW) classification test by Warringtonfire on 4 June 2020. The *BS 8414-2:2015+A1:2017* full-scale façade test method, as specified within *AS 5113:2016* was applied.

The rendered EPS wall system that was tested failed to meet the external wall (EW) classification acceptance criteria specified in AS 5113:2016. The test demonstrated that a rendered EPS wall system will result in a rapid vertical fire spread when exposed to a large fire source such as post flashover apartment fires with flames emerging from windows or large external fire sources.

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2 Scope and limitations

2.1 Scope of report

This report is the Fire test witness and review report for the Rendered expanded polystyrene clad wall system AS 5113 external wall fire spread test sponsored by the VBA.

This report presents an explanation of:

- key points relevant to this test from the CSIRO's literature review on the fire safety of EIFS and ISP as an external wall system
- what was tested (i.e., the test specimen)
- how the fire behaved during the test, and
- what the results of the test indicate.

The scope of CSIRO's work on this project included:

- providing advice prior to test regarding the wall system specimen to be tested
- reviewing and witnessing of the test specimen at final construction, the test being conducted and test specimen deconstruction post-test, and
- providing a "plain English" report summarising the above work and what the outcomes of the test mean.

2.2 Limitations

The reader's attention is drawn to the following limitations with respect to the fire engineering review undertaken in this report:

a. The report is limited to the scope identified in this report.

b. Warringtonfire was the registered testing authority providing the test. Warringtonfire has provided formal test reports in accordance with the relevant standards and these should be referred to for exact details of the test specimen and test results.

c. This report by CSIRO does not constitute a test report and should not be taken as representing the test laboratory opinions or advice. This report contains review, assessment and opinions provided by a CSIRO Fire Safety Engineer and does not represent a CSIRO NATA accredited test laboratory report.

d. This report contains assessment or opinion of likely fire behaviour of variations to a tested system and of likely fire behaviour if the subject test had not been supressed at the time reported. This assessment or opinion is based on information available but has not been verified by further testing. It is possible systems may perform differently to the assessments and opinions provided in this report if tested.

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e. This report is based on information provided by others, including test reports and specimen details provided by VBA and Warringtonfire. CSIRO has not verified the accuracy and/or completeness of this information (beyond the inspections and witnessing detailed in this report) and accepts no responsibility or liability for any errors or omissions which may be incorporated into this report as a result.

f. The conclusions, data and methodology documented in this report are based on the documentation in Section 3 and specifically apply to the subject test specimen, being rendered EPS on light weight construction. This report cannot be used to directly indicate or extrapolate the fire performance of wall systems which significantly differ from the tested system .

g. CSIRO reserves the right to revise this report at any time in response to any new information or knowledge.

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3 Reference Information

3.1 Reference codes and guidelines

CSIRO has considered the following reference codes and guidelines in the preparation of this report:

1. Building Code of Australia (NCC) 2019, Australian Building Codes Board, 2019.
2. Building Code of Australia (NCC) 2019 Amendment 1, Australian Building Codes Board, 2020
3. AS 5113:2016 Amendment 1 – Fire propagation testing and classification of external walls of buildings.
4. BS 8414-2:2015+A1:2017 - Fire performance of external cladding systems Part 2: Test method for non-loadbearing external cladding systems fixed to and supported by a structural steel frame.
5. BR 135 - Fire performance of external thermal insulation for walls of multistorey buildings: (BR 135) Third edition, by S Colwell and T Baker (15-Mar-2013).
6. Engineers Australia, Society of Fire Safety, Code of Practice for Fire Safety Design, Certification and Peer Review, 2006[1].
7. Society of Fire Protection Engineers, Guidelines for peer review in the fire protection design process. October, 2009[2].

3.2 Documentation and information considered

This report is based on the following design documentation and information:

1. Literature Review on Fire Safety of Exterior Insulation Finish Systems and Insulated Sandwich Panel. Revisions E DRAFT. Dated 16 October 2019. By CSIRO. CSIRO Document Number EP192002. Commercial-in-confidence, Client: VBA.
2. Meetings attended by Nathan White (CSIRO) with VBA and Warringtonfire to discuss and review details of specimen construction.
3. Classification Report – Classification of a non-loadbearing external wall system in accordance with AS 5113:2016 Amendments 1, by Warringtonfire, Job Number: RTF190234, Revision: ASCR1.0, Date: 30 July 2020.
4. Reaction-to-fire report – A reaction-to-fire test of a non-loadbearing external wall system in accordance with BS 8414-2:2015+A1:2017, by Warringtonfire, Job number RTF190234, Revision: R1.0, Date:30 July 2020.
5. Photos and video of test provided by VBA.
6. Inspection of the test specimen upon completion of construction by Nathan White on 27 May 2020.
7. Witnessing of the test by Nathan White (and numerous other attendees) on 4 June 2020.
8. Inspection of the post-test specimen deconstruction by Nathan White on 5 June 2020.

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4 Overview of AS 5113:2016: Classification of external walls of buildings based on reaction-to-fire performance

The full-scale façade fire test was conducted in accordance with *AS 5113:2016: Classification of external walls of buildings based on reaction-to-fire performance*, external wall (EW) classification testing. The *BS 8414-2:2015+A1:2017* full-scale façade test method, as specified within AS 5113:2016 was applied. This section provides an overview of the test standard including the test method applied and classification criteria and the risks that it is intending to mitigate.

4.1 Scope of standard

AS 5113 provides a test methodology for classifying fire performance of external walls in terms of two distinctly different parameters:

- External Wall (EW) – Fire spread performance in response to an ignition fire directly impinging on the wall, and
- Building-to-building (BB) – ignition and fire spread performance in response to radiant heat exposure from an adjacent building fire.

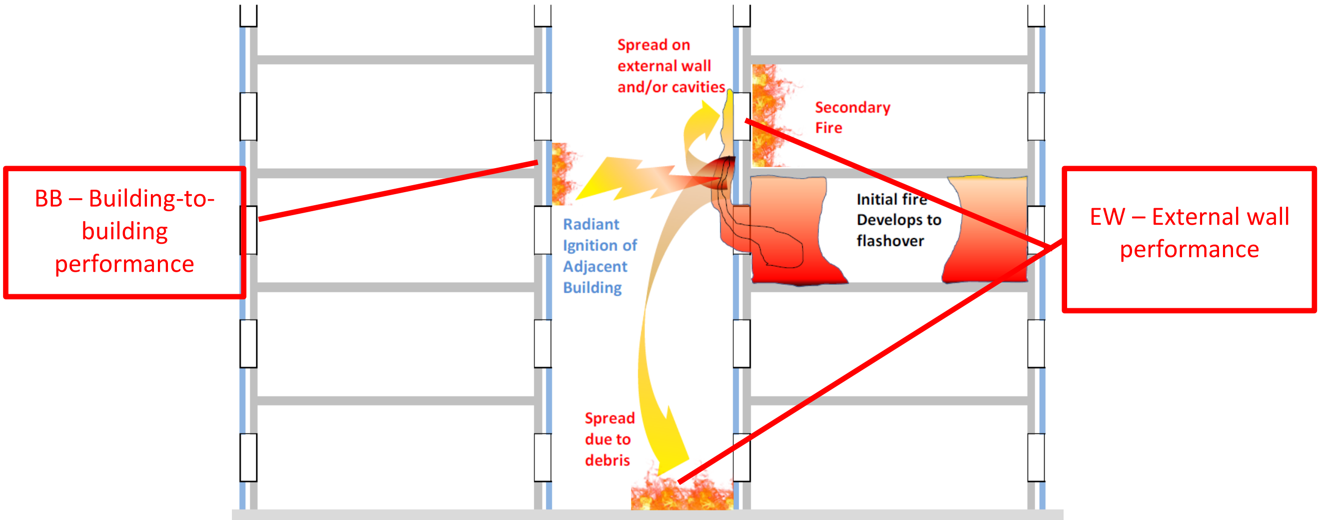

Figure 1. The difference between AS 5113 EW and BB fire performance

The VBA's full-scale façade test was an external wall reaction-to-fire test (EW). It did not conduct a building-to-building (BB) test.

4.2 Test method

External wall (EW) fire tests are required to be performed according to ISO 13785-2 or BS 8414 (with some additional measurement requirements). In practice, all Australian test labs are currently only

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testing according to BS 8414 as this is more commonly adopted internationally. The VBA's test was performed according to BS 8414-2: 2015+A1:2017.

BS8414-2 is a full-scale fire test for non-load bearing external cladding systems fixed to and supported by a structural steel frame. In the case of the VBA test specimen, this represented a light weight rendered EPS infill wall construction.

The test simulates the scenario of flames emerging from a compartment fire via a window at the base of the wall. The test façade is installed as a re-entrant corner "L" arrangement. The test wall extends at least 6 m above the combustion chamber (simulated window) soffit. The main wall is at least 2.6 m wide and the wing wall is at least 1.5 m wide. The combustion chamber at the base of the main wall and is 2 m wide x 2 m high. The façade is installed around the window down to the bottom of the window.

Thermocouples to measure temperatures are installed at the following locations:

- non-fire side (rear of interior facing wall) 900 mm above combustion chamber opening
- level 1, exposed face 2.5 m above combustion chamber opening, and
- level 2, exposed face and internal wall system cavities and insulation layers 5 m above combustion chamber opening.

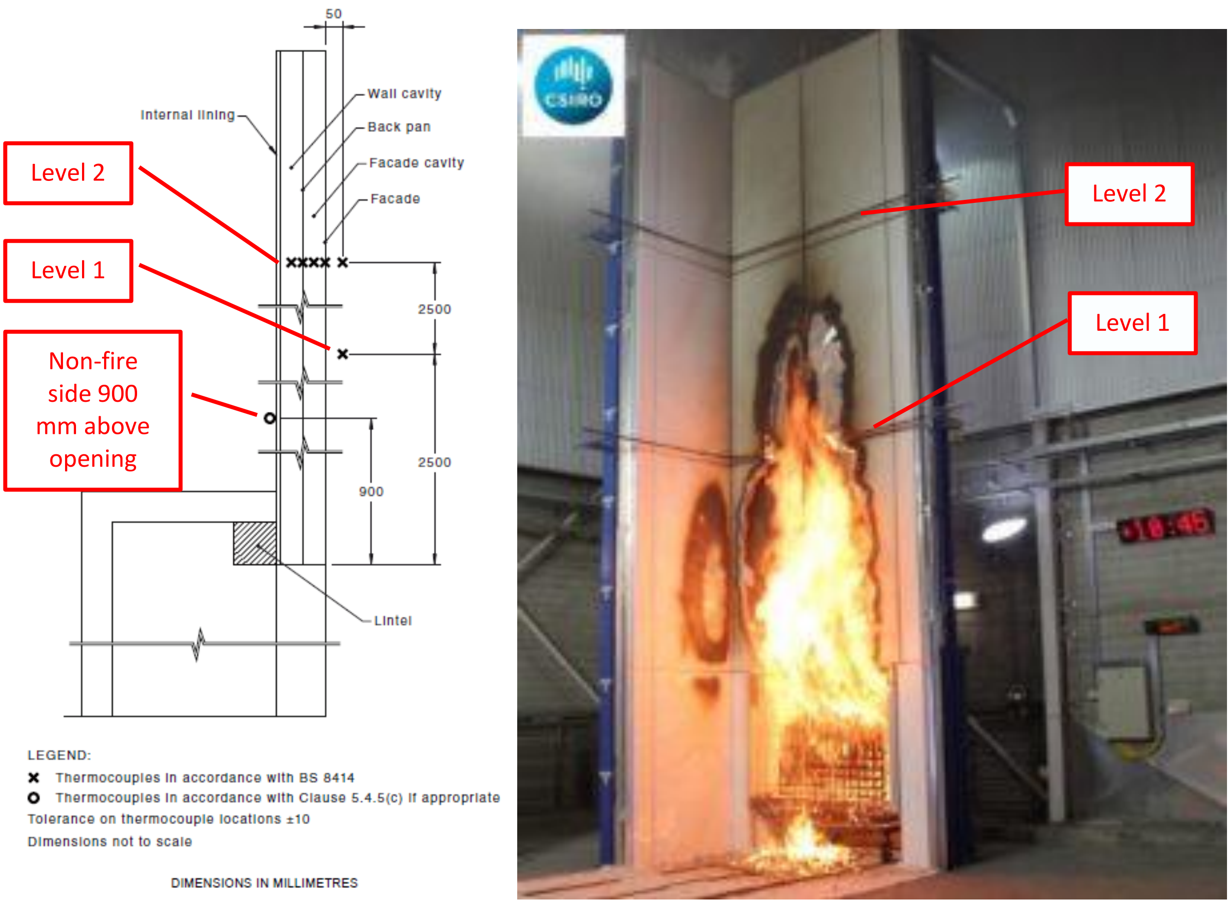

Figure 2. AS5113 thermocouple locations (left), Example of CSIRO AS5113/BS8414 test rig (right)

The standard fire source is a large timber crib which has:

- dimensions 1.5 m wide x 1 m deep x 1 m high
- mean mass of ~ 400 kg, and

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- peak HRR of ~ 3±0.5 MW.

The crib is removed/extinguished 30 minutes after ignition, or earlier where flame spread beyond the extents of the test specimen occurs.

Start time (t_s) is defined in BS 8414 to account for time taken for crib fire to grow from ignition to a sufficient size to impact upon the face of the test wall system as early crib development time can be variable. Start time (t_s) is defined to be the time any external thermocouple at level 1 height is ≥ 200 °C above ambient temperature for at least 30 seconds.

4.3 EW classification criteria

The EW classification criteria relating to BS8414 tests is specified in Clause 5.4 of AS 5113:2016. This criteria and the risk mitigation intent is summarised below.

Table 1 AS 5113:2016 EW classification criteria applied to BS 8414 test method:[1]

Classification Criteria		**Related classification measure**	**Risk mitigation intent of criteria**
5.4.5(a) T_{w5m}	Temperatures 5 m above the opening measured 50 mm from the exposed specimen face shall not exceed 600°C for a continuous period greater than 30 seconds.	≤600°C	Prevention of fire spread to two floor levels above fire
5.4.5(b) $T_{layer5m\text{ - Cavity}}$	Temperatures at the mid-depth of each combustible layer or any cavity 5 m above the opening shall not exceed 250°C for a continuous period of greater than 30 seconds.	≤250°C	Prevention of incipient fire spread to two floor levels above fire
5.4.5(b) $T_{layer5m\text{ – insulation}}$			
5.4.5(c) $T_{unexposedside0.9m}$	Where the system is attached to a wall that is not required to have an FRL of –/30/30 or 30/30/30 or more, the temperature on the unexposed face of the specimen 900 mm above the opening shall not exceed a 180 K rise.	≤180 K rise	Prevent fire spread to floor above if wall not fire resistant
5.4.5(d) flaming	Where the system is attached to a wall not required to have a fire resistance of –/30/30, 30/30/30 or more, flaming or the occurrence of openings in the unexposed face of the specimen above the opening shall not occur.	No flaming	
5.4.5(d) openings		No openings	
5.4.5(e) spread	Flame spread beyond the confines of the specimen in any direction, as determined during the post-test examination, shall not occur. The examination shall include flame damage such as melting, charring but not smoke discolouration or staining of the surface, any intermediate layers and the cavity.	No Spread beyond specimen	Prevent fire spread to two floor levels above fire and lateral spread
5.4.5(f) debris flaming	Continuous flaming on the ground for more than 20 s from any debris or molten material from the specimen shall not occur.	≤20 s	Prevent fire spread to floors below
5.4.5(g) debris mass	The total mass of debris falling in front of the specimen shall not exceed 2kg. The mass shall be measured after the end of the test result.	≤2 k	Limit debris impact with fire fighters, occupants and passers-by

All of the above criteria must be met for a wall system to achieve the AS 5113:2016 EW classification.

[1] AS 5113:2016 Clause 5.4.5 and Table B4.1(B) of Attachment B.

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5 Test specimen

This section presents the VBA's intent for the test specimen to represent typical Australian rendered EPS wall construction, the information that was considered to determine what typical Australian rendered EPS wall construction is and the description of the specimen tested.

5.1 Intent for test specimen

The VBA's intention was to test an external wall specimen that reasonably represented typical Australian rendered EPS external wall construction with a reasonably good level of construction and no defects (cracks, openings etc).

The test specimen was intended to be a generic representation of a typical Australian rendered EPS external wall system without representing any single specific manufacturer's product or system.

5.2 Consideration of test specimen construction detail

The VBA decided upon the specimen construction details, taking advice from CSIRO. Warringtonfire also provided advice regarding construction of the test specimen to fit the BS8414 test rig. Key considerations for the construction details of the test specimen were based primarily upon:

- literature review findings for typical Australian rendered EPS external wall construction
- review of installation manuals for a range of different commercially available rendered EPS systems within Australia, and
- reflection upon examples of rendered EPS construction found installed to buildings of Type A and B construction within the scope of the Statewide Cladding Audit.

The CSIRO literature review conclusions regarding rendered EPS NCC non-compliance as a combustible external wall for buildings of Type A and B construction, and likelihood of poor fire spread performance, are summarised in the background section of this report.

The following further CSIRO literature review findings informed the VBA's decisions regarding the test specimen construction detail:

- While there have been a range of rendered EPS products and systems sold and used in Australia, typical Australian rendered EPS external wall construction applies externally rendered EPS board as a light-weight cladding system directly to a light-weight wall frame. The supporting frame is typically timber stud frame construction and less commonly light weight steel frame construction. A fire-resistant board is not typically installed between the EPS and the wall frame/cavity unless this is specified to achieve a required FRL.
- Rendered EPS cladding construction applied in Australia typically differs from European EIFS systems which have been tested in overseas full-scale façade tests as summarised in Table 2.

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Table 2: Key differences between typical Australian EIFS construction and European full-scale façade fire tested EIFS

EIFS construction detail	Australian Typical Construction	European full-scale façade fire tested construction
Predominant External insulation polymer type	EPS	EPS
EPS thickness	50-100 mm	100-300 mm thick
Cavity/substrate behind EPS	Combustible surfaces directly exposed to wall cavity. Direct fix – EPS directly fixed to Light weight wall frame with sarking and wall cavity with timber or steel framings directly behind Cavity – same as direct fix but EPS, timber or steel battens forming ~ 25 mm air gap/drainage cavity directly behind EPS. Fire-resistant board not typically installed between EPS a wall frame/cavity unless specified to achieve required FRL.	Solid substrate (typically masonry/concrete) or thick substrate board between insulation and stud walls.
Render thickness	~ 5mm typically specified but in practice may typically be installed as less than 5 mm thick	~ 5 mm (installed for tested systems)
Cavity barriers/ fire stop barriers installed within EPS	None	~200 mm thick mineral wool fire barriers at regular horizontal intervals (e.g. 900 mm, first floor level, then every second-floor level) and sometimes around openings

- Full-scale external wall fire spread tests such as AS 5113 and BS 8414 represent large fire exposure scenarios and can provide suitable evidence as input to a performance-based solution. However, this is reliant upon ensuring the end use installation is consistent with that of the tested system.
- The differences in construction between typical Australian EIFS and European tested EIFS systems are expected to significantly influence façade fire spread performance. It is noted that European EIFS fire tests and fire incidents without suitable cavity fire barriers installed have resulted in unacceptable vertical fire spread and this indicates that typical Australian EIFS which has no cavity fire barriers (for Type A and B construction) would support similar unacceptable vertical fire spread. Beyond this, European EIFS full-scale façade fire tests cannot be directly applied to typical Australian EIFS fire spread behaviour.
- The render layer can provide some protection against ignition and fire spread from small/medium sized ignition fires. However, this is impacted by the render thickness, and any damage, cracking jointing and penetration details for the render. For large radiant heat or flame immersion fire exposures the render is likely to fail and expose the EPS due to a mixture of render cracking and due to the EPS melting/receding away resulting in unsupported render.
- The literature review did not identify a publicly available test report or test summary for an AS 5113 (or other standard) full-scale façade fire spread test conducted on a typical Australian EIFS construction.
- Based on European full-scale façade fire tests and several fire incidents involving rapid external fire spread on rendered EPS, it was expected that a typical Australian rendered EPS wall system would not meet the AS 5113 EW acceptance criteria. However, a test on such a system would provide a tangible verification of this.

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There were numerous construction detail options that needed to be decided for the test specimen. It is not possible to represent all construction detail variables in a single test. See Appendix B for a detailed summary of all construction detail options considered and the rationale for the options selected and included in the test specimen.

5.3 Description of test specimen

The test specimen is summarised as:

- the wall system represented a non-load bearing, light-weight construction rendered EPS wall system
- the wall system was installed to a load bearing steel framed test support rig in accordance with BS 8414-2
- the wall system had dimensions of ~10 m tall, 207 mm thick. The main wall was ~2.8 m wide and the wing wall was ~ 1.5 m wide
- the wall system had the following key components (from external side to internal side):
    - ~ 5 mm total thickness of polymer modified render, including finishing/primer coat, manually applied render and ~ 1 mm factory applied render base coat (pre-coated on external face of EPS boards
    - 100 mm thick EPS with density of 20 kg/m^3 and pre-coated with 1 mm thick render base coat including embedded fibreglass mesh over entire external face
    - screw fixings with plastic washers
    - sarking
    - 90 mm pine timber framing with max 600 mm stud spacings
    - no wall cavity insulation
    - 10 mm thick non-FR grade plasterboard
    - 10 mm vertical expansion joint extending along centre line of main wall above combustion chamber, sealed with polymer backing rod and silicon sealant
    - 10 mm horizontal expansion/drainage joint located ~2.4 m above combustion chamber sealed with steel flashing to lower EPS panels and PVC starter channel to upper EPS panels
    - vertical edges at outer limits of wall specimen capped with 1 x layer 13 mm FR plasterboard and rendered over
    - top edge of wall specimen capped with steel capping
    - bottom edge of wall specimen capped with PVC starter channel and located ~ 75 mm above finished ground level. Hebel blocks located at base of timber stud wall behind rendered EPS simulating slab edge, and
    - sides and top edge of combustion chamber capped with 18.3 mm thick timber reveal simulating a timber window frame reveal.

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Figures 3 to 6 show the test specimen prior to the conduct of the test.[2]

Figure 3. Front face of main wall and wing wall during CSIRO inspection of completed construction at Warringtonfire.

[2] These images were taken by CSIRO during inspection of final specimen construction on 27 May 2020.

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Figure 4. Rear of wing wall (left) and main wall (right) during CSIRO inspection of completed construction at Warringtonfire.

Figure 5. Vertical construction joint (left) and edge of combustion chamber (right) showing simulated timber window reveal and Hebel block simulating slab edge) during CSIRO inspection of completed construction at Warringtonfire.

Figure 6. Cut section of 100 mm thick EPS with 1 mm base coat render to one side (left over section not installed to specimen) during CSIRO inspection of completed construction at Warringtonfire.

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6 Test Results

This section summarises the overall test results, discusses the key aspects of fire behaviour observed and compares the results against the AS 5113 EW classification criteria.

6.1 Test result overview

In summary:

- the rendered EPS wall system tested **failed** to meet the external wall (EW) classification acceptance criteria stated in AS 5113:2016 Amendment 1. This was primarily due to flaming molten EPS forming a significant pool fire and fire spread beyond the top of the specimen
- the test demonstrated that a rendered EPS wall system will result in rapid vertical fire spread when exposed to a fire source similar to the large crib source used, and
- fire sources that could potentially result in similar fire exposure are post flashover apartment fires with flames emerging from windows or large external fire sources.

Appendix C provides:

- CSIRO observations during the test
- CSIRO observations during post-test specimen deconstruction
- photos during the test and post-test, and
- tabulated summary of test measurements.

Detailed test results are provided in the following two Warringtonfire reports:

- Reaction to fire report - presents all test results and measurements required by BS 8414-2:2015+A1:2017. This report includes photos. This report does not state Pass/Fail against any criteria as BS 8414-2:2015+A1:2017 only specifies the test method and does not specify acceptance criteria, and
- Classification Report - presents test results and measurements required by AS 5113:2016 Amendment 1 including the pass/fail result against AS 5113:2016 Amendment 1 EW acceptance criteria. This report does not include photos.

6.2 Key aspects of fire behaviour

The following key aspects of fire behaviour were either observed or can be inferred from the test data:

1. The rendered EPS wall system resulted in rapid vertical fire spread with:
    a. fire spread to level 2 (5 metres above combustion chamber) by 8 minutes after crib ignition, and
    b. fire spread to top of specimen (8 metres above top of combustion chamber) by 8 minutes after crib ignition time.

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2. Due to crib fire development time, crib flames did not start impinging on the wall system until ~ 3:30 (min:s) after crib ignition. Start time (ts = time any external thermocouple at level 1 height is ≥ 200 °C above ambient temperature for at least 30 seconds) was 3:50 (min:s).
3. The test was suppressed with water at an early time of 12:12 (min:s).
4. Fire had spread to the top of the specimen and was still increasing in size at time of suppression. If the system had been installed to a taller wall with more levels the fire would have continued to spread to all levels above.
5. The system resulted in flaming molten EPS forming a large pool fire at ground level. This indicated that the system would be prone to downward fire spread to the base of the wall, balconies or other horizontal projections located below the level of fire origin.
6. Prior to failure/opening of the render surface some limited flaming at the exposed surface of the specimen in the region of crib impingement was observed. It is difficult to determine if this was flashing ignition of the polymer modified render surface or if it was ignition of volatiles from pyrolyzed EPS passing through the render surface and burning (particularly via joints or cracks/fissures in render).
7. The failure/opening of the rendered surface coincided with increased exposure of EPS and increased fire size. The initial point of failure of the rendered surface was the vertical expansion joint located centrally above the combustion chamber. This joint progressively failed firstly by sealant falling/burning out and eventually the render surface peeling away from either side of this joint. However the render layer also appeared to form cracks or openings at other locations away from this vertical joint, including around the upper perimeter of the combustion chamber, on the wing wall in the region of most severe crib flame impingement (between the combustion chamber and level 1) and vertically along the intersection of the wing wall and main wall above the combustion chamber. Based on witnessing the test and review of the available test data, CSIRO is of the opinion that, if no vertical control joints had been included in the tested specimen, it would have been likely to have resulted in similar fire spread behaviour, however the onset of significant fire spread may have been marginally delayed. This opinion is based on:
    a. the observation of formation of openings and cracks of the render at locations other than the vertical control joint
    b. the observation of flaming molten EPS dropping from the upper perimeter of the combustion chamber at locations other than directly at the vertical control joint
    c. the fact that the BS8414 crib burn rate typically is still increasing at 15 minutes after crib ignition
    d. without early failure of the vertical control joint and formation of pool fire, it is considered that the increasing crib fire size would be likely to degrade the render surface resulting in eventual formation of cracks or holes in the render leading to similar fire spread behaviour, and
    e. rendered EPS walls without inclusion of suitable control joints are prone to formation of cracks over time which would form a similar weak point in the render.
8. Formation of openings or flaming on the non-fire exposed side did not occur and the peak temperatures measured on the non-fire exposed side (rear face of the plasterboard) were ~ 106 °C prior to suppression of the test. This is likely due to a combination of:

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a. significant amount of heat from façade fire buoyantly convected upwards rather than being contained within enclosure (as for interior compartment fire)

b. standard grade plaster having some limited intrinsic resistance to fire due to H_2O bonded within gypsum plaster and therefore takes some limited time to lose integrity, and

c. the early suppression of the test fire. It is considered highly likely that if the test fire had not been suppressed the 10 mm standard grade plaster may have lost integrity resulting in fire spread to the non-fire exposed (interior) side of the wall system. This is indicated by the non-fire side plasterboard temperature being 106 °C at 900 mm above combustion chamber, a temperature >100 °C indicates that the plaster may have been close to having the majority of moisture driven out of it at which point integrity failure is more likely to occur.

VBA have requested CSIRO to comment on the likely horizontal fire spread for the tested rendered EPS construction. CSIRO provides the following comments:

1. The AS 5113 EW classification criteria applying the BS8414 test method does include fire spread beyond the confines of the test specimen, including horizontally to the edges of the specimen.
2. The VBA sponsored test did result in flaming both at the top of the specimen and at the edge of the wing wall.
3. However, the BS8414 test specimen arrangement, being tall and relatively narrow is particularly focused on enabling observation of vertical fire spread. The test is also conducted under limited low wind speed conditions. For these reasons, this test in not specifically focused on investigating propensity for horizontal fire spread under conditions which may promote this.
4. In this test, the flaming at the horizontal extent of the wing wall was possibly due to 3 factors:
    a. air induction into the fire plume typically induces the fire plume to lean into the intersection of the wing wall and main wall (away from the opposite edge of the main wall)
    b. radiant heat exposure to the lower wing wall from the combustion chamber and fire plume, and
    c. pool fire formation at the base of the wing wall and combustion chamber.
5. Although some horizontal fire spread was observed in this test, the speed and extent of horizontal fire spread observed was significantly less than for the vertical fire spread. Vertical fire spread is typically more rapid than horizontal fire spread due to buoyancy of flames and heat.
6. However based on this test, it could be reasonably concluded that some degree of horizontal fire spread could be expected for the tested rendered EPS system if applied to a building in a larger horizontal extent, and that this could possibly become enhanced under specific conditions including:
    a. high wind conditions, and
    b. areas with horizontal projections or gutters continuing along base of rendered EPS wall which promotes pool fires growing and spreading horizontally along base of EPS.

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6.3 Results against test criteria

Table 3 summarises the AS 5113 EW classification result reported by Warringtonfire and summarises the risk mitigation intent of each criteria as stated in AS 5113:2016 Amendment 1 Appendix B4.

Table 3. Summary of AS 5113 EW classification result

Classification Criteria	**Related classification measure**	**Result in test**	**Pass/Fail**	**Risk mitigation intent of criteria**
5.4.5(a) T_{w5m}	≤600°C	Exceeded 600 °C > 30 seconds at 8:51 (min:s) after crib ignition	Fail	Prevention of fire spread to two floor levels above fire
5.4.5(b) $T_{layer5m - Cavity}$	≤250°C	Exceeded 250°C >30 seconds at 9:41 (min:s) after crib ignition	Fail	Prevention of incipient fire spread to two floor levels above fire
5.4.5(b) $T_{layer5m - insulation}$	≤250°C	Exceeded 250°C >30 seconds at 10:20 (min:s) after crib ignition	Fail	
5.4.5(c) $T_{unexposedside0.9m}$	≤180 K rise	Maximum temperature of 106 °C immediately prior to suppression	No failure at time of suppression*	Prevent fire spread to floor above if wall not fire resistant
5.4.5(d) flaming	No flaming	No flaming on unexposed side of specimen occurred	No failure at time of suppression*	
5.4.5(d) openings	No opening	No opening occurred on unexposed side of specimen	No failure at time of suppression*	
5.4.5(e) spread	Spread beyond specimen	Flaming occurred beyond minimum confines of specimen located at both top and wing wall of specimen	Fail	Prevent fire spread to two floor levels above fire and lateral spread
5.4.5(f) debris flaming	≤20 s	Flaming pool fire at ground level	Fail	Prevent fire spread to floors below
5.4.5(g) debris mass	≤2 kg	Total mass of debris collected was ~ 13 kg. It is noted that a significant mass of molten EPS at ground level burnt away during test prior to mass measurement	Fail	Limit debris impact with fire fighters, occupants and passers-by
		Classification	**Not classified (Failed classification criteria)**	

* Due to flame spread extending above the test apparatus the test was terminated early. They system had not failed this criterion at 12 minutes 12 seconds, the point of early test termination.

Section 5 of AS 5113:2016 Amendment 1 requires that the fire performance of an external wall system shall be classified in the following format:

FP: [External wall performance]/[Building-to-building performance].

The Warringtonfire classification report expressed the above results as follows which is in accordance with the standard (with explanatory notes marked up by CSIRO):

“Fire Performance (FP): NIL/-“

The test according to BS 8414 failed AS 5113 External Wall classification criteria and no EW classification could be stated

No AS 5113 Building-to-Building classification test was conducted

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7 Comparison against similar tests on other wall systems

This section compares the results of the VBA rendered EPS full-scale façade fire test against European rendered EPS full-scale façade fire tests and full-scale façade fire tests on ACP wall systems. It concludes that although the rendered EPS and ACP-PE wall systems are constructed of significantly different products/materials, the propensity for rapid fire spread when exposed to a large fire source is similar.

7.1 Comparison against European rendered EPS full-scale façade fire tests

The CSIRO's *Literature Review on Fire Safety of Exterior Insulation Finish Systems and Insulated Sandwich Panel as External Wall Systems* identified several previous full-scale façade fire tests on European rendered EPS systems which were typically installed directly to a solid concrete/masonry substrate and included thicker EPS. The European tests reviewed included:

- German MFPA Leipzig 200 kg crib EIFS tests done on different wall systems with no internal fire barriers (Mineral wool breaks installed between levels of EPS) and with internal fire barriers
- German iBMB tests including 200 kg crib tests and 200 L iso-propanol tray fire tests on different wall systems with no internal fire barriers and with internal fire barriers
- BRE tests comparing EPS EIFS performance in BS 8414 tests and DIN 4102-20 tests (which uses a significantly small crib source), and
- University of Zagreb, Croatia EIFS tests based on BS 8414.

As the above tests applied a range of ignition sources, test specimen sizes and test specimen construction details, a detailed comparison of the VBA rendered EPS test against each of the above tests is not provided, however general comparison concludes the following:

- the VBA rendered EPS test had similar results in terms of rapid vertical fire spread and formation of large pool fires when compared to European EIFS systems without fire barriers
- in some cases, the European EIFS systems when fitted with fire barriers (typically 200 mm non-combustible mineral wool inserted to break continuity of EPS) did prevent or slow fire spread to the top of the specimen, however they still produced significant pool fires, and
- fire barriers were not included in the VBA test as these are not typically included in Australian rendered EPS construction. It is unclear if fire barriers would have a similar effectiveness for typical Australian rendered EPS construction which includes a cavity behind the EPS with light weight timber frame and non-fire-resistant internal plaster board behind the EPS. In many cases a concrete slab edge may not be present directly behind the EIFS (for example where light-weight floor structures are used).

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7.2 Comparison against BRE DCLG post Grenfell BS8414 tests on ACP

In response to the Grenfell Tower fire an independent expert panel on fire safety recommended that a series of full-scale facade fire tests be undertaken to establish how different types of ACP in combination with different types of insulation behave in fire. The UK Department for Communities and Local Government (DCLG) sponsored BRE Global to undertake a total of seven BS 8414 Façade Tests on three different categories of ACPs with three different Insulation types[3-9]. The tested systems included ACP cladding with 100 percent polyethylene cores (ACP-PE) which are known to be the ACP type having the poorest fire performance involved in the majority of the large façade fire incidents around the world including Grenfell UK, and Lacrosse Australia and numerous incidents in UAE.

The BRE DCLG post Grenfell BS8414 tests were originally assessed against the BR-135[10] pass/fail criteria. BR-135 applies the same test method that is applied in Australia for AS 5113. However, AS 5113 applies different and more stringent test criteria compared to BR-135

Appendix D provides:

- detailed summary of the different ACP wall systems tested in the BRE DCLG post Grenfell BS8414 tests
- detailed summary of the BR-135 pass/fail criteria, and
- detailed comparison of BRE DCLG post Grenfell BS8414 test results against the VBA Rendered EPS test.

In Summary:

1. The rendered EPS system tested by VBA fails to meet BR 135 classification acceptance criteria.
2. The rendered EPS and the ACP-PE systems had similar times to:
    a. level 2 temperatures exceeding 600 °C,
    b. frequent flaming at Level 2, and
    c. frequent flaming at top of specimen.
3. Based on the above it can be concluded that, although the rendered EPS and ACP-PE wall systems are constructed of significantly different products/materials, the propensity for rapid fire spread when exposed to a large fire source is similar.
4. It is noted that time to flaming debris/pool fire was delayed for the rendered EPS compared to the ACP-PE. This could possibly have been due to either of the following (not possible to verify from data available):
    a. the 5 mm render may have provided greater initial protection against melting and ignition of EPS core compared the protection that the 0.5 mm aluminium may have provided to the PE core during the early stages of fire development, and/or
    b. the start times for the BRE tests were shorter than the start time for the Warringtonfire test crib (105-130 seconds compared to 230 seconds. This indicates a longer initial growth time of the timber crib to establish 200 °C and level 1 exterior. If the crib growth rate past this time continued to be slower compared to the BRE tests, then this might account for a delay in flaming debris and pool fire development. However, CSIRO confirms based on our observations that the Warringtonfire crib appears to be in accordance with the AS 5113

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standard which requires the same crib construction as BS 8414 but permits Pinus radiata to be used instead of Pinus silvesterus. Regardless of the type of pine timber used, it is known that the early growth time of the crib (from ignition) can be variable and this is the reason the t_s start time criteria are specified.

5. Regardless of the above, significant sized pool fires at ground level did develop at an early stage for both the ACP-PE and the rendered EPS wall systems as an early stage in the test. On this basis the two systems may be concluded to have a similar propensity for pool fires and fire spread to levels below when exposed to a large fire source.
6. It is noted that the BRE ACP-PE tests were supressed at an earlier time and that the Warringtonfire rendered EPS test was permitted to continue for longer (~ 2 minutes) well past the failure time of most of the AS 5113 EW criteria which may have resulted in a larger fire and more damage to the test specimen at time of suppression.
7. On this basis it is considered reasonable that the Risk Assessment Tool used for the Statewide Cladding Audit[3] should apply an equivalent risk ranking to both rendered EPS wall systems and ACP-PE wall systems.

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[3] The Risk Assessment Tool (RAT) used for the Statewide Cladding Audit is a spreadsheet-based tool used by Advisory Reference Panels (ARP) to assess a preliminary/initial risk ranking for buildings identified and reviewed by the audit. It is a generic, simplified risk assessment tool which does not necessarily capture all aspects of risk assessment for a specific building and is not intended as a substitute for expert judgement. Rather it is intended as a tool to support suitably qualified experts in an ARP to follow a consistent method in assigning an initial risk ranking to buildings.

The RAT risk against 18 building elements (covering overall fire safety risks, risk of fire spread and exit risks) which includes:

- type of occupancy, number of occupants
- types of cladding
- extent of automatic sprinkler protection
- extent and configuration of cladding and other details such as fixing
- factors which effect ability to safely exit and fire brigade intervention

A semi-quantitative risk matrix is used to assign an overall risk ranking of low, moderate, high or extreme. This overall risk ranking influences the recommendations and actions of the VBA, Municipal Building Surveyor and Cladding Safety Victoria.

The RAT applies a weighted risk score to cladding types ranging from 0 (lowest risk) to 1 (highest risk). This score has a significant impact on the overall risk ranking of the building. The RAT applies the following weighted risk score to cladding types:

- expanded polystyrene : 1
- ACP PE : 1
- ACP unclear : 1
- ≤30% PE content ACP: 0.5
- ≤10% PE content ACP: 0.25

Rendered EPS is classed under 'Expanded polystyrene' and is currently given the same weighted risk score as ACP-PE.

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8 Conclusions

A full-scale façade fire test completed on a rendered EPS wall system, sponsored by the VBA. The tested system was selected to be reasonably representative of typical Australian rendered EPS construction.

This provides clear test-based evidence to support the following conclusions:

1. The rendered EPS wall system tested failed to meet the external wall (EW) classification acceptance criteria stated in AS 5113:2016 Amendment 1. It also failed to meet BR-135 classification acceptance criteria.
2. The test demonstrated that a typical Australian rendered EPS wall system has a propensity for rapid vertical fire spread and pool fires when exposed to large fire sources. It demonstrated some propensity for horizontal fire spread but this was to a lesser degree than for vertical fire spread.
3. Although rendered EPS and ACP-PE wall systems are constructed of significantly different products/materials, the propensity of a rendered EPS wall system for rapid vertical fire spread and pool fires when exposed to large fire sources is similar to that of ACP-PE wall systems when exposed to large fire sources.
4. It is reasonable that rendered EPS wall systems and ACP-PE wall systems should continue to be given the same risk ranking in the Risk Assessment Tool used for the Statewide Cladding Audit when undertaking preliminary building risk assessments.
5. Fire sources that could potentially result in similar fire exposure are post flashover apartment fires with flames emerging from windows or large external fire sources.

It is important to note that:

1. The test does not simulate a medium sized balcony fire of the order of 100 kW-300 kW.
2. The test does not simulate Building to Building (BB) fire spread. No AS 5113:2016 AS 5113:2016 Amendment 1 BB classification test was undertaken.

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Appendix A Table of Abbreviations

Abbreviation	Definition
A2	ACP-A2 is a common naming used to represent ACP core with ~1-7 mass% organic polymer.
ABCB	Australian Building Codes Board
ACP	Aluminium Composite Panel. Also called aluminium composite material (ACM) or metal composite material (MCM).
ACP-PE	Aluminium composite panel having a polyethylene core with minimal or no inert fillers or other fire retardants.
ARP	Advisory Reference Panels conducted in Victoria on behalf of either VBA, DELWP or the Victorian Cladding Taskforce. Panel typically includes a fire engineering representative, a building surveyor representative and a fire brigade representative. The purpose of the panel is to review inspection reports and other information provided on specific building identified to have combustible cladding, risk assess the building and make recommendations to the municipal building surveyor.
AS	Australian Standard
BAL	Bush fire attack level as defined by AS 3959.
BB	Building to Building classification as defined by AS 5113.
BCA	Building Code of Australia
BRE	Building Research Establishment Limited, BRE Global Limited
BS	British Standard
CSIRO	Commonwealth Science and Industrial Research Organisation
DCLG	Department for Communities and Local Government (UK)
DTS	Deemed-to-satisfy
Δh_c	Gross Heat of combustion (MJ/kg)
EIFS	Exterior insulation finish system
EN	European Norm (standards)

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Abbreviation	Definition
EPS	Expended polystyrene
EW	External Wall - specifically refers to AS 5113 External wall classification determined via full scale façade fire testing.
FER	Fire Engineering Report
FM	Factory Mutual
FR	Fire retardant, ACP-FR is a common naming used to represent ACP core with ~ 30 mass% organic polymer.
HRR	Heat Release Rate, a unit of energy release per unit time (kW).
ISP	Insulated Sandwich Panel
LPCB	Loss Prevention Certification Board (UK)
LPS	Loss Prevention Standard
MW	Mineral wool fibre insulation (note – MW also denotes the units Mega Watts)
NATA	National Association of testing authorities, Australia. Provides independent accreditation of laboratory technical competence for specific test methods.
NCC	National Construction Code
PE	Polyethylene
PIR	PolyIsocyanurate
PVC	polyvinyl chloride
PU	Polyurethane
RAT	Risk Assessment Tool
VBA	Victorian Building Authority

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Appendix B Test specimen construction requirements and rationale

This Appendix provides a detailed summary of all construction detail options considered and the rationale for the options selected and included in the test specimen.

Construction detail item	Requirements	Rationale
Test specimen dimensions	Minimum standard BS 8414 test specimen dimensions in terms of width and height.	The specimen was required to be minimum Height ≥ 8 m, Main face ≥ 2.6 m wide, Wing ≥ 1.5 m wide.
	More than 1 level higher than standard specimen height.	Installed specimen was 10.02 m high, main wall width = 2.815 m, wing wall width = 1.46 m The 10 m height was preferred as this could be accommodated by the testing facility and would enable clear demonstration of continued vertical fire spread beyond level 2 (if that occurred). Given a “level” is represented in BS 8414 by 2.5 m height, this represented more than one additional level of height above the minimum standard specimen height. It is noted that the wing wall width of 1.46 m being marginally less than 1.5 m did not impact the outcome of the test. A specimen of significantly greater height was not considered to be practical or necessary as fire spread to top of 10 meter specimen would be sufficient to indicate that fire spread beyond this height would continue for a taller installation.
Supporting wall construction	Light weight construction.	EIFS in Australia is most typically applied to light weight construction. Solid construction (masonry/concrete) was not considered to be typical for EIFS in Australia (more typical for Europe).
Light weight framing material	Timber in accordance with AS 1684 National Timber Framing Code.	Rendered EPS in Australia is installed to both steel and timber framed construction. Timber framed rendered EPS clad walls have been observed in many buildings of Type A and B construction, and may be more prevalent for 2-4 story residential buildings. Timber was considered to be representative and would possibly demonstrate any impact of the combustible timber framing on the total system performance.
Light weight framing dimensions	90 mm studs.	Considered to be the most common.
Stud spacing	Maximum 600 mm.	Studs were at max 600 mm centers as this was considered likely to be typical in Australia. Installation guides permit this for horizontal EPS panel installation. It was noted that some vertical EPS panel installation guides require 450 mm stud spacing, but not for horizontal EPS panel installation.

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Construction detail item	Requirements	Rationale
Slab to slab infill walls or continuous vertical multistory installation	Continuous Vertical EIFS spanning multiple levels.	This arrangement was considered to be typical. The stud cavity was broken by the steel beams of the BS 8414 test support rig representing false slabs. EIFS installed at infill wall broken vertically at each level by floor slab was not required as it was considered to be less typical. It was noted that this may be less prone to fire spread due to a break at each level.
Cavity fire barriers	No mineral wool cavity fire barriers.	Mineral wool cavity barriers providing a complete break across the EPS are not typically installed in Australia. Note that these are required by NCC BCA Vol 1 CV3 but have not been observed installed to existing Rendered EPS clad buildings.
Internal wall linings	No mineral wool cavity fire barriers.	This arrangement was considered to be typical for Australia for non-load bearing walls not requiring an FRL. FR plaster board may be used for non-loadbearing walls < 3 metres to the fire source feature requiring FRL (but this can sometimes be missed/omitted).
Stud cavity insulation	No insulation.	EIFS may be installed without additional cavity insulation if the external insulation board provides the required insulation. Recommend testing a thicker EPS board with no stud cavity insulation so the test focus is on the fire performance of the EIFS/EPS. Fiberglass insulation will tend to melt/fuse in the area of direct flame impingement but not contribute significantly to fire spread. Polyester insulation will melt away in the area of direct flame spread and may contribute to molten pool fire or cavity fire spread. Mineral wool insulation may impede cavity fire spread, and is not typical for EIFS in Australia.
Sarking	Woven Polyester foil faced sarking.	EIFS is typically installed with sarking moisture barrier. Woven polyester foil faced sarking was considered to be the most common sarking (as opposed to Kraft Paper foil faced sarking or Polyolefin foil faced sarking).
EIFS substrate	No EIFS Substrate (nothing between stud frame and external insulation except sarking).	This is a board layer such as plasterboard, cement sheet, plywood or other that could potentially be installed between the stud wall frame and the external insulation board. No substrate considered to be most typical in Australia. It was noted that fire resistant board is sometimes installed to achieve an FRL (when tested from external side only) if required for walls in close proximity to boundaries or BAL Flame Zone applications.
EIFS Cavity System or Direct Fix System	EIFS Direct Fix System.	The external insulation board is screw fixed directly to the sarking and stud frame behind. This option was selected as it was the simplest and considered to be typical of many installations in Australia. It was noted that an EIFS cavity system installs ~ 25 mm spacers/battens between the sarking layer and the insulation board to improve drainage airflow and moister resistance, and that battens are often made of EPS which creates an additional air cavity that may influence cavity fire spread. It is not known to CSIRO which type of system is more prevalent in Australia. Both systems are sold and installed. An EIFS cavity system probably represents a better quality installation in terms of moisture

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Construction detail item	Requirements	Rationale
		performance but may provide an additional combustible cavity for fire spread.
Insulation board type	EPS-FR.	EPS with HBCD fire retardant was considered to be most typical in Australia and the purpose of this test was to investigate the fire performance of this specific materials used as EIFS. The following were not considered to be most typical: • EPS (non-FR) • XPS • PUR • PIR • Phenolic foam • Mineral fiber, and • Conpolcrete/QT.
EPS Board thickness	100 mm.	Noted that EPS board thickness used for rendered EPS in Australia appears to range from 50 mm -125 mm. However, 100 mm considered to be the thickest that could be reasonably considered typical in Australia.
EPS Board with or without precoated render base coat	EPS with pre-coated base render layer.	Raw EPS board and EPS with a pre-coated base render layer are both sold and used in Australia. EPS with a pre-coated render base coat of ~ 1mm thickness was selected for ease of construction and to facilitate uniform total render thickness and avoid any issues with render adhesion to EPS.
Insulation board orientation	Horizontal orientation.	Typical Board dimensions are 2.4 m x 1.2 m or 2.5 m x 1.2 m Horizontal insulation board orientation was considered most typical in Australia. Due to size of the AS 5113 test rig, the insulation boards were required to be cut to fit. This was selected based on most typical and ease of installation (as opposed to vertical board orientation which would require more than two boards per main wall width and more than one board per wind wall width).
Insulation board fixings	Fixed using screws and plastic washers at 400 mm vertical spacing along each stud.	Insulations boards are typically screw fixed using screws and plastic washers. Fixing spacings specified vary between manufactures but generally are: • fixings at minimum 20 mm from edge of board, and • fixings at 200-400 mm centers vertically along each stud.
Insulation board jointing (not control joints)	All straight joints between EPS panels must be either at a double stud or between studs using back blocking EPS across joint to provide joint support. Expanding PU foam adhesive is sprayed between the EPS panel edges when butt jointing at these locations.	Installation manuals for a range of rendered EPS systems specify this as typical.

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Construction detail item	Requirements	Rationale
	Vertical joints vertically aligned.	Vertical joints between EPS panels would typically/ideally be staggered at least one stud spacing. However this is not practical for the size of the test specimen so all vertical joints were vertically aligned.
Render system type	Polymer/Acrylic modified render.	Most EIFS Systems specify polymer/acrylic modified render for the: • base coat • mesh layer • second coat, and • finishing coats/sealer/paint. Cement based render is not typically specified due to adhesion and cracking issues with EPS.
Render system thickness	~ 5 mm.	Considered to be typical of good construction. It was observed that most systems appear to specify approximately this total thickness.
Mesh type	Fibre glass reinforcing mesh.	Fibre glass reinforcing mesh is typical specified for EIFS systems and has been adopted.
Window reveal /combustion chamber opening detail	Timber window frame construction.	The finishing of the EIFS around the head and sides of the combustion chamber were required to be installed to simulate the typical window details for an EIFS system. This should include the rendered EPS with a significant rebate and the gap between the rendered EPS and the stud wall sealed by the window frame/reveal construction. T It was noted that either aluminium or timber window frame/reveal can both typically be used. Timber window frame/reveal construction was adopted as it was considered representative and more easily installed to the test specimen. It was noted that it would be likely to char/burn away during crib flame exposure.
Base wal ground clearance	75 mm.	The ground clearance between EIFS and ground slab at bottom of test rig was required to be 75 mm. Hebel blocks were required to be installed to simulate concrete slab edge behind the EIFS on the ground (with edge of EIFS exposed PVC starter channel). This was considered to be representative of typical installation requirements to keep EIFS above finished ground level for moisture protection.
Base wall starter channel	PVC starter channel.	Having no starter channel (bare exposed EPS at base of wall) was considered likely to be typical, but is not commonly specified by suppliers. PVC starter channel with weepholes is typically specified in EIFS installation manuals. Aluminium starter channel with weepholes is also typically specified (often interchangeable with PVC). PVC starter channel with weepholes was required on the basis that they provide some exposure of the EPS core. Upon completion of construction CSIRO confirmed solid PVC starter channel (without weepholes) had been installed. However, CSIRO confirmed that the solid PVC starter channel was unlikely to significantly impact the test outcome, as the system was likely to be involved in fire spread to areas above the combustion chamber before a pool fire or crib collapse exposed the base of the wall to fire.
Control joints	Include horizontal control joint and	It was decided to include control joints based on the following: Manufacturers generally specify control joints:

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Construction detail item	Requirements	Rationale
	vertical control joint.	• horizontally at every floor level, and • vertically at intervals of ~ 6 metres, particularly at stress concentrations such as doors or windows. Control joints often appear to be omitted due to poor construction, but should be included in a test specimen representing good construction. If control joints are not included then cracking around opening such as windows are likely to occur over time. BS8414 section 6.2 states the following: *"If horizontal joints are incorporated into the external wall cladding system, the test specimen shall incorporate horizontal joints at intervals specified by the manufacturer, with at least one joint placed (2 400 ±100) mm above the combustion chamber opening. If vertical joints are incorporated into the external wall cladding system, the test specimen shall incorporate vertical joints at intervals specified by the manufacturer, with a joint extending upwards on the centre line of the combustion chamber opening, with a tolerance of ±100 mm."* Control joints would typically be located extending from sides of openings rather than centre of openings. However BS8414 requires vertical control joint to be centrally located. It was discussed that both options would be within area of direct crib flame immersion during test. Control joints may influence render delamination and EPS exposure in the fire test. However, CSIRO considered that even with control joints omitted the heat exposure from direct flame immersion of the timber crib is very likely to result in failure of the render and that the only impact is likely to be a slight delay in the time to failure of the render.
Horizontal control joint	One Horizontal control joint be located ~2.4 m above the combustion chamber opening extending across both main wall and wing wall, steel flashing installed across the top edge of the lower EPS panels and PVC or aluminium starter channel installed across the bottom edge of the upper EPS panels with an ~ 10 mm gap between.	This type of horizontal joint is typical of drainage joints between levels included in various installation manuals for rendered EPS. It is at the height required by BS 8414.

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Construction detail item	Requirements	Rationale
Vertical control joints	One vertical control joint be located above the center line of the combustion chamber extending vertically to the top of the specimen. Expansion joint to be 10 mm gap filled with closed cell polymer backing rod and a continuous bead of silicon adhesive. Control joints must be at double studs.	This type of vertical joint is typical in various installation manuals for rendered EPS. The location is in accordance with BS 8414. It is noted that some installation manuals also include aluminium mesh angle embedded in the render at the corners of the EPS along this joint, however some installation manuals do not include this detail. This item was originally specified to be included but was omitted by the builder during construction. The builder stated that it was too difficult to install the mesh angle with the backing rod etc. and that this was not typically installed. CSIRO review considers that omission of the aluminium mesh angle along the vertical control joint can be considered representative of typical likely construction and omission of the mesh angle is unlikely to have a significant impact on the overall outcome of the test.
Jointing at intersection of wing wall and main wall	Butt joint with fiberglass mesh and render.	Installation manuals typically vertical internal (re-entrant) corners on rendered EPS as a butt joint with fiberglass mesh and render but not metal angle embedded (metal angle is typically specified on external corners only, to provide durability against knocks). This detail was applied to the vertical re-entrant corner at intersection of wing wall and main wall.
Treatment of edges and tops of specimen	The top edge of the specimen capped with steel capping channel.	Based on typical installation manual details for top edges/parapets.
	Vertical edges of the EPS capped with single layer of 13 mm FR plasterboard screw fixed so as to cover the edge of both the EPS and the supporting timber stud framing. This was then rendered over with an alloy mesh render reinforcement angle embedded within render.	Steel channel capping of vertical edges of specimen would not be typical. The detail specified was provided in some system installation manuals.
Simulated render damage/defects	Not included.	It was agreed that the specimen was to represent well installed and maintained EIFS. Simulated damage or defects (particularly cracked or missing sections of render) were not included.

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Appendix C Detailed test observations, results and photos

C.1 Observations during the test

The following summarises visual observations recorded by CSIRO during witness of the test conducted on 4 June 2020.

Time after crib ignition (min:sec)	Observation
0:00	Crib ignited.
2:00	Crib fire still establishing. Smoke spilling out of combustion chamber but no flames spilling out of combustion chamber or impinging on the test specimen.
3:30	Crib fire still establishing/growing. Smoke spilling out of combustion chamber. Crib flames just begin to impinge upon lintel of combustion chamber opening.
4:00	Flames from crib are intermittently reaching 1 metre above combustion chamber on front face of main wall. Test specimen has not ignited. Crib fire is still growing.
5:00	Flames from crib are intermittently reaching level 1 (2.5 metres above combustion chamber) and continuously reaching 1 metre above combustion chamber on front face of main wall. Test specimen has not ignited. Crib fire is still growing.
5:30	Non sustained (flashing) surface ignition and flaming of external face of specimen in small areas ~ 1 metre above combustion chamber. It is not possible to determine if this is the polymer modified render surface or pyrolyzed EPS (possibly emitting from small cracks in render or joint surfaces) that is undergoing non-sustained ignition.
6:15	Sealant is coming out of vertical control joint ~1-2 metres above combustion chamber but hanging in place. Render in region 1 metre above combustion chamber is heavily baked/discoloured with char marks showing where screw washers are located behind render. Crib flames are now impinging continuously upon level 1 external face with some intermittent contribution to flaming from specimen.
6:40	Sealant from vertical control joint ~1-2 metres above combustion chamber falls and is hanging in front of combustion chamber and flaming.
7:00	Molten flaming EPS is dripping from the vertical control joint (and possibly from the bottom edge of the window reveal around combustion chamber) and falling to ground where it continues flaming to form a small pool fire. Flames are now intermittently impinging on level 2 (5 metres above combustion chamber) on external face. Flaming is also sustained at right top corner of combustion chamber opening which appears to be due to combination of timber and molten EPS burning at this location.
8:00	Molten flaming EPS has continued to fall from the vertical control joint and along the top edge of the combustion chamber to ground and has formed a flaming pool fire of ~ 1 metre diameter. Flames

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Time after crib ignition (min:sec)	Observation
	continue to intermittently impinge on level 2 at external face. No large sections of render have fallen away at this stage. Thick black smoke issuing from ground EPS pool fire.
8:30	Flames are continuously impinging on level 2 external face. Flaming EPS now appears to be dripping to ground from the Horizontal control joint ~ 2.4 metres above combustion chamber. Pool fire has increased and is now impinging on base of wing wall and producing thick black smoke. Flaming is issuing from vertical control between level 1 and level 2.
8:45	The wing wall between combustion chamber and level 1 appears to have ignited (however difficult to see due to smoke from pool fire).
9:00	Fire plume is intermittently reaching the top of the specimen (specimen not flaming at top yet). Flames issuing from vertical control joint just above level 2. Pool fire at ground level now extends the width of the combustion chamber. Flaming of wing wall between combustion chamber and level 1 continues to increase.
9:40	Render along vertical control joint between combustion chamber and level 1 is starting to peel open but remains in one piece and hangs in place rather than cracking. Flaming from the opening in the render at this location increases.
9:50	Render between combustion chamber and level 1 directly above combustion chamber breaks open with further increase in fire size. Surface of wing wall is now burning in area extending from combustion chamber to ~ 0.5 m below level 2. Fire plume is now continuously reaching the top of the specimen with flames issuing from vertical control joint on main wall up to ~1 metre below top of specimen.
10:00	Fire size continues to increase. Surface of specimen is now flaming along intersection of wing wall and main wall from combustion chamber to top of specimen.
11:00	Fire size continues to increase. Render is still mostly hanging in place in all regions except for main wall combustion chamber to level 1. However flaming or molten or pyrolyzed EPS is occurring on main wall and wing wall extending to top of specimen at numerous open joints or cracks in render. The render surface also appears to be flaming at the outer perimeter of the specimen surface flaming region.
11:55	Fire continues to increase. Flames have spread to the outer extent of the wing wall. The fire plume continuously extends ~ 1-2 metres above the top of the specimen.
12:00	Debris catch mat dragged away from front of specimen.
12:12	Test terminated. Water applied to test specimen to extinguish fire.

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C.2 Post-test observations

CSIRO inspected the post-test specimen deconstruction on 5 June 2020 and recorded the following observations:

- On the main wall the render had fallen away with EPS behind completely consumed to the top of the specimen in a diagonal pattern leaning towards the wing wall. Some of the render is assumed to have been knocked off by the water hose stream during suppression.
- On the wing wall, the render had fallen/peeled away with EPS behind mostly consumed in an area extending from finished ground level to Level 1.
- A significant region of the render which remained in place on the main wall and wing wall was heat effected showing charring with a white discolouration, with screw/washer heads visible and bounded at perimeter by black sooty discolouration. EPS behind this heat effected render region had mostly melted/burnt away.
- Regions of render externally along the outer edges of the main and wing wall had render which was either not heat effected or was black and sooty. EPS behind these regions above Level 1 was still in place and had mostly not melted or burnt away. EPS behind these regions below Level 1 had mostly melted or burnt away all the way to the outer edge of the wall specimen.
- Timber framing had surface charring in all regions where the EPS had mostly melted/burnt away but all timber framing elements remained in place and had not burnt away. This may be in part due to the early suppression of the test.
- Standard grade 10 mm plasterboard was exposed with some charring of paper surface within cavity where the EPS had melted/burnt away. However, no opening or gaps had formed in the plasterboard which resulted in no flaming on the non-fire exposed side of the wall system. This is due to the early suppression of the test.
- During post-test deconstruction Warringtonfire took a total of 15 hole saw samples distributed over the remaining regions of non-heat effected render and measured the render thickness. An average render thickness of 4.9 mm, minimum render thickness of 4.0 mm and maximum render thickness of 6.4 mm was measured.

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C.3 Photos

Figures 7 and 8 show the test specimen at various stages during the test.[4]

Figure 7. Rendered EPS external wall system at 4 minutes (left), 6 minutes (centre) and 8 minutes (right) after crib ignition

Figure 8. Rendered EPS external wall system at 10 minutes (left), 11:50 minutes (centre), immediately after water suppression (right)

[4] These images were taken from test video provided to CSIRO from VBA. The video was made by Warringtonfire and provided to the VBA.

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Figures 9 to 13 show the test specimen post-test.[5]

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Figure 9. Post-test external rendered EPS wall system prior to any deconstruction. Main wall (left) wing wall (right)

Figure 10. Post-test wall system non-fire exposed side. Wing wall (left), Main wall (tight)

[5] The images were taken by CSIRO during the post-test inspection on 5 June 2020.

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Figure 11. Post-test wall system with all regions of heavily heat affected render removed showing EPS behind melted/burnt away

Figure 12. Post-test wall system close-up of combustion chamber opening and region of most heavily charred timber framing and heat effected plasterboard

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Figure 13. Post-test wall system showing render thickness hole saw samples. Right photo shows close up hole saw sample on left side of combustion chamber with EPS behind completely melted/burnt away.

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C.4 Tabulated summary test measurements

The following summary test measurements (Table 4) have been determined from the Warringtonfire test report and CSIRO review of the test video. In some cases, timing of temperatures has been interpolated from temperature versus time graphs and are approximate only.

Table 4. Summary test measurements

Parameter	**Results**
t_s test start time. The time when the temperature measured by any external thermocouple at level 1 exceeds 200 °C above ambient.	3 minutes 50 seconds (230 seconds) after ignition of crib
Time level 1 external temperature > 600 °C above ambient for 30 seconds or more.	~2 minutes (120 seconds) after t_s
Time level 2 external temperature > 600 °C above ambient for 30 seconds or more.	4 minutes 59 seconds (299 seconds) after t_s
Time level 2 EPS layer temperature > 250 °C above ambient for 30 seconds or more.	6 minutes 30 seconds (390 seconds) after t_s
Time level 2 EPS layer temperature > 600 °C above ambient for 30 seconds or more.	~ 7 minutes 10 seconds (430 seconds) after t_s
Time level 2 cavity temperature > 250 °C above ambient for 30 seconds or more.	5 minutes 51 seconds (351 seconds) after t_s
Time level 2 cavity temperature > 600 °C above ambient for 30 seconds or more.	~ 7 minutes 30 seconds (450 seconds) after t_s
Time of pool fire starting at base	~ 3 minutes 10 seconds (190 seconds) after t_s
Time of frequent flaming at Level 2	~ 4 minutes 40 seconds (280 seconds) after t_s
Time of frequent flaming at top of specimen	~ 5 minutes 40 seconds (340 seconds) after t_s
Time of test suppression with water	8 minutes 22 seconds (502 seconds) after t_s 12 minutes 12 seconds (732 seconds) after crib ignition

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Appendix D Details of comparison against BRE DCLG post Grenfell BS8414 tests

The UK Department for Communities and Local Government (DCLG) sponsored BRE Global to undertake a total of seven BS 8414 Façade Tests on three different categories of ACPs with three different insulation types[3-9]. This appendix summarises the details of the seven BRE façade tests on ACP and provides a table summarising timing of key events and measurements and comparing this to the VBA Rendered EPS test.[6]

The range of ACP and Insulation materials tested are summarised in Table 5.

Table 5. Material types tested in BRE DGLC BS8414 tests

Material Type	Material Name	Description
ACP	ACP-PE	ACP with Gross heat of combustion of ~46.4 MJ/kg, total thickness = 4 mm, core thickness = 3 mm. (BRE CAT3 – No flame-retardant properties - > 35 MJ/kg)
	ACP-FR	ACP with Gross heat of combustion of ~ 13.6 MJ/kg, total thickness = 4 mm, core thickness = 3 mm. (BRE CAT2 – Limited flame retardant - > 3 MJ/kg and ≤ 35 MJ/kg)
	ACP A2	ACP with Gross heat of combustion of ~ 2.3 MJ/kg, total thickness = 4 mm, core thickness = 3 mm. (BRE CAT1 Limited combustibility - ≤ 3 MJ/kg)
Insulation	PIR	100 mm, foil faced, density 31.2 kg/m3, moisture content from 2.4% to 3.9%
	MW	180 mm, density 47.7 kg/m3, moisture content from 0.5% to 0.6%
	Phenolic	100 mm, foil faced, density 32 kg/m3, moisture content 8.5%

The installation details are summarised in Table 6, Figure 14 and Figure 15 below.

The installations included vertical and horizontal cavity barrier. These have not typically been installed to ACP clad buildings in Australia.

[6] Information on DGLC sponsored BRE BS8414 tests on ACP is provided at https://www.gov.uk/government/news/expert-panel-recommends-further-tests-on-cladding-and-insulation

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Table 6. Installation details for BRE DGLC BS8414 tests

Installation Detail	Description
Framing and fixings	Cladding brackets and framing were generally aluminium profiles with steel screws and fixings.
Vertical cavity barriers	75 mm wide stone wool with stated integrity/insulation performance of 90/30 minutes, compressed 10 mm. Depth of cavity barriers was varied between tests with different insulation thickness to maintain 55 mm air gap cavity for all tests. Two vertical cavity barriers on were installed on main wall 1980 mm apart with the combustion chamber opening centred between them. The wing wall had the vertical barrier at the outside edge about 1250 mm from the main wall.
Horizontal cavity barriers	75 mm wide stone wool with intumescent. Stated integrity/insulation performance of 90/30 minutes. The intumescent looks like a 15mm thick foam attached to the edge of the stone wool horizontal barrier. Depth of cavity barriers was varied between tests with different insulation thickness to maintain a 25mm gap between the horizontal cavity barrier and the ACP to allow ventilation vertically. The horizontal cavity barriers were installed at the following locations: • directly above the combustion chamber opening • 2395 mm above the first cavity barrier • 2330 mm above the second cavity barrier • close to the top of the rig, 1635 mm above the third cavity barrier and 6360 mm above the combustion chamber opening.
Air gap cavity	The air cavity between the insulation and the rear surface of the ACP was 50-55 mm.
ACP fixing and jointing	ACP panels were mechanically fixed as flat sheets (edges were not folded). They were installed with 20 mm gaps between all edges of ACP panels. The core was exposed at the panel edges and the gaps between panels were left open (not filled with sealant).
Window pod	A prefabricated welded window pod constructed of 5 mm thick aluminium was fixed to the combustion chamber opening with steel screws. The window pod extended perpendicular from the masonry wall so that it extended ~ 30 mm beyond the front face of the finished cladding system.
Total installation dimensions	• Height above combustion chamber = 6492 mm (requirement ≥ 6000 mm). • Width across main wall = 2615 mm (requirement ≥ 2400 mm). • Width across wing wall = 1340 mm (requirement ≥ 1200 mm) • Wing wall to combustion chamber opening = 222 mm (requirement = 260 ±100 mm • Combustion chamber opening = 2000 mm x 1940 mm (requirement = 2000 mm x 2000 mm ±100 mm).

Figure 14 Left – Horizontal and vertical cavity barrier installed through entire depth and aluminium cladding support brackets bolted to masonry wall (MW insulation being installed to wing wall), Centre – cavity barriers and MW insulation installed, Right – Aluminium railing sub structure installed (all photos taken from BRE test report.

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Figure 15. Left – Aluminium window pod, combustion chamber and ACP joints and fixing detail. Right – complete façade system prior to test (all photos taken from BRE Test report

The BS 8414 standard specifies a test method but does not specify any pass/fail criteria.

BRE published BR-135 as a guidance document which also specifies the pass-fail criteria to be applied for assessment of BS 8414 façade fire tests. The UK and some of Europe apply the BS8414 test in conjunction with BR135 test criteria. This is the same test method that is applied in Australia for AS 5113 however AS 5113 applies different and more stringent test criteria compared to BR-135, and requires some additional rear face thermocouples and debris measurements compared to BS 8414 test in conjunction with BR-135 test criteria.

The UK based Loss Prevention Certification Board (LPCB) and BRE Global ltd has subsequently published LPS 1581[11] and LPS 1582[12] standards for certification of cladding for industry and insurers. These standards build upon BR-135. LPS 1581 and LPS 1582 standards apply all the following tests to classify external wall systems:

- EN 13501-1 Fire classification of construction products and building elements. Part 1: Classification using test data from reaction to fire tests
- all insulation materials assessed for potential glowing combustion via a ramped basket oven test, and
- BS 8414 part 1 and/or part 2 test methods with specified test criteria which are more stringent than BR1-35 but different to AS 5113.

A detailed comparison of these three different sets of classification criteria for BS 8414 tests is provided in Table 7. The VBA Rendered EPS test failed to pass the classification criteria for both BR-135 and LPS 1582.

The BRE DCLG post Grenfell BS8414 tests on ACP were conducted in accordance with BS8414 but applied BRE BR-135 classification acceptance criteria.

A detailed comparison of BRE DCLG post Grenfell BS8414 tests on ACP and the VBA BS8414 test on rendered EPS is provided in Table 8.

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Table 7. Comparison of classification criteria applied to BS 8414 tests by AS 5113, BR-135 and LPS 1582-1.

Classification criteria summary	AS 5113 Criteria	BR-135 Criteria	LPS 1582-1 criteria
Temperatures 5 m above the opening measured 50 mm from the exposed specimen face	shall not exceed 600°C for a continuous period greater than 30 seconds, within entire test period.	shall not exceed a rise of 600°C above T_s (ambient temperature) for a continuous period greater than 30 seconds, within 15 minutes of start time (t_s).	shall not exceed a rise of 600°C above T_s (ambient temperature) for a continuous period greater than 30 seconds, within 30 minutes of start time (t_s).
Temperatures at the mid-depth of each combustible layer or any cavity 5 m above the opening	shall not exceed 250°C for a continuous period of greater than 30 seconds, within entire test period.	shall not exceed a rise of 600°C above T_s (ambient temperature) for a continuous period greater than 30 seconds, within 15 minutes of start time (t_s).	shall not exceed a rise of 600°C above T_s (ambient temperature) for a continuous period greater than 30 seconds, within 30 minutes of start time (t_s).
Temperatures on the unexposed face of the specimen 900 mm above the opening	Where the system is attached to a wall that is not required to have an FRL of –/30/30 or 30/30/30 or more, the temperature on the unexposed face of the specimen 900 mm above the opening shall not exceed a 180 K rise.	No Criteria – not required to be measured.	No Criteria - not required to be measured.
Flaming or the occurrence of openings in the unexposed face of the specimen above the opening	Where the system is attached to a wall not required to have a fire resistance of –/30/30, 30/30/30 or more, flaming or the occurrence of openings in the unexposed face of the specimen above the opening shall not occur.	No Criteria – observations typically recorded.	Burn through of the system and continuous flaming (flame with a duration in excess of 60 seconds) observed anywhere on the internal surface of the test specimen at or above a height of 2m below Level 1 within the duration of the full 60 minute test period.
Flame spread beyond the confines of the specimen	Flame spread beyond the confines of the specimen in any direction, as determined during the post-test examination, shall not occur. The examination shall include flame damage such as melting, charring but not smoke discolouration or staining of the surface, any intermediate layers and the cavity.	No Criteria. However, this is captured by early test termination criteria.	Failure of the system is deemed to have occurred if visible flaming, which exceeds the confines of the test rig either vertically or laterally during the full 60 minute test period, is observed. For the purposes of this clause, visible flaming is defined as a continuous flame which is observed for more than 60 seconds duration (i.e. not intermittent or glowing).
Debris flaming	Continuous flaming on the ground for more than 20 s from any debris or molten material from the specimen shall not occur.	No Criteria - observations typically recorded.	Failure is deemed to occur if burning debris or a pool fire develops on the floor of the test facility, outside the designated crib collapse zone. Burning debris is defined as visible flaming for more than 60 seconds duration (i.e. not intermittent or glowing) within the duration of the full 60 minute test period. The crib collapse zone is defined as a 2.4m x 1.2m positioned centrally on the centre line of the hearth opening (2.4m length parallel to the face of the hearth).

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Classification criteria summary	**AS 5113 Criteria**	**BR-135 Criteria**	**LPS 1582-1 criteria**
Debris mass	The total mass of debris falling in front of the specimen shall not exceed 2kg. The mass shall be measured after the end of the test result.	No Criteria - observations typically recorded.	Failure will be deemed to have occurred if there is collapse of the system or part thereof, flaming or not, onto the floor of the test facility outside the designated crib collapse zone, within the duration of the full 60-minute test period. The crib collapse zone is defined as a 2.4m x 1.2m positioned centrally on the centre line of the hearth opening (2.4m length parallel to the face of the hearth). Note – no debris mass limit is specified in this criteria.
Early test termination	No classification criteria However early test termination is required by BS 8414 if: a) flame spread extends above the test apparatus at any time during the test duration, or b) there is a risk to the safety of personnel or impending damage to equipment.	In order for a classification to be undertaken, the system must have been tested to the full test-duration requirements of BS 8414 without any early termination of the full fire-load exposure period.	Failure of the system is deemed to have occurred if the test is terminated within the duration of the full test period for any safety reason.
Glowing combustion	No classification criteria.	No classification criteria.	Where an insulation product exhibits the propensity for glowing combustion failure in relation to this standard is deemed to occur: • if the area of system damage spreads vertically beyond level 2 or reaches the outer edge of the wing wall, in the area between Level 1 and Level 2, within 24 hours of the termination of the full 60-minute test period and /or, • if penetration through the internal surface of the system is found at in any point on the test specimen.

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Table 8. Comparison of VBA rendered EPS BS8414 test against BRE DCLG post Grenfell BS8414 tests on ACP

	Test	1	2	3	4	5	6	7	VBA Rendered EPS test
	ACP	ACP-PE	ACP-PE	ACP-FR	ACP-FR	ACP-A2	ACP-A2	ACP-FR	
	Insulation	PIR	MW	PIR	MW	PIR	MW	Phenolic	
BR135 classification criteria	BR135 result	Fail	Fail	Fail	Pass	Pass	Pass	Fail	Fail
BR135 classification criteria	Flame spread above top of test rig and test terminated early (< 30 min) after ignition	Yes	Yes	Yes	No Note 8	No	No	Yes	Yes
BR135 classification criteria	Level 2 external temperature > 600 °C above ambient for a period of at least 30 s, within 15 minutes of t_s	Yes	Yes	No	No	No	No	No	Yes
BR135 classification criteria	Level 2 cavity temperature > 600 °C above ambient for a period of at least 30 s, within 15 minutes of t_s	N/A Note 7	N/A Note 7	No	No	No	No	No	Yes
BR135 classification criteria	Level 2 insulation temperature > 600 °C above ambient for a period of at least 30 s, within 15 minutes of t_s	N/A Note 7	N/A Note 7	No	No	No	No	No	Yes
Start time, t_s (seconds after crib ignition) Note 1		130 s	118 s	110 s	85 s	105 s	105 s	115 s	230 s
Time Level 2 external temperature > 600 °C above ambient for a period of at least 30 s		360 s	305 s	1190 s	Not clearly reported ~ 1270-1340 s	Did not occur	Did not occur	1500 s	299 s
Time of frequent flaming above level 2		300 s	275 s	475 s	Not clearly reported ~ 1000 s	945 s Note 3	998 s Note 4	Not clearly reported	280 s
Time of frequent flaming above top of test rig		370 s	305 s	1390 s	Did not occur	Did not occur	Did not occur	1566	340 s
Test Termination (crib ext.) time		395 s (early)	314 s (early)	1402 s (early)	1775 s (30 min after ign)	1695 s (30 min after ign)	1695 s (30 min after ign)	1579 s (early)	502 s
Time of flaming debris burning > 20 s (s)		170 s	195 s	375 s	335 s	435 s	Not reported	390 s Note 5	420
Time of pool fire starting at base (s)		200 s	Not reported	430 s	485 s	505 s	Not reported	611 s Note 6	420

- Note 1 - Start time, t_s is measured from crib ignition time is defined as the time when the temperature measured by any external thermocouple at level 1 exceeds 200 °C above ambient.
- Note 2 – All other times in above table are measured from Start time, ts.

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- Note 3 – report states *"Flickering flames observed in the horizontal joint above panels 2C&2D"* at level 2.
- Note 4 - report states *"Flame tips to Level 2 thermocouples*".
- Note 5 – report states "*Steady stream of flaming debris from the system"*.
- Note 6 – report states *"Flaming material in front of hearth"*.
- Note 7 – temperature criteria cannot be applied as test was terminated early prior to 15 minutes of t_s. Failure may possibly have occurred if test had not been terminated early.
- Note 8 – Test 4 ACP-FR with MW test report states at 1340 s *"Frequent flaming along main-wing wall junction to top of the cladding system"*. Based on this it is assumed flames reached the top of the test rig but did not extend above the test rig and therefore the test was not terminated early. It is noted that Test 3 ACP-FR with PIR test report states that flame tips extended > 1m above test rig prior to early test termination.

15 minutes = 900 s, 30 minutes = 1,800 s.

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