Fire Protection Association®

FIRE RESEARCH AND TESTING REPORT

REFERENCE NUMBER: FPA/107586

PREPARED BY THE FIRE PROTECTION ASSOCIATION, MORETON-IN-MARSH, GL56 0RH

THE UK'S NATIONAL FIRE SAFETY ORGANISATION

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1.0	10/09/2025	Initial Release
2.0	04/11/2025	Updated with client comments
3.0	20/01/2026	Updated with client comments
4.0	02/04/2026	Updated with client comments

Contents

1 Introduction

1.1 Background

This report is produced by the Fire Protection Association (FPA) to provide technical documentation of the methodology, data analysis and summary of results into the fire performance of insulation products within a flat roof assembly while exposed to a PV solar panel fire.

This was requested by Insulation Manufacturers Association. Conducted in response to purchase order ref QUT-10436.

1.2 Aim

The aim of this research was to assess the fire performance and behaviour of two different insulation products, readily available from the UK market and known to the test laboratory, within a flat roof assembly with reinforced bituminous roofing membranes while being exposed to a PV solar panel fire.

The two insulation products selected were:

1. Polyisocyanurate (PIR) Insulation product
2. Stone wool insulation product

The FPA was requested to conduct these tests using the enclosed burn hall and testing facility in order to avoid wind influence which would be expected if the test was conducted outside.

1.3 Scope

Two tests were conducted by the FPA for this research.

The behaviours measured/observed were:

- Temperatures between the two layers of insulation and below of the insulation layer using thermocouples.
- The surface area of fire spread on the cap sheet of the roof.

Both tests had identical test layouts and procedural variables. The primary difference between the two roof assemblies was the insulation product used between the roof membrane and roof underlayer:

- TEST 1 : PIR Insulation product was conducted by the FPA on the 24th of June 2025
- TEST 2: Stone wool insulation product was conducted by the FPA on the 14th of August 2025

2 Test Specimen

2.1 PIR insulation Product

Figure 1: PIR insulation test roof assembly and set-up of solar panels.

Figure 2: PIR insulation assembly and thermocouple layout.

2.2 Stone wool insulation Product

Figure 3: Stone wool insulation test roof assembly and set-up of solar panels.

Figure 4: Stone wool insulation assembly and thermocouple layout.

3 Methodology

3.1 Overview

Testing was conducted at the Fire Testing Laboratory in Blockley, Gloucestershire, GL56 9LH, using the FPA's burn hall and research testing facility. The burn hall has a capacity of 10m x 10m x 5m height and incorporates safety and environmental controls.

This research was to assess the fire performance and behaviour of two different insulation products within a flat roof assembly with reinforced bituminous roofing membranes while being exposed to a PV solar panel fire.

3.2 Test setup

3.2.1 Test configuration

The roof assembly had a total span of 7.4m x 8.4m.

Both tests had identical test layouts and procedural variables. The independent variable for the two tests was the insulation product between the roof membrane and roof underlayer.

The two insulation products selected were:

1. PIR Insulation product
2. Stone wool insulation product

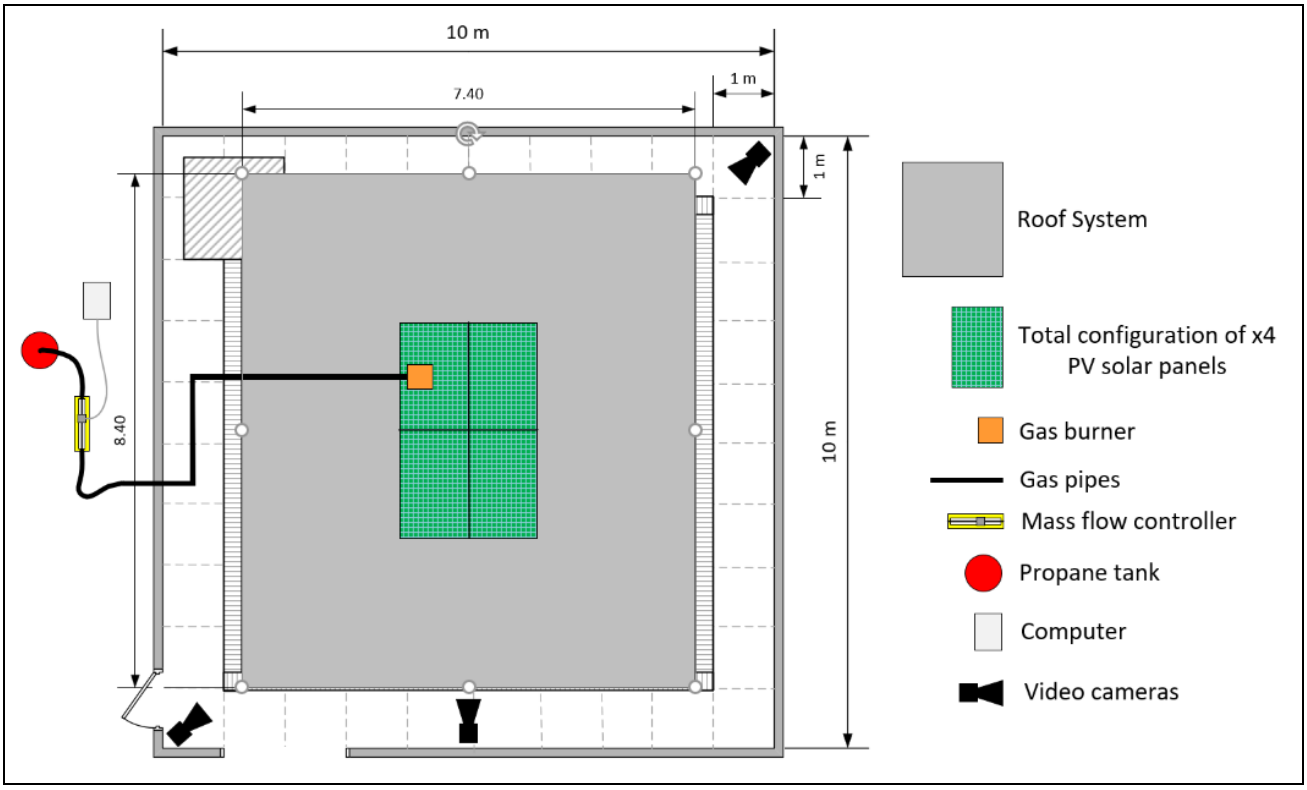

Figure 5: Test configuration.

3.2.2 Materials

The clients roof system was configured of 6 principal components:

1. Wooden roof frame
2. Steel deck
    a. Thickness – 0.7mm
    b. Depth – 100mm
    c. Primer
    d. Lamellas for infill of outer ends of troughs to prevent airflow
3. Membrane below insulation
    a. Bituminous air and vapour control layer (AVCL)
4. Insulation product (PIR insulation product / Stone wool insulation product)
    a. PIR and stone wool with equivalent thermal performance to achieve a U-value of 0.15 kW/m^2 K.
        i. PIR – Two layers of 80mm each = 160mm total (U-value 0.152 rounded to 0.15) Reaction to fire classification F in accordance with EN1350-1
        ii. Stone wool – Two layers of 150mm base layer + 105mm layer (Bonded together then bonded with a PU adhesive) Reaction to fire classification A1 in accordance with EN13501-1
    b. The insulation materials were sourced from the UK market, and the brands are known to the test laboratory.
5. Membrane above insulation layer (Waterproofing layer)
    a. Bituminous self-adhesive underlayer
    b. Torch-applied SBS elastomeric bitumen capping sheet
6. PV panels and mounting system
    a. Mount – K2 D-DOME in East/West orientation
    b. Modules – 4 x Solarwatt classic

3.2.3 Fuel load

Four PV solar panels had a central placement to the roof assembly with a span of 2.25m x 3.52m.

The solar panels were in the centre of the roof assembly. As the solar panel configuration was rectangular, the longer edges were facing away from the shutter doors (See Figure 6).

A 15kW propane gas burner regulated by a mass flow controller was used to maintain a 10 minute exposure thus igniting one of the solar panels. The gas burner was placed under one of the solar panels at a depth of 120mm and a height of 80mm (See Figure 6).

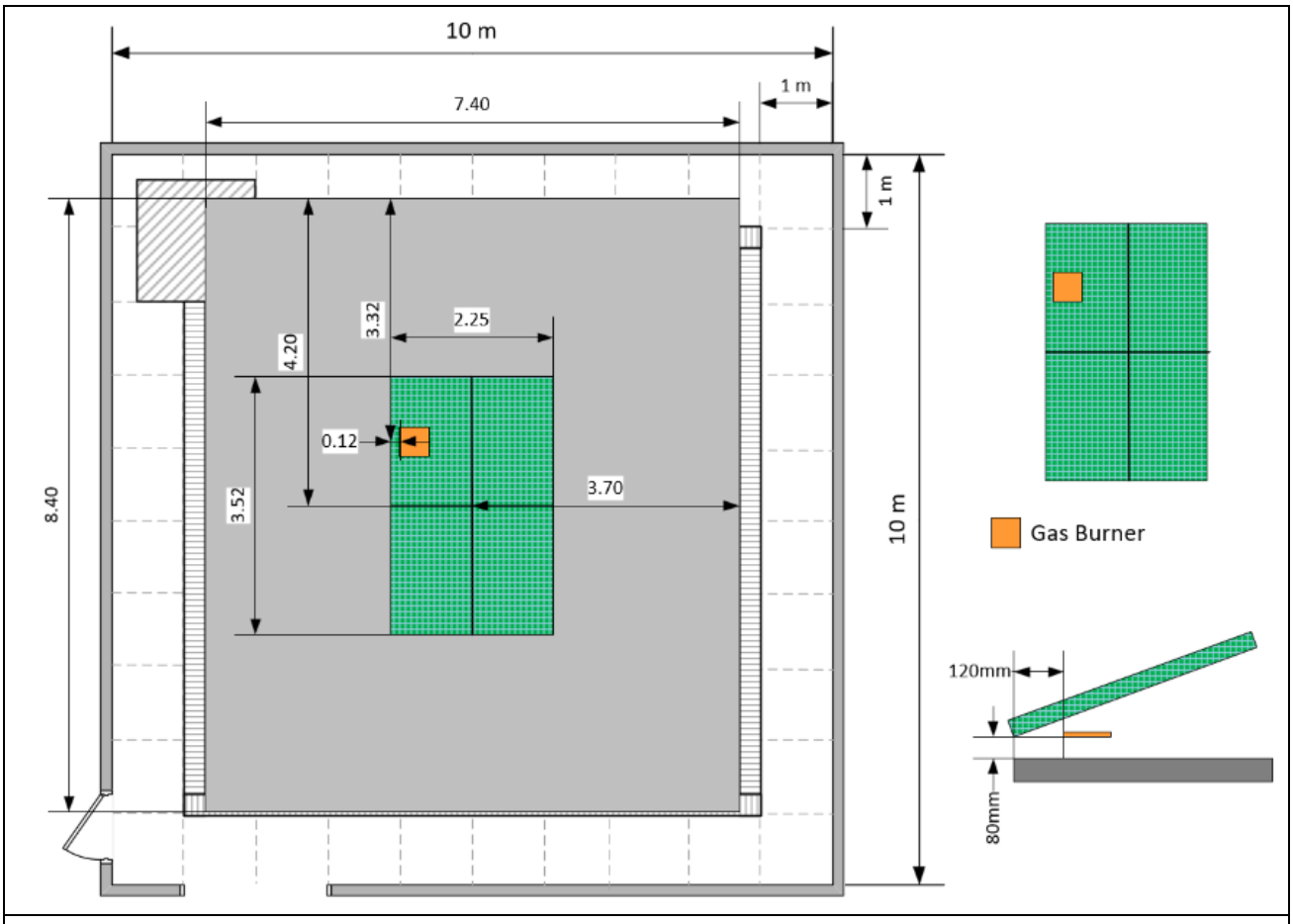

Figure 6: PV solar panel and gas burner configuration.

Figure 7: Mass flow controller set-up.

3.2.4 Instrumentation

A mass flow controller was used to regulate the propane gas burner (See Figure 7).
A datalogger was used to record all thermocouple readings throughout the tests.

x20 K-Type Thermocouples were used for each test in total.

See Figure 8 for the array of thermocouples between the AVCL and insulation product. (x9 Thermocouples)

See Figure 9 for the array of thermocouples between the two layers of insulation product. (x9 Thermocouples)

(All thermocouples within the roof assembly were set at an offset of 100mm from the alignment of the solar panel configuration to prevent the solar panel base frame being directly over the top of the thermocouples.)

See Figure 10 for the array of thermocouples located within the testing facility. (x2 Thermocouples)

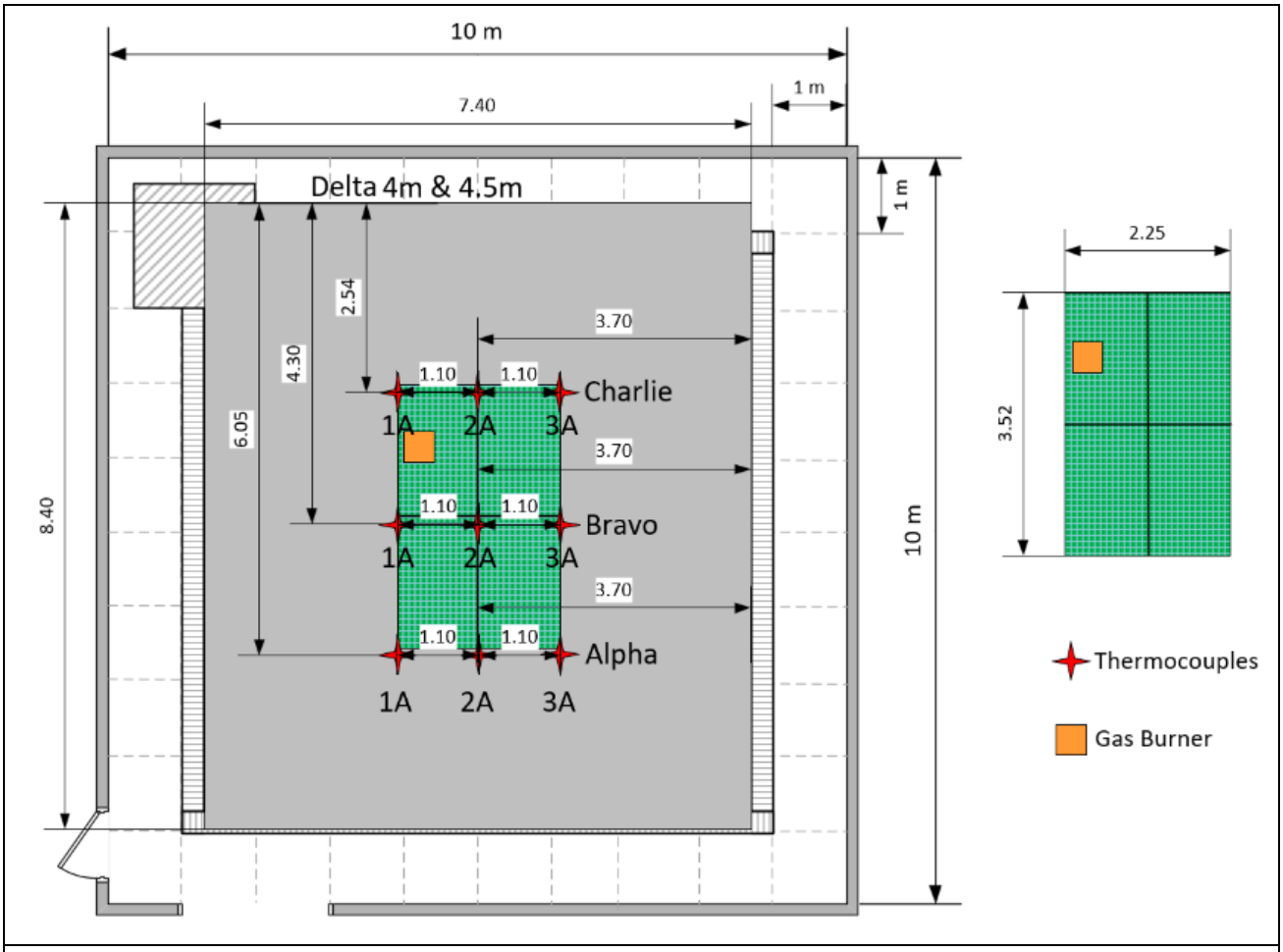

Figure 8: Array of thermocouples between the AVCL and the insulation.

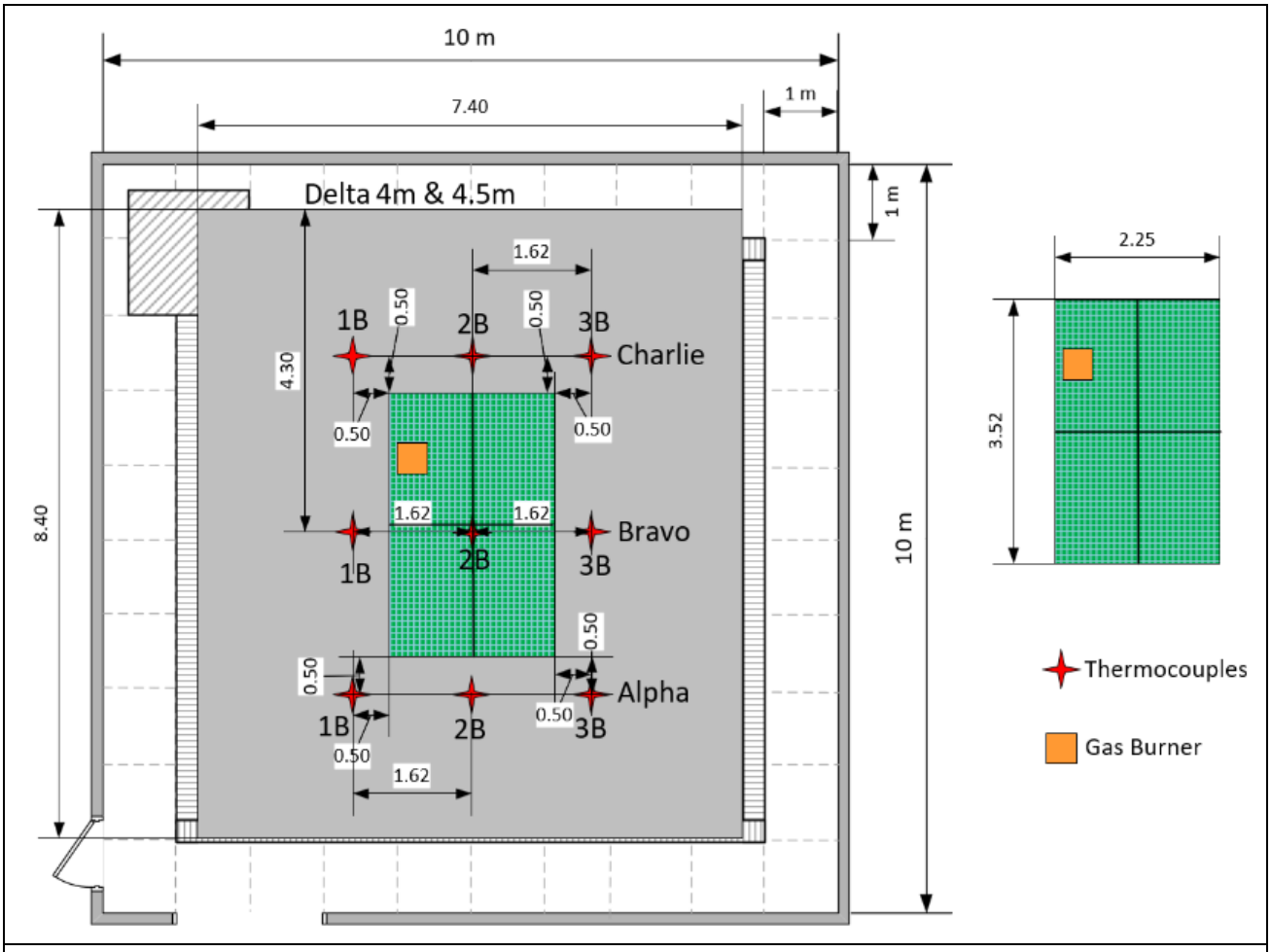

Figure 9: Array of thermocouples between the two layers of insulation.

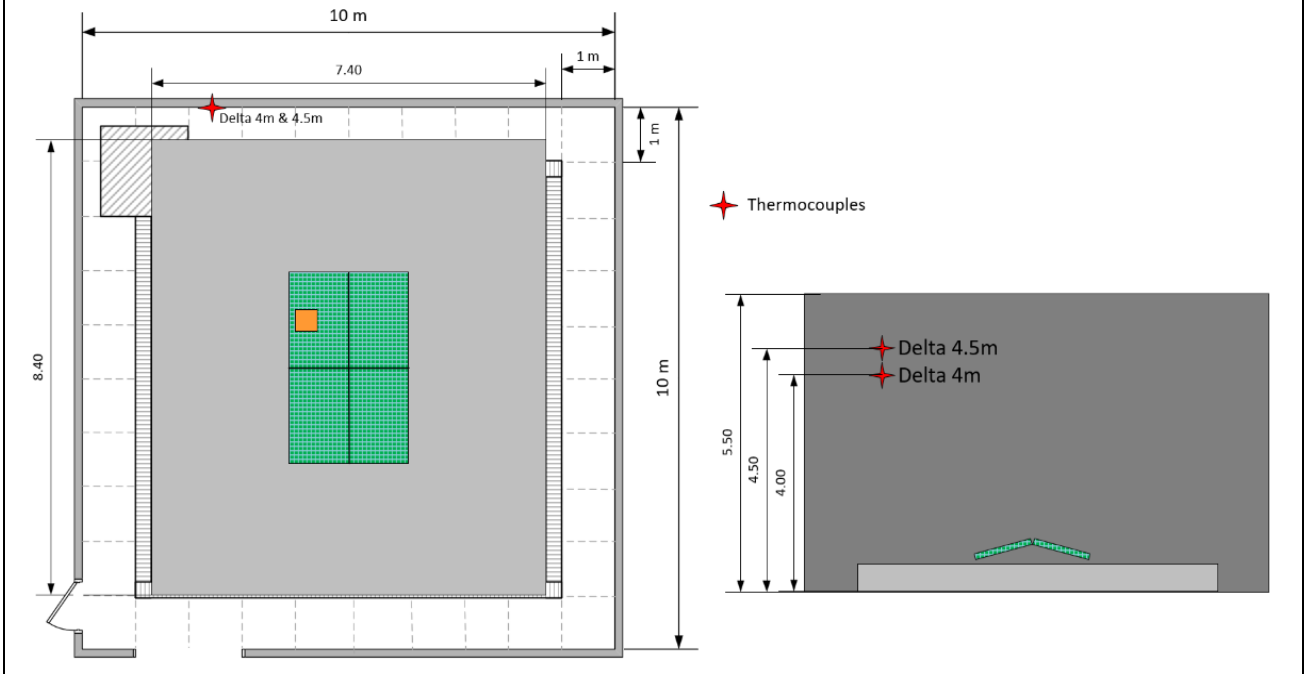

Figure 10: Array of thermocouples within the testing facility

3.2.5 Video recording

Three video cameras were installed throughout the facility.

Camera locations:

- Camera 1 / Front left corner of the roller shutter
- Camera 2 / Back right corner of the roller shutter
- Camera 3 / Central to the solar panels

See figure 5 for diagram of video camera locations.

Figure 11: Video camera view front left corner of the roller shutter. (Camera 1)

Figure 12: Video camera view back right corner of the roller shutter. (Camera 2)

Figure 13: Video camera view central to the solar panels. (Camera 3)

3.3 Test procedure

3.3.1 Test method

1. Start datalogger and check instrumentation is operating correctly
2. Begin regulating gas burner flow
3. Gas ignition + Start stopwatch
4. Maintain gas exposure for 10 minutes
5. Stop gas fire exposure
6. Allow fire to continue
7. Terminate test at burnout or if the fire poses a threat to personnel or the facility

Table 1 – Test procedure

Nominal time (ss:mm)	Event
-10:00	Start datalogger and check instrumentation
-00:05	Begin regulating gas burner flow
00:00	Ignite gas burner + start stopwatch
+10:00	Stop gas fire exposure
+21:50	Terminate test + turn on suppression systems

3.3.2 Suppression systems

The FPAs burn hall and research testing facility has an incorporated overhead suppression system which was used to terminate the tests.

Additional suppression method was a firefighting hose which was used to ensure all flames are extinguished and for post-test temperature control.

3.3.3 Ventilation Conditions

A smoke extraction system was in use providing minimal forced ventilation.

Vents on the side of the burn hall and testing facility were open, and the roller shutter remained partially open to allow for natural ventilation during the test.

During Test 1, wind was travelling in a West direction allowing wind to enter through the vents on the side of the facility. Post- test observations saw majority of fire spread was in the West direction.

During Test 2, wind was travelling in a South direction allowing wind to enter through the partially open roller shutter. Post-test observations saw majority of fire spread was in the Southwest direction.

3.3.4 Test termination

Test 1 was terminated at 21 minutes and 50 seconds due to temperatures in the facilities smoke scrubbing system getting too hot.

Test 2 was chosen to have the same termination time at 21 minutes and 50 seconds for consistency.

3.4 Test programme

Two tests were conducted by the FPA for this research.

TEST 1 : PIR Insulation product was conducted by the FPA on the 24th of June 2025.

TEST 2: Stone wool insulation product was conducted by the FPA on the 14th of August 2025.

Both tests had identical test layouts and procedural variables. The primary difference between the two roof assemblies was the insulation product used between the roof membrane and roof underlayer.

3.5 Test criteria

There were no set criteria for the tests.

The behaviours measured/observed were:

- Temperatures between the two insulation layers and below the insulation layer above the AVCL using thermocouples.
- The surface area of fire spread on the cap sheet of the roof.
- Damage to the insulation.

4 Test Results

4.1 Test 1 results – PIR Insulation Product

4.1.1 Photographs

Figure 14: Ignition of gas burner (Camera 3)

Figure 15: Solar panel above gas burner fully involved (Camera 1)

Figure 16: Solar panel opposite gas burner fully involved (Camera 1)

Figure 17: Roof assembly begins to catch alight (Camera 3)

Figure 18: Fire begins to spread across roof assembly (Camera 3)

Figure 19: Solar panel diagonally across from gas burner fully involved (Camera 1)

Figure 20: Solar panel next to gas burner begins to catch alight (Camera 3)

Figure 21: Fire continues to spread across roof assembly (Camera 2)

Figure 22: Fire exhibits further spread across roof assembly (Camera 2)

Figure 23: Test fully extinguished (Camera 3)

4.1.2 Visual observations

Table 2 - Visual observations for test 1

Time from ignition (mm:ss)	Visual observations
00:00	Ignition of gas burner
+06:00	Solar panel above gas burner fully involved
+07:00	Solar panel opposite gas burner fully involved
+07:00	Roof assembly begins to catch alight
+10:00	Stop gas fire exposure
+13:00	Fire begins to spread across roof assembly
+14:00	Solar panel diagonally across from gas burner fully involved
+15:00	Solar panel next to gas burner begins to catch alight
+15:30	Fire continues to spread across roof assembly
+18:00	Fire exhibits further spread across roof assembly
+21:50	Test terminated + turn on suppression systems
+23:00	Test fully extinguished

4.1.3 Fire spread measurements

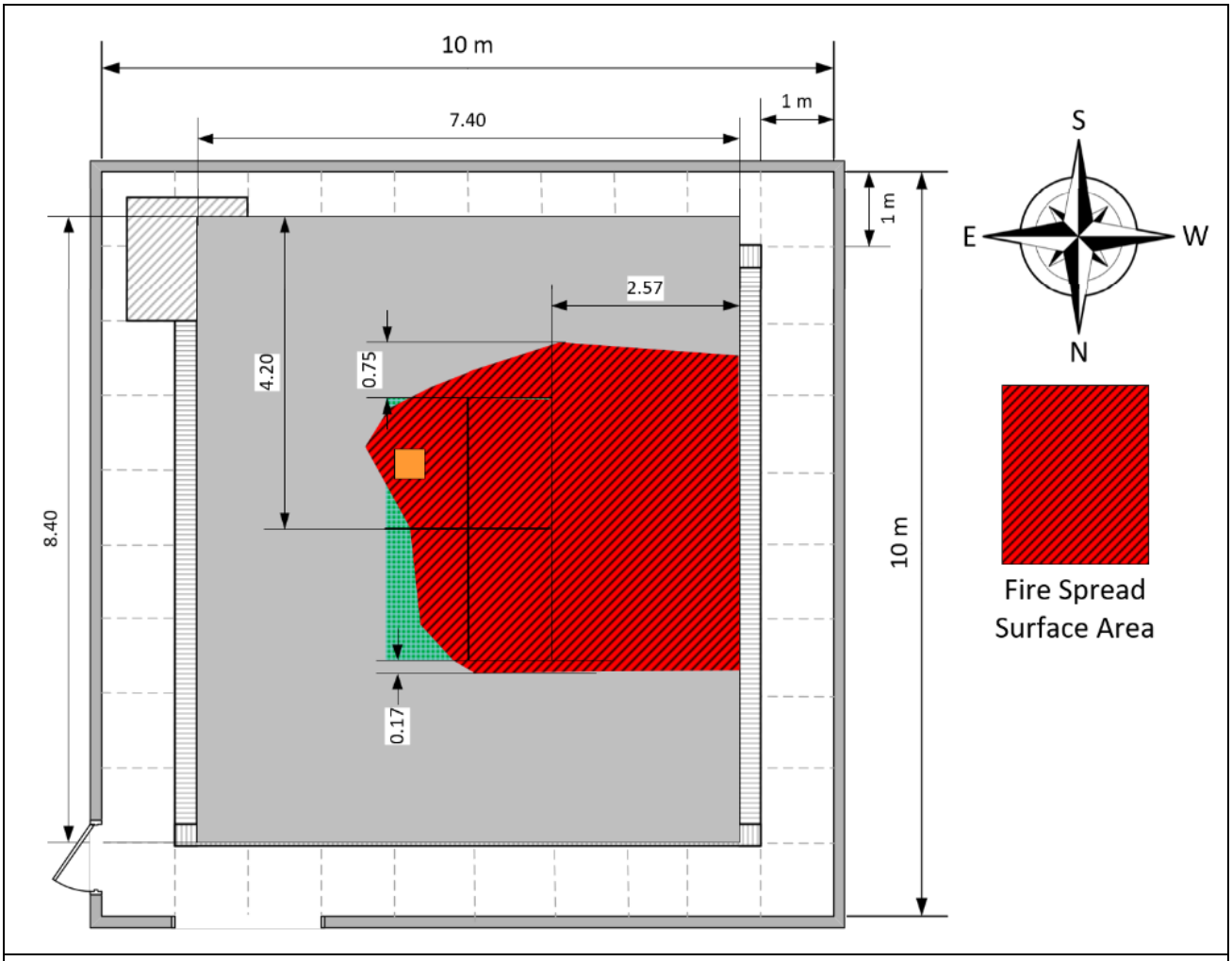

Figure 24: Total fire spread across PIR insulation roof assembly.

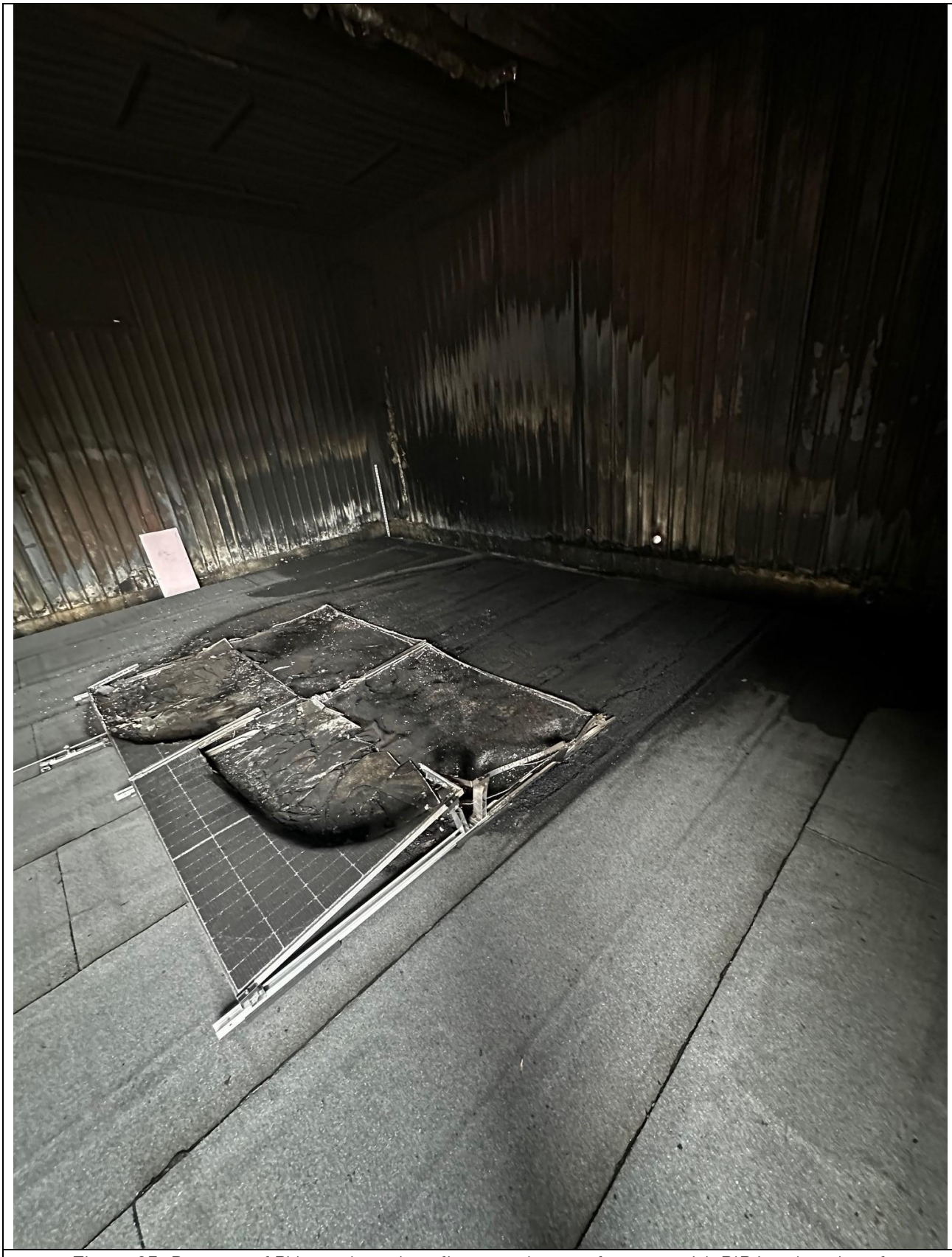

Figure 25: Damage of PV panels and roofing membrane after test with PIR insulated roof.

Figure 26: Damage of PV panels after test with PIR insulation roof.

Figure 27: PIR insulation Post-test.

Figure 28: Charring depth within the PIR insulation Post-test

4.1.4 Test data

4.1.4.1 Thermocouples located between the AVCL and insulation product.

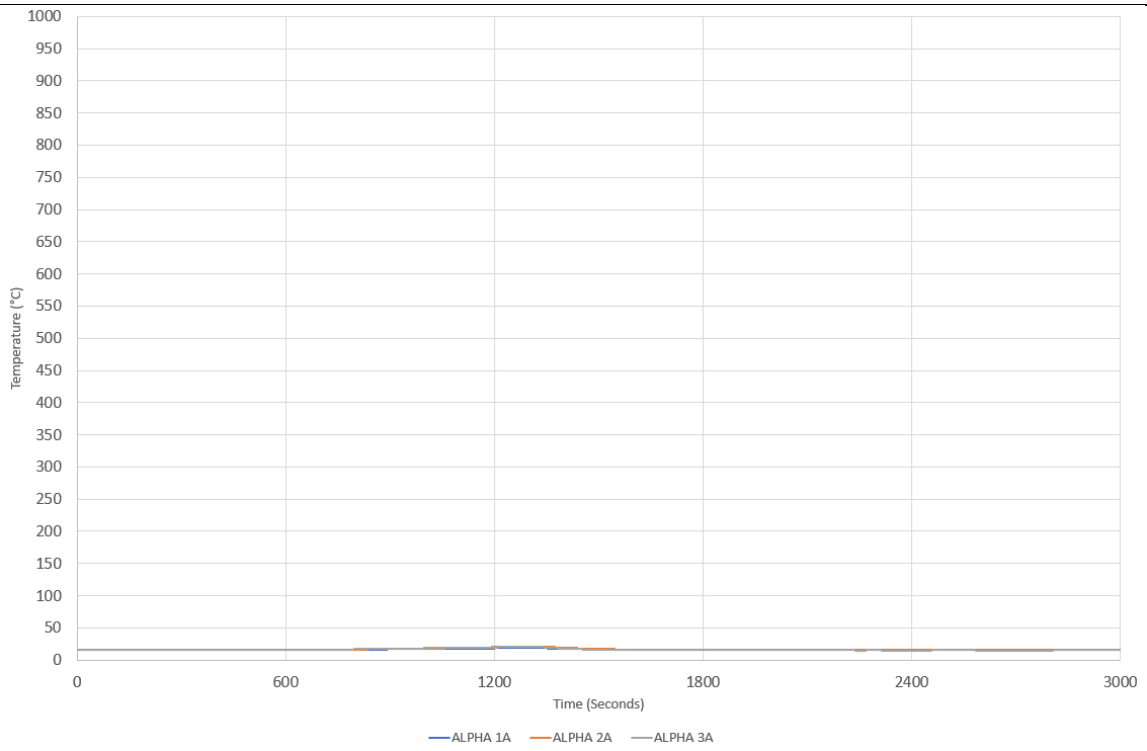

Figure 29: Alpha 1A / 2A / 3A Thermocouple data.

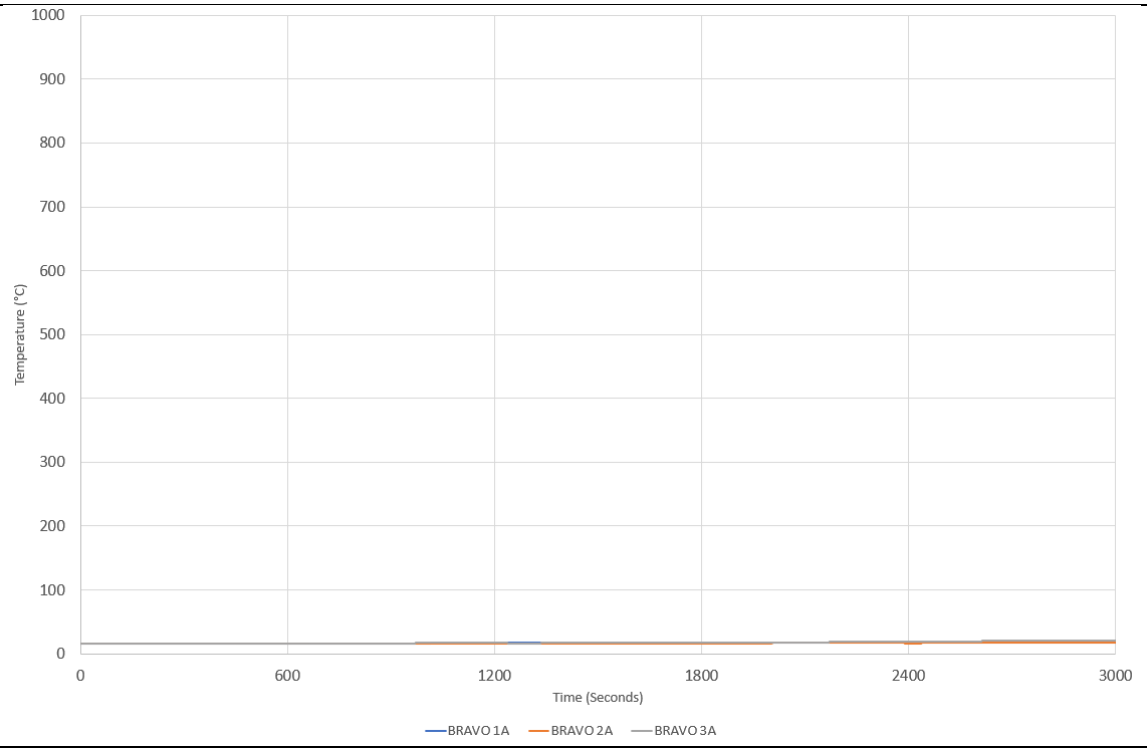

Figure 30: Bravo 1A / 2A / 3A Thermocouple data.

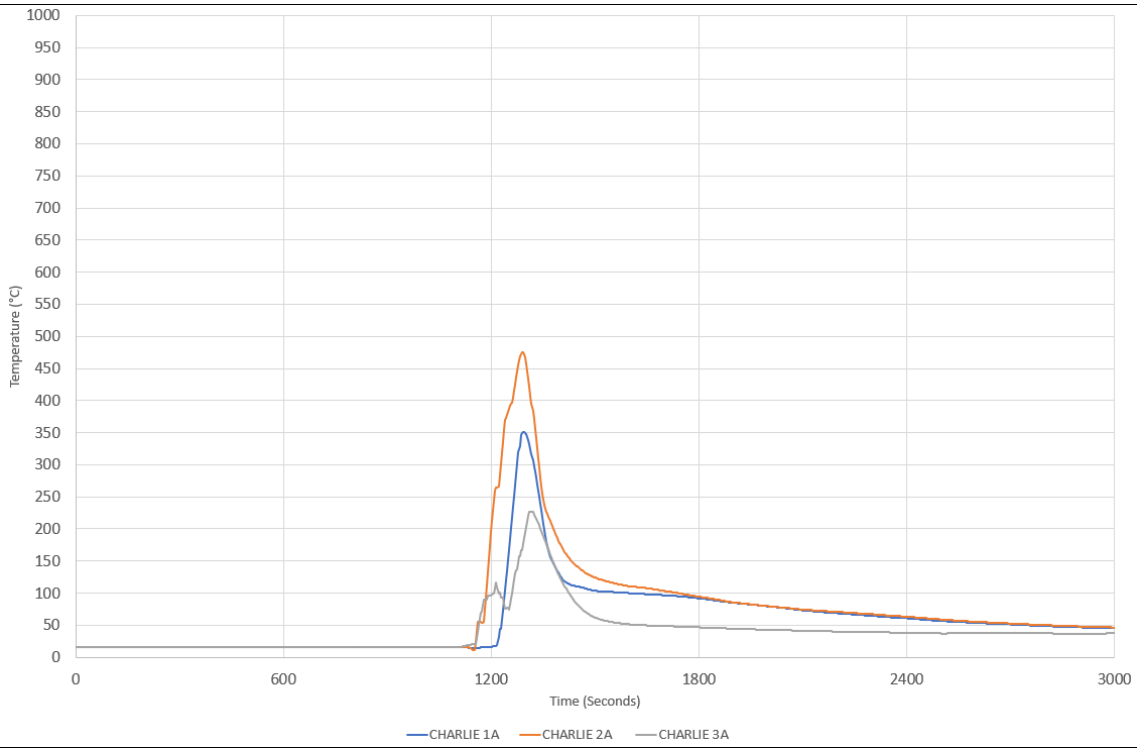

Figure 31: Charlie 1A / 2A / 3A Thermocouple data.

4.1.4.2 Thermocouples located between the two insulation layers.

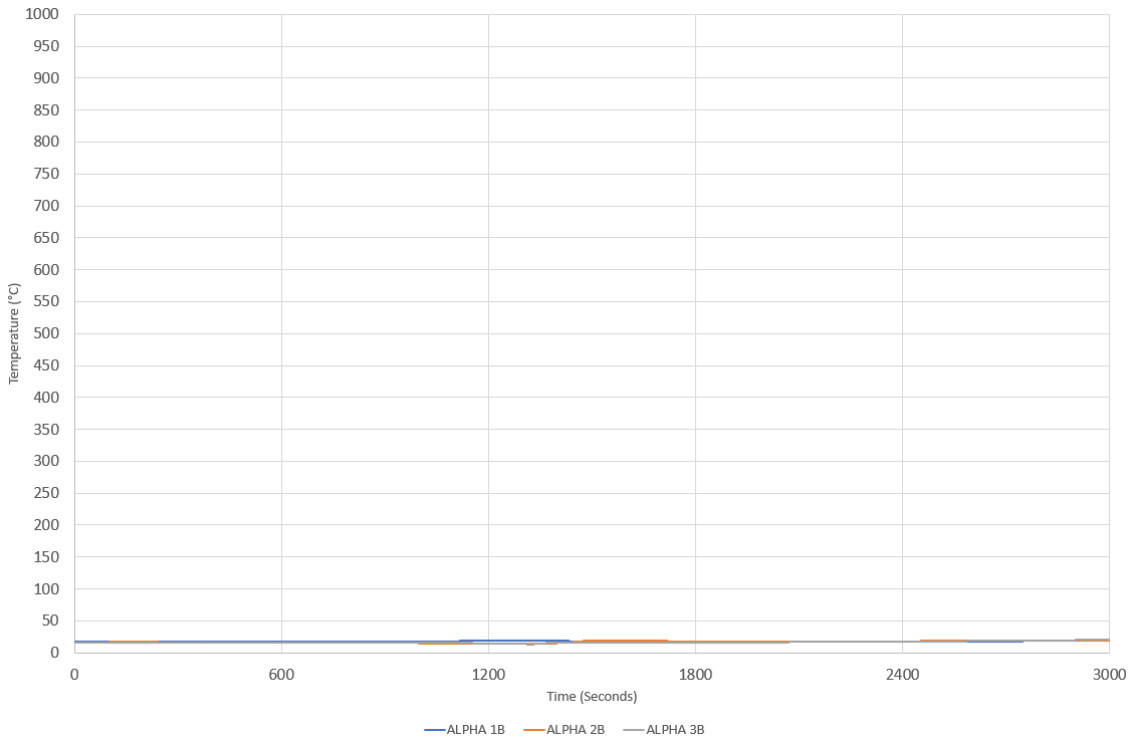

Figure 32: Alpha 1B / 2B / 3B Thermocouple data.

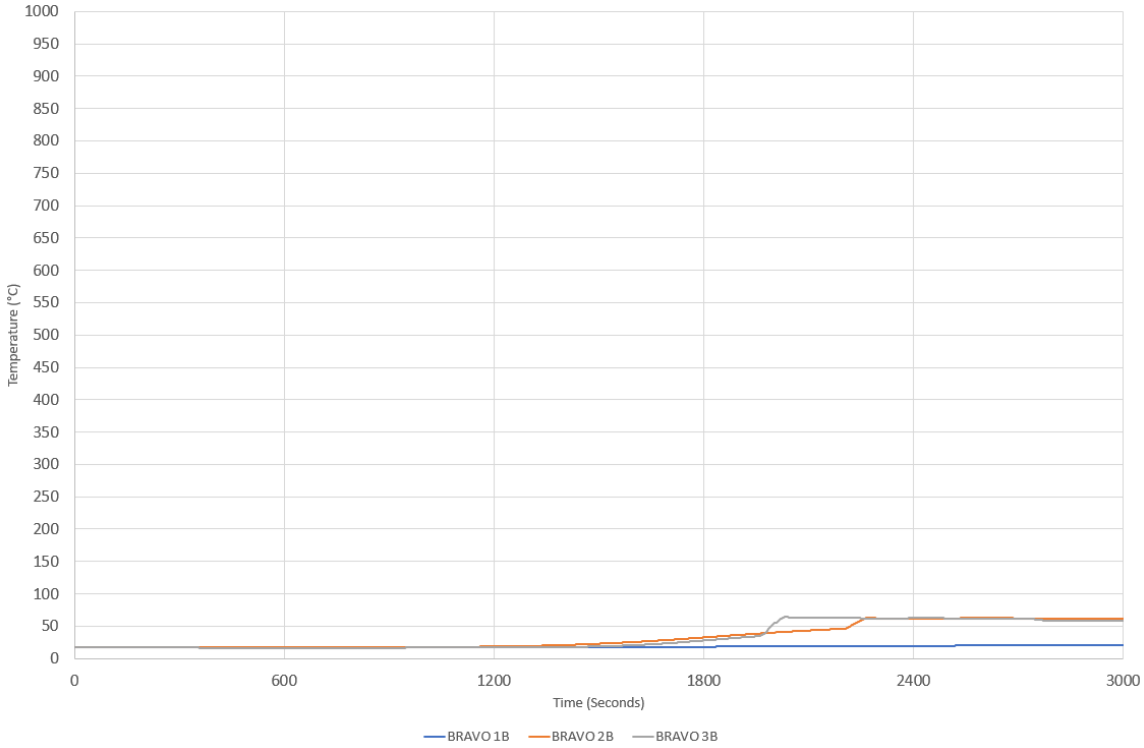

Figure 33: Bravo 1B / 2B / 3B Thermocouple data.

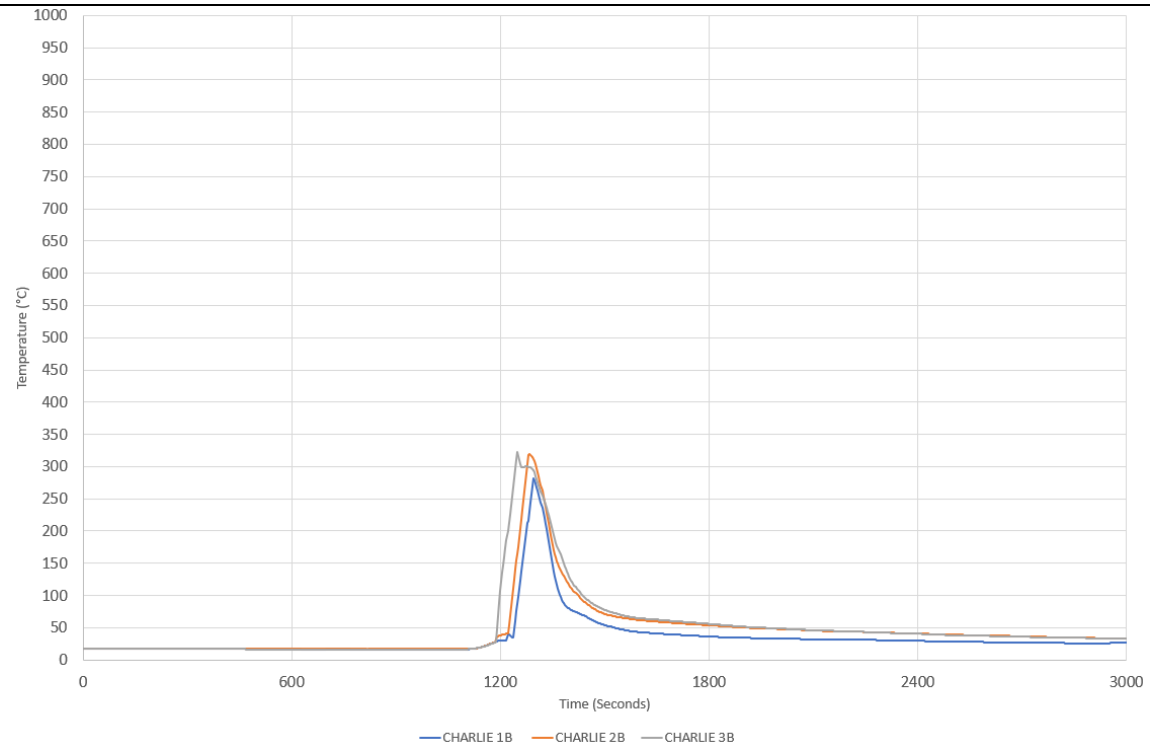

Figure 34: Charlie 1B / 2B / 3B Thermocouple data.

4.1.4.3 Thermocouples located within the testing facility (4m and 4.5m).

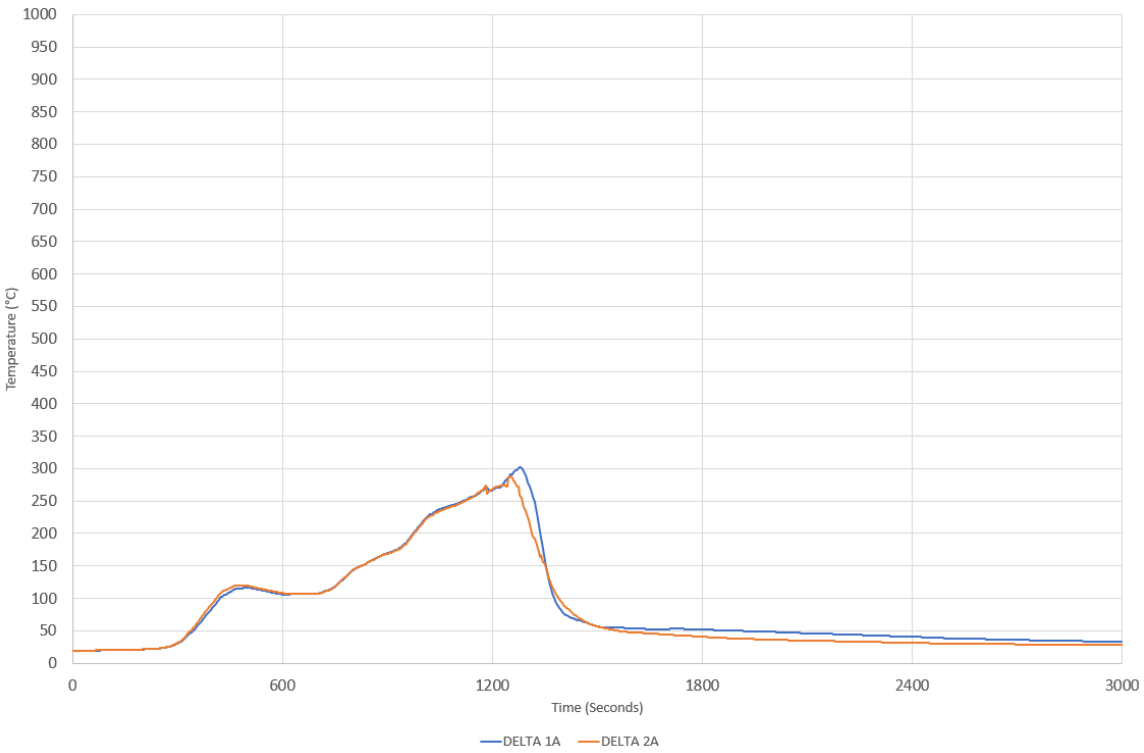

Figure 35: Delta 1A (4m) / 2A (4.5m) Thermocouple data.

4.2 Test 2 results – Stone wool insulation Product

4.2.1 Photographs

Figure 36: Ignition of gas burner (Camera 1)

Figure 37: Solar panel above gas burner fully involved (CCTV)

Figure 38: Roof assembly begins to catch alight (Camera 2)

Figure 39: Solar panel opposite gas burner begins to catch alight (Camera 1)

Figure 40: Solar panel opposite gas burner fully involved (Camera 1)

Figure 41: Solar panel diagonally across from gas burner begins to catch alight (Camera 1)

Figure 42: Solar panel next to gas burner begins to catch alight (Camera 1)

Figure 43: Fire continues to spread across roof assembly (Camera 3)

Figure 44: Fire exhibits further spread across roof assembly (Camera 3)

Figure 45: Test fully extinguished (CCTV)

4.2.2 Visual observations

Table 3 - Visual observations for test 2

Time from ignition (mm:ss)	Visual observations
00:00	Ignition of gas burner
+05:00	Solar panel above gas burner fully involved
+05:10	Roof assembly begins to catch alight
+07:00	Solar panel opposite gas burner begins to catch alight
+08:50	Fire begins to spread across roof assembly
+09:40	Solar panel opposite gas burner fully involved
+10:00	Solar panel diagonally across from gas burner begins to catch alight
+10:00	Stop gas fire exposure
+10:50	Solar panel next to gas burner begins to catch alight
+17:45	Fire continues to spread across roof assembly
+21:45	Fire exhibits further spread across roof assembly
+21:50	Test terminated + turn on suppression systems
+25:40	Test fully extinguished

4.2.3 Fire spread measurements

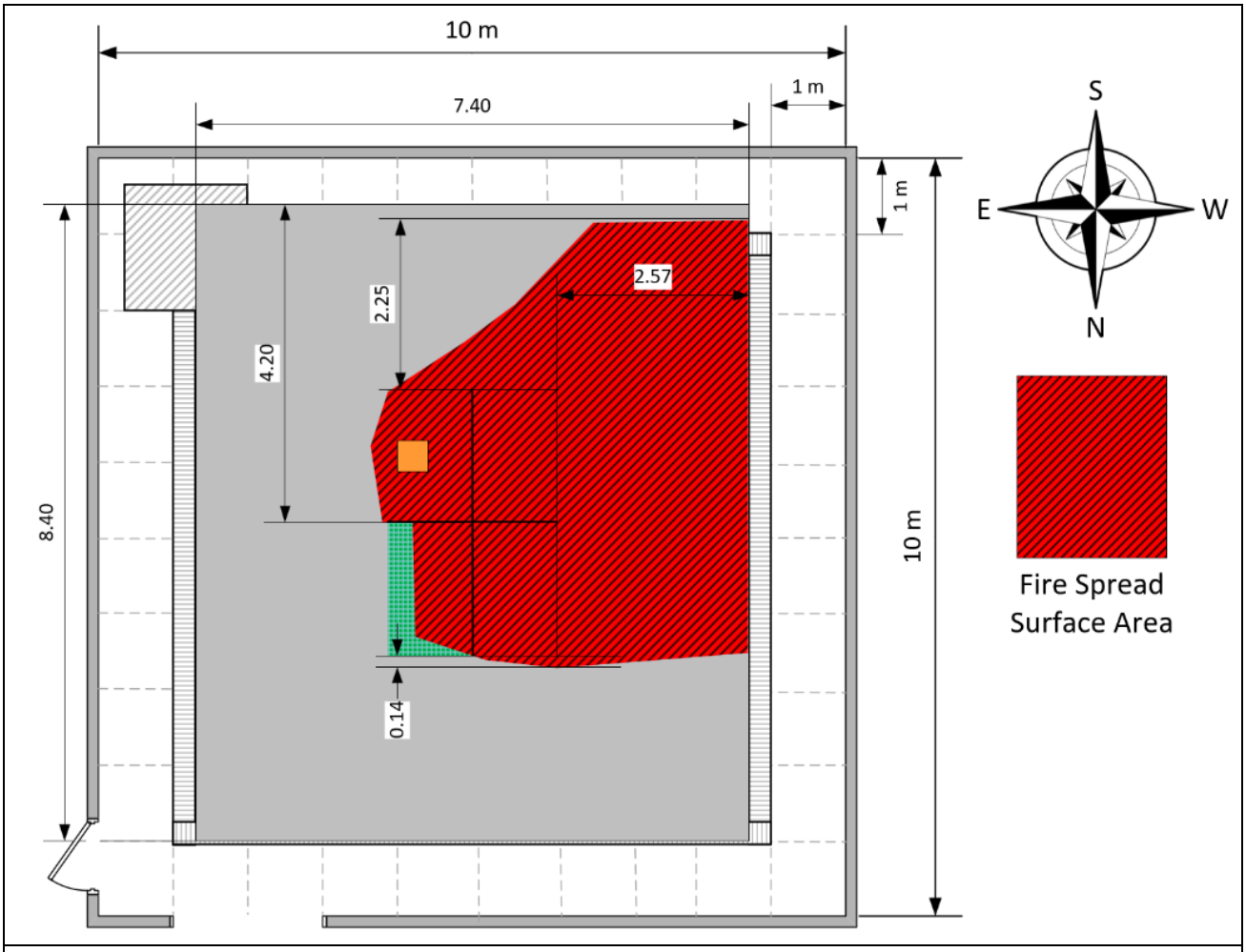

Figure 46: Total fire spread across stone wool insulation roof assembly.

Figure 47: Damage of PV panels and roofing membrane after test with Stone wool insulation Roof.

Figure 48: Damage of roofing membrane after test with Stone wool insulation roof.

Figure 49: Stone wool insulation Roof Assembly Post-test

Figure 50: Charring depth within the Stone wool insulation Post-test

4.2.4 Test data

4.2.4.1 Thermocouples located between the AVCL and the insulation product.

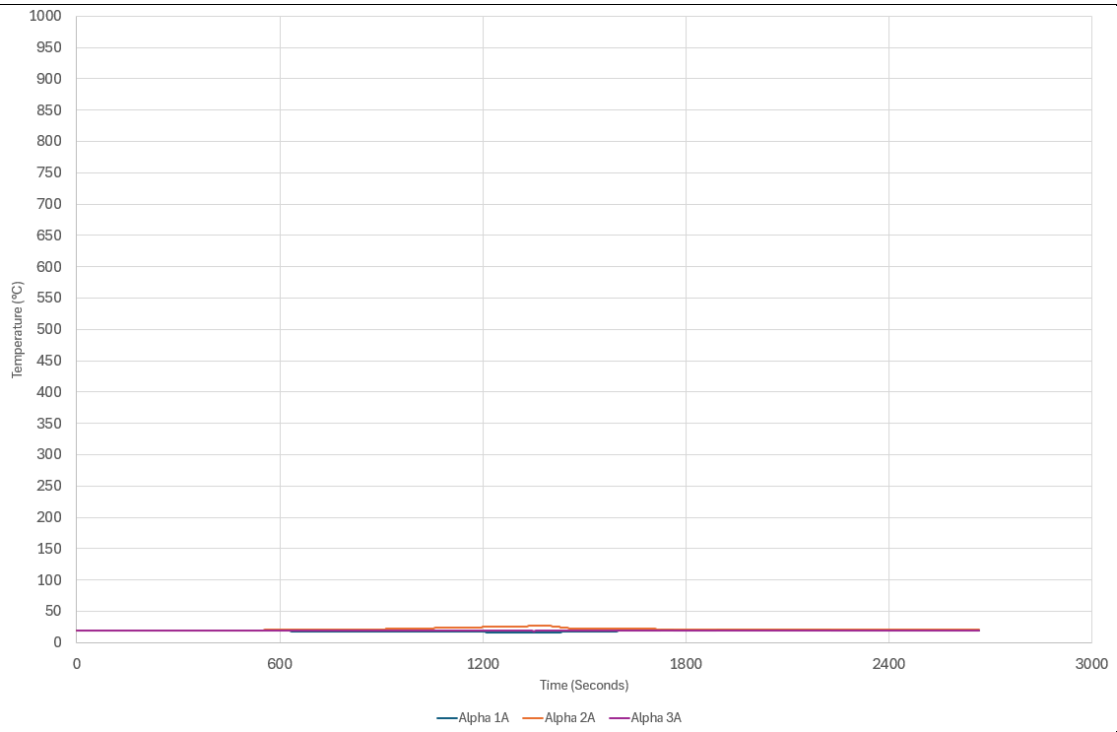

Figure 51: Alpha 1A / 2A / 3A Thermocouple data.

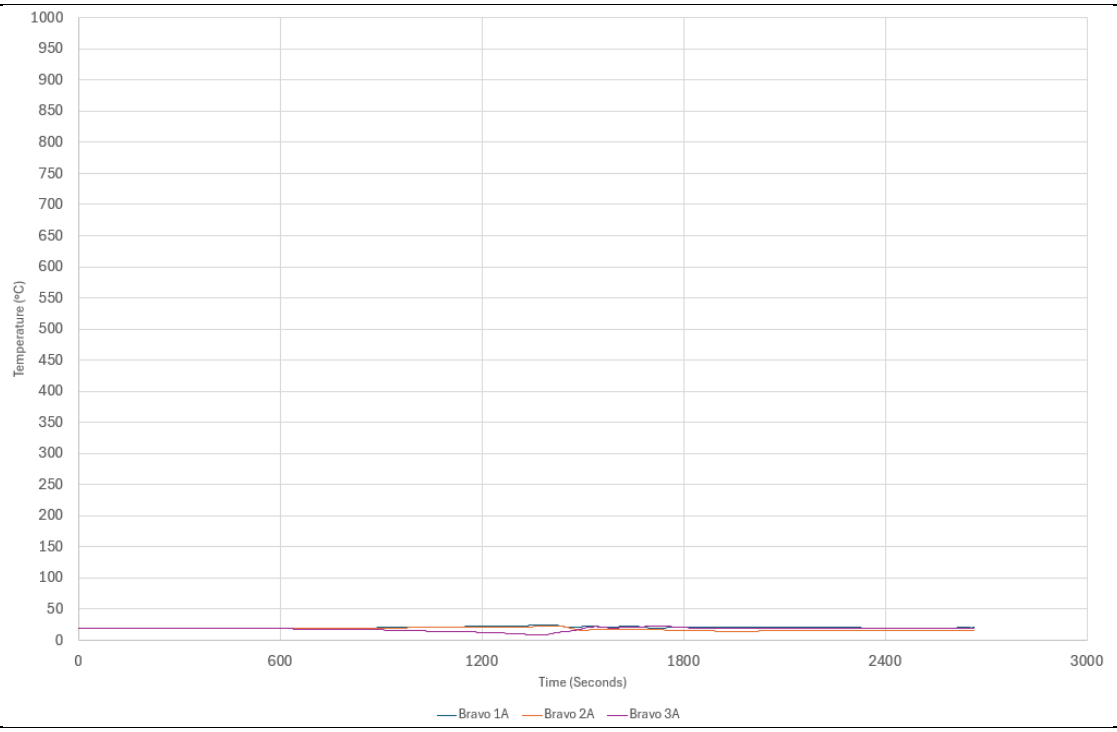

Figure 52: Bravo 1A / 2A / 3A Thermocouple data.

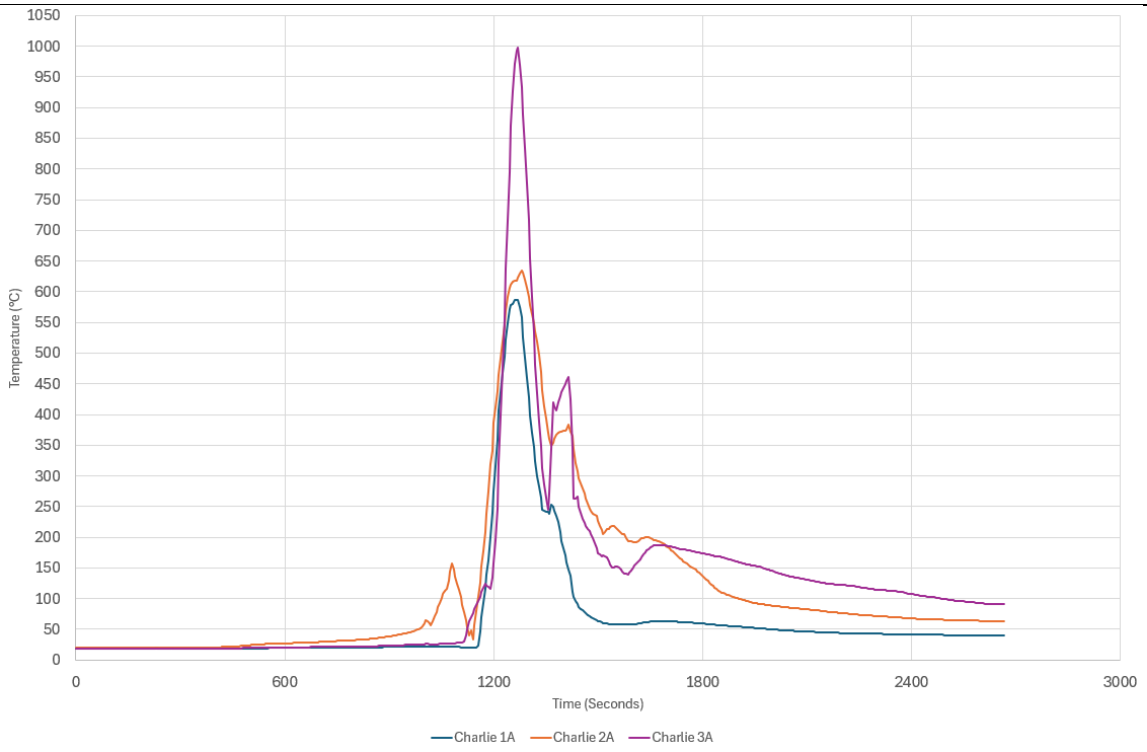

Figure 53: Charlie 1A / 2A / 3A Thermocouple data.

4.2.4.2 Thermocouples located between the two insulation layers.

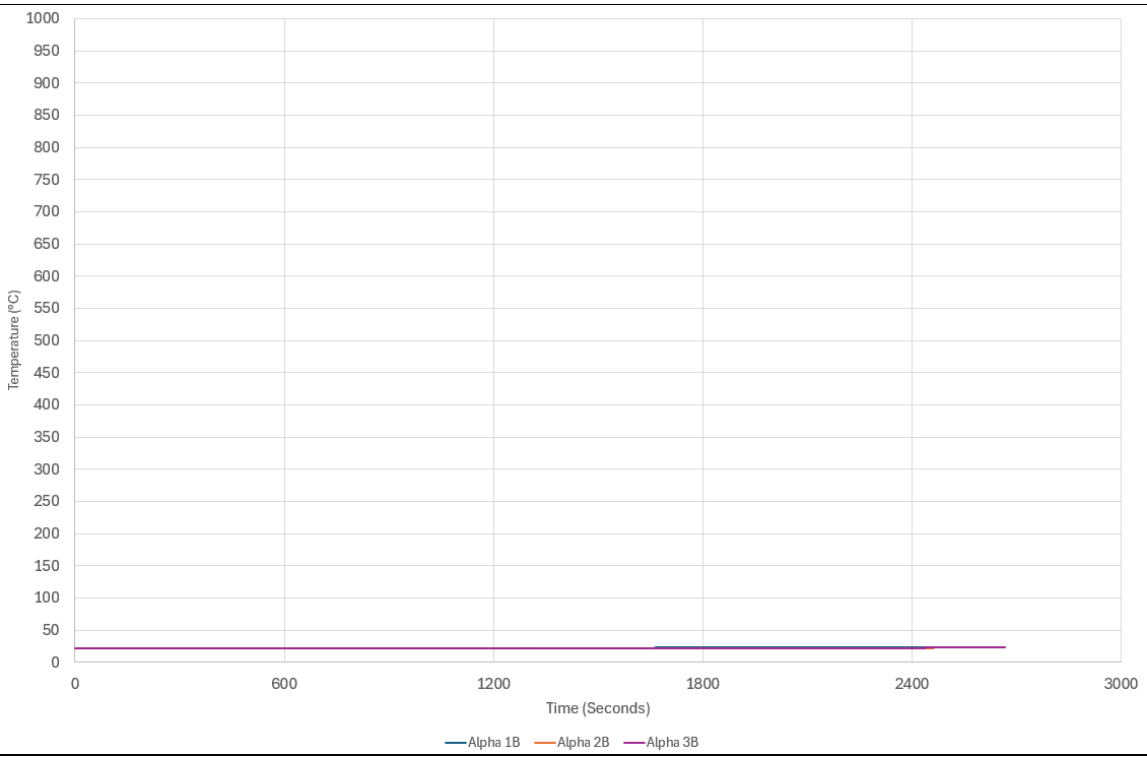

Figure 54: Alpha 1B / 2B / 3B Thermocouple data.

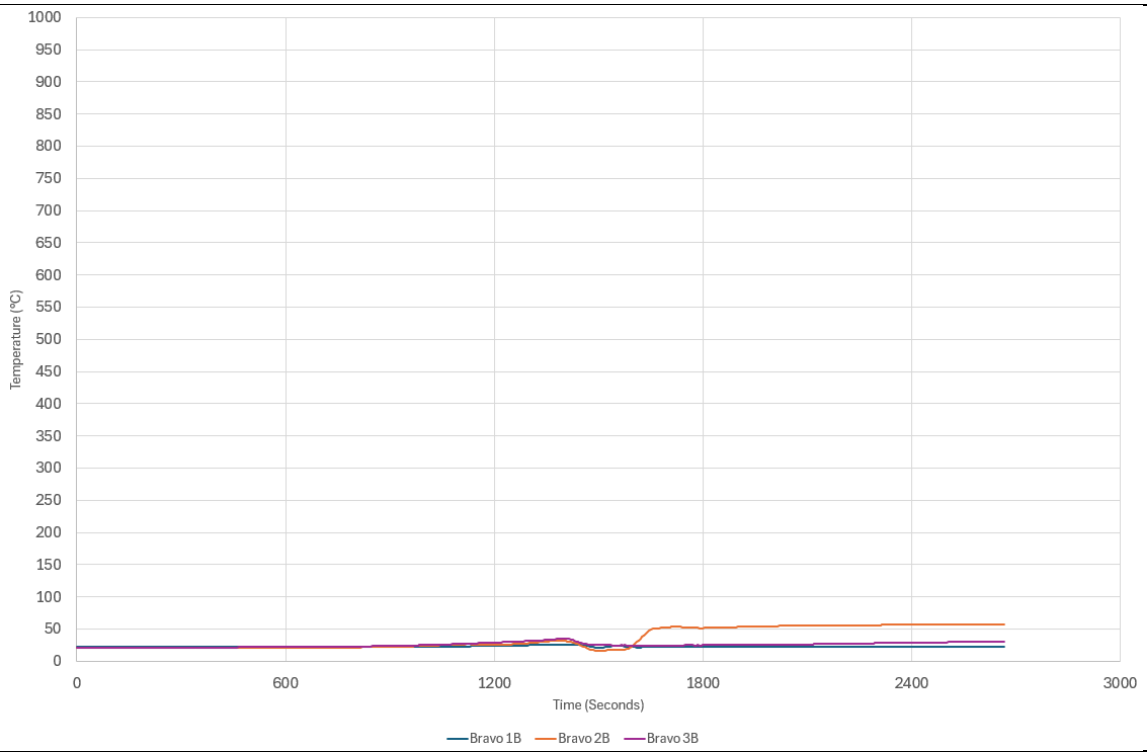

Figure 55: Bravo 1B / 2B / 3B Thermocouple data.

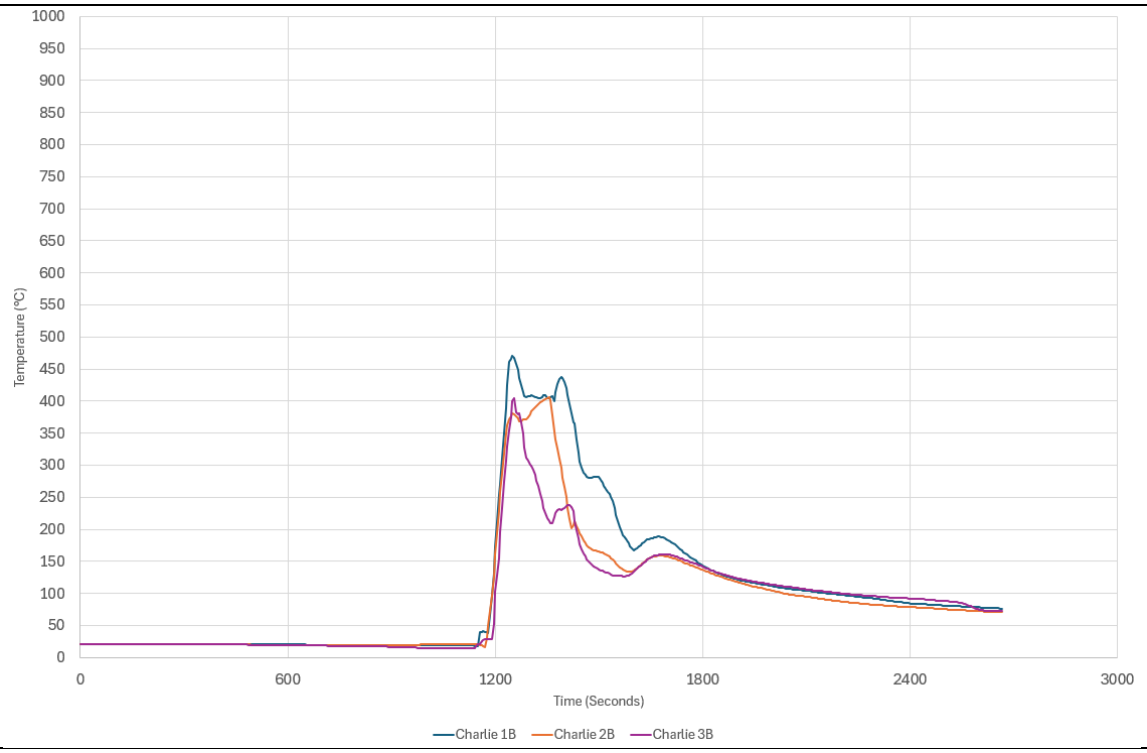

Figure 56: Charlie 1B / 2B / 3B Thermocouple data.

4.2.4.3 Thermocouples located within the testing facility (4m and 4.5m).

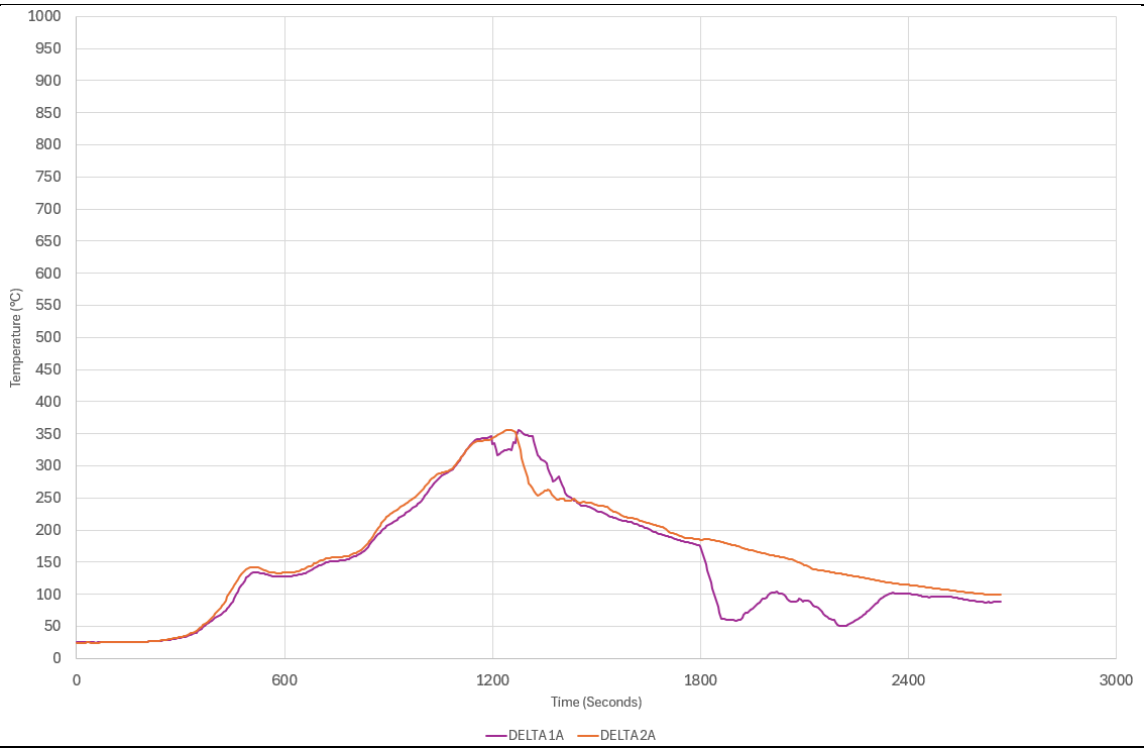

Figure 57: Delta 1A (4m) / 2A (4.5m) Thermocouple data.

5 Results Discussion

5.1.1 Notable observations

- All thermocouples in the Charlie locations recorded noticeably higher temperatures during both tests in comparison to the Alpha and Bravo locations. This could potentially be due to where the gas burner was situated, and the fire spread travelling in West and North directions.

- During the stone wool insulation test (Test 2), Charlie 3A recorded a significantly higher temperature of 1225.4°C. This could potentially be due to bitumen melting and getting between the insulation panels directly onto a thermocouple.

- During both tests, Charlie 1A and Charlie 2A had higher temperature readings than Charlie 1B and Charlie 2B. This could likely be because, although the 'A' thermocouples are located underneath the insulation layer, they are located more directly underneath the fire source. The 'B' thermocouples are spread further apart.

6 Summary

The aim of this research was to assess the fire performance and behaviour of two different insulation products within a flat roof assembly with reinforced bituminous roofing membranes while being exposed to a PV solar panel fire.

Research was accumulated upon:

- Temperatures between the two insulation layers and below the insulation on top of the AVCL using thermocouples.
- The surface area of fire spread on the roofs cap sheet.
- Damage to the insulation.

The roof assembly system was configured of 6 principal components:

1. Wooden roof frame
2. Steel deck
3. Bituminous membrane below insulation
4. Insulation product (PIR / Stone wool)
5. Bituminous membrane above insulation layer
6. PV panels and mounting system

The insulation product was the primary component to be tested as the independent variable. All other components within the roof assembly remained the same for both tests.

The testing programme included two tests, both lasting 21 minutes and 50 seconds and following the same test procedure as below:

Nominal time (ss:mm)	Event
-10:00	Start datalogger and check instrumentation
-00:05	Begin regulating gas burner flow
00:00	Ignite gas burner + start stopwatch
+10:00	Stop gas fire exposure
+21:50	Terminate test + turn on suppression systems

One test was conducted per each of the insulation products chosen by the client:

Test 1: PIR insulation product conducted by the FPA on the 24th of June 2025.

Test 2: Stone wool insulation product was conducted by the FPA on the 14th of August 2025.

6.1.1 Summary results

- Maximum temperatures throughout the Charlie thermocouples were all significantly higher during the stone wool insulation tests than the PIR insulation tests (See figure 64).
- The majority of all other thermocouples also show the stone wool insulation product having higher temperatures throughout the roof assembly.
- Fire spread on the water proofing layer during the PIR insulation test, wind was travelling in a West direction allowing wind to enter through the vents on the side of the facility. Post- test observations saw majority of fire spread was in the West direction (See figure 24, 25 and 26).
- Fire spread on the water proofing layer during the stone wool insulation test, wind was travelling in a South direction allowing wind to enter through the partially open roller shutter. Post-test observations saw majority of fire spread was in the Southwest direction (See figure 46, 47 and 48).
- During both tests the fire spread reached the entire West edge of the roof assembly, travelling 2.57m (See figure 24 and 49).
- The total fire spread surface area during the PIR insulation test was noticeably smaller than the stone wool insulation test. Having a total North-to-South fire spread of 0.92m.
- The total fire spread surface area during the stone wool insulation test was noticeably larger than the PIR insulation test. Having a total North-to-South fire spread of 2.39m.

7 Disclaimers

- The FPA is not responsible for the validity of results that rely on information supplied by the customer.
- If any information displayed in the report is to be queried by a third party after the publication of the report, The Fire Protection Association will be available to assist where possible.
- This report may only be distributed in its entirety, without amendment.
- Results presented relate only to the specimens tested.
- FPA takes no responsibility for the design, materials, workmanship or performance of the product tested.
- The report does not constitute an approval, certification or endorsement of the products tested.
- Any references made to this work must be accompanied by provision of the full, unabridged, report.

---------- End of Report ----------

FPA SERVICES

The Fire Protection Association provides a range of fire safety and prevention services. Our aim is to make the built environment a safer place to live and work so we offer:

Research testing

RISC 501 cladding testing

Material analysis testing

Sprinkler head testing

Pipework inspections

Sprinkler inspection surveys

Fire risk assessments

DSEAR risk assessments

Compartmentation and fire door inspection surveys

Fire strategies

Fire safety training

Membership

UKAS ACCREDITED TESTING SERVICES

BS 8414 cladding testing

BS 8458 watermist system testing

Fire resistance testing

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