

24L0241/1

2 September 2024

Test report

DM405M10-54HBB Solar panel (1) / PV 60-TSM6-270 (2) /
Solarstell connect mounting system / Rhenofol CV 1,5 /
Allshield barrier sheet / Unilin / PE foil MU 200 /
trapezoidal steel deck



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Subject

test on external fire exposure to roofs
in combination with photovoltaic (PV)
arrays according to the principles of
CLC/TR 50670

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1 Introduction

By order of Allshield Holding B.V, Kiwa BDA Testing has determined the fire behaviour of the below mentioned two buildups with a realistic PV panel array positioned on top of the roof. The roof has been exposed to external fire exposure according to the principles of CLC/TR 50670:2016.

The aim of this investigation was to determine the fire spread on the surface and downwards on the roof waterproofing system when a burner is placed between the surface of the roof and the PV panel array and ignited.

The roof waterproofing system has been built up as follows:

- substructure of a **trapezoidal steel deck VD 106R/750**;
- vapour barrier of a **PE foil MU 200**;
- thermal insulation of **Unilin**;
- fire barrier of a **Allshield barrier sheet**;
- roof waterproofing sheet **Rhenofol CV**.

The test 1 has been performed with four DM405M10-54HBB PV modules from DMEGG Solar in combination with an Connect mounting system of Solarstell in east-west configuration. The glass of all four PV modules was broken before the start of the test.

For test 2 one of the PV modules has been replaced for PV 60-TSM6-270 PV module from Luxra AG. The rest of the PV modules (including the burnt PV module) has been used from the first test.

2 Test specimens

On 23 July 2024 the test specimens have been built up by members of AllShield Coating B.V. and supervised by Troned.

According to the prescription of the principal the test specimens, with dimensions 6000 mm × 6000 mm, have been built using the following products from the bottom up.

Substructure

- Trapezoidal steel deck, VD 106R/750, mass 9,81 kg.m⁻², steel quality S320GD.

Vapour barrier

- PE foil MU 200 roof waterproofing sheet, width of the sheet: 6000 mm, production code: not revealed

Thermal insulation

- Unilin, production code: not revealed, insulation boards made of rigid polyisocyanurate foam, faced on both sides with an alu multi-layer complex, dimensions: 2400 mm × 1200 mm, thickness: 50 mm, mechanically fastened with 4 fasteners for each board.

Fastening system (thermal insulation)

- Roofing screw / plastic tube washer combination: Eurofast® TRPS-45-50, production code: not revealed.

Fire Barrier

- **Allshield barrier sheet**, production code: not revealed, dimensions: 2000 mm × 950 mm, thickness: 1,2 mm. mechanically fastened with 5 fasteners for each board.

Fastening system (fire barrier)

- Roofing screw / plastic tube washer combination: Eurofast® TRPS-45-50, production code: not revealed.

Roof waterproofing sheet

- Rhenofol CV, a polyester reinforced PVC roof waterproofing sheet, thickness: 1,5mm, width of the sheet: 1500 mm, production code: 24/05/2024 02:18:16.
- The spacing between the individual fasteners has been set at 0,25 m.
- The spacing between the rows of fasteners has been set at 1,40 m.
- The joint has been welded with a hand-held welding gun.
- The nominal width of the overlap is 100 mm.
- The nominal effective width of the welded joint is 40 mm.

Fastening system (roof waterproofing sheet)

- Roofing screw / plastic tube washer combination: Eurofast® TRPS-45-50, production code: not revealed.

PV panel array (test 1)

- four DM405M10-54HBB PV modules from DMEGG Solar with a broken sheet of glass.
- Connect mounting system of Solarstell.
- the PV panel array is positioned in east-west configuration.

PV panel array (test 2)

- two DM405M10-54HBB PV modules from DMEGG Solar with a broken sheet of glass.
- one PV 60-TSM6-270 PV module from Luxra AG with a hole sheet of glass.
- Connect mounting system of Solarstell
- the PV panel array is positioned in east-west configuration.

3 Investigation

3.1 General information

The investigation has been performed in accordance with the principles of CLC/TR 50670:2016 – External fire exposure to roofs in combination with photovoltaic (PV) arrays – Test method(s).

The test has been performed on a realistic roof waterproofing system as mentioned in chapter 2, including a substructure, thermal insulation, a roof waterproofing sheet and PV panel arrays in East / West configuration, consisting of four PV modules.

The test has been performed by Mr A.R. Hameete and Mr W.J.B. Middag of Kiwa BDA Testing at Twente Safety Campus in Enschede on 24 July 2024, and was witnessed by representatives of AllShield Coatings B.V. and Troned.

During and after the test the temperatures have been measured with thermocouples which have been positioned on several positions on top of the insulation and underneath the insulation above the steel deck. From these measurements graphs have been made. The positions of the sensors are shown on the drawing in annex III.

The fire spread on top of the surface has been measured by Kiwa BDA Testing. The temperature measurements have been performed by Troned. The results of the temperature measurements during and after the test have been made available by Troned afterwards.

During the first test the average wind speed was approximately the 3 m.s⁻¹. Because the wind direction changed during the test, no wind direction can be given. At the start of the test the ambient temperature was 25 °C. The temperature was 24,1 °C underneath the insulation and 33,7 °C on top of the insulation.

During the second test the average wind speed was approximately the 3 m.s⁻¹. Because the wind direction changed during the test, no wind direction can be given. At the start of the test the ambient temperature was 24 °C. The temperature was 24,3 °C underneath the insulation and 27,2 °C on top of the fire barrier.

3.2 Test procedures

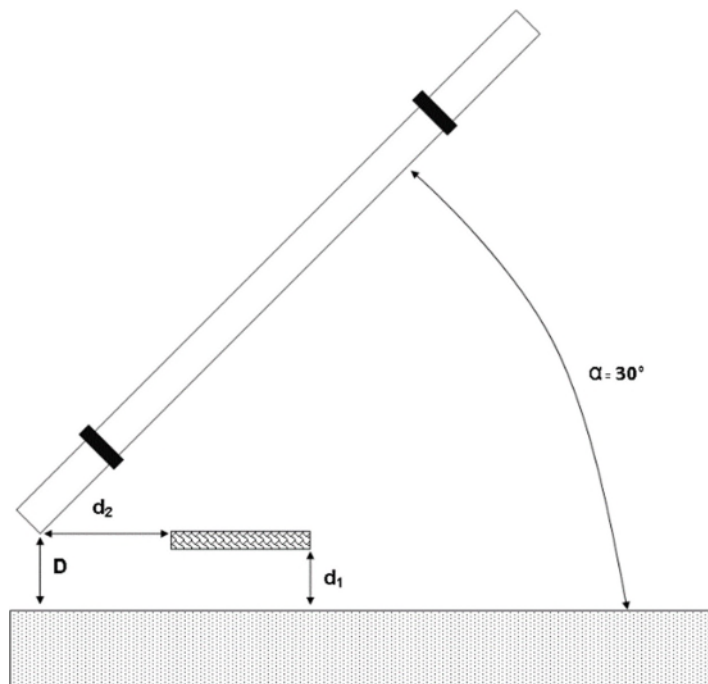
As defined in CLC 50670:2015, the gas burner was adjusted to provide a flow rate of $(324 \pm 20) \text{ mg.s}^{-1}$, generating a heat output of $(15 \pm 1) \text{ kW}$. After 10 minutes the gas flow has been shut down.

The gas burner has been made of a stainless tube with an external diameter of $(15,0 \pm 0,1) \text{ mm}$ and an internal diameter of $(13,0 \pm 0,1) \text{ mm}$, ending in a square part with 265 mm side length. In the square part of the burner, 32 holes with a diameter of 1,3 mm have been drilled, 8 holes at each side. The holes have been oriented to the inside of the burner. Half of the holes have an upward inclination of 45° and half of the holes have a downward inclination of 45° with respect to the burner plane. The gas supplied to the burner has been propane with a purity of 95% or higher. The propane mass flow rate has been $(324 \pm 20) \text{ mg.s}^{-1}$, generating a heat output of $(15 \pm 1) \text{ kW}$. A mass flow controller has been used to ensure that the flow rate is maintained throughout the test.

The gas burner has been applied at lowest edge of the PV module between the backside of the module (exposed surface) and the top of the roofing system surface, centred in the module's width and placed at a distance of $d_2 = 120 \text{ mm}$ from the lowest edge of the module. The burner has been positioned in parallel to the roofing system, with a distance of $d_1 = 80 \text{ mm}$ measured from the underside of the burner to the test deck surface.

The PV module has been installed with an inclination of 13° to the test deck. The slope of the simulated roof deck (test deck) has been set at 0° .

Figure 1 – Position of the burner according CLC/TR 50670:2016



During and/or after the test the following parameters are observed, measured and recorded.

3.3 External fire spread

- The time when the sustained flaming has progressed left, every 200 mm until the edge of the test specimen. Measured from the left side (seen from the side from which the burner has been positioned) of the projection of the gas burner on to the exposed specimen surface.
- The time when the sustained flaming has progressed right, every 200 mm until the edge of the test specimen. Measured from the right side (seen from the side from which the burner has been positioned) of the projection of the gas burner on to the exposed specimen surface.
- The time when the sustained flaming has progressed forward, every 200 mm until the edge of the test specimen. Measured from the front side (seen from the side from which the burner has been positioned) of the projection of the gas burner on to the exposed specimen surface.
- The time when the sustained flaming has progressed backward, every 200 mm until the edge of the test specimen. Measured from the rear side (seen from the side from which the burner has been positioned) of the projection of the gas burner on to the exposed specimen surface.

In annex I a photo report of the test and the test results is given.

4 Results

4.1 Test 1

(four DM405M10-54HBB PV modules with a broken sheet of glass)

4.1.1 Temperature measurements, measured by Kiwa BDA Testing

4.1.1.1 Fire behaviour during test

Description	Result [min:s]			
Roofing burning	1:44 ¹⁾			
Burner turned of	10:00			
Fire extinguished	17:37			
Fire spread [mm] ²⁾	left	right	forward	backward
▪ 100	5:20	2:54	2:32	4:00
▪ 300	5:48	3:04	3:05	5:32
▪ 500	8:21	3:15	5:22	- ³⁾
▪ 700	- ³⁾	4:54	6:42	- ³⁾
▪ 900	- ³⁾	5:32	- ³⁾	- ³⁾
▪ 1100	- ³⁾	5:57	- ³⁾	- ³⁾
¹⁾ This time refers to the roof waterproofing sheet. ²⁾ Length of fire spread measured from the edge the projection of the gas burner on to the exposed specimen surface. ³⁾ Not been reached.				

4.1.1.2 Measurements made after test

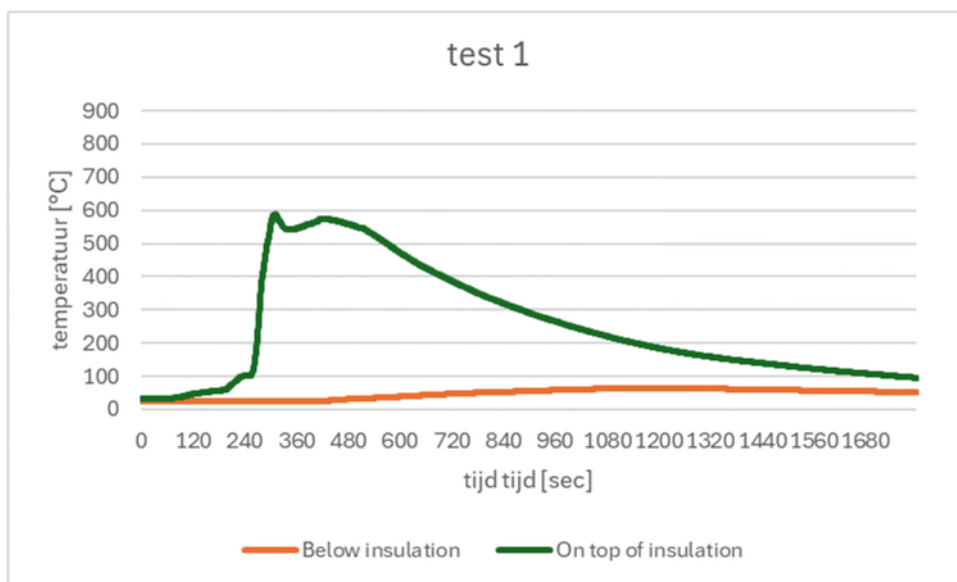
External fire spread / burnt length ¹⁾	Results [mm]		
	roof waterproofing sheet	fire barrier	thermal insulation
▪ left	48	46	44
▪ right	116	105	83
▪ forward	75	51	13
▪ backward	32	22	16
¹⁾ Length of fire spread and damaged area measured from the edge the projection of the gas burner on to the exposed specimen surface.			

4.1.2 Temperature measurements, measured by Troned

4.1.2.1 Temperature rising during the test at the position nearby the burner

Highest temperature measured after	Results [°C]	
	underneath insulation (sensor II A)	on top of insulation (sensor II B)
Start of the test	24,1	33,7
2 minutes	24,2	46,0
4 minutes	24,2	101,0
6 minutes	24,5	544,1
7 minutes	25,5	575,1
8 minutes	30,5	558,7
10 minutes	38,2	473,5
12 minutes	46,4	387,7
14 minutes	52,1	320,2
16 minutes	57,8	265,8
18 minutes	62,5	220,9
19 minutes	63,2	198,5
20 minutes	63,1	184,8
22 minutes	62,0	158,5
24 minutes	59,3	139,6
26 minutes	56,5	122,5
28 minutes	54,0	108,1
30 minutes	51,0	95,1

4.1.2.2 Graph of temperature rise during the test in °C



4.2 Fire test 2

(two DM405M10-54HBB PV modules with a broken sheet of glass + one PV 60-TSM6-270 PV module with a hole sheet of glass)

4.2.1 Temperature measurements, measured by Kiwa BDA Testing

4.2.1.1 Fire behaviour during test

Description	Result [min:s]			
Roofing burning	1:33 ¹⁾			
Burner turned of	10:00			
Fire extinguished	17:53			
Fire spread [mm] ²⁾	left	right	forward	backward
▪ 100	2:52	4:49	4:21	3:04
▪ 300	6:02	5:19	5:23	7:00
▪ 500	6:47	6:17	6:53	10:08
▪ 700	7:29	7:50	7:08	- ³⁾
▪ 900	7:37	- ³⁾	7:21	- ³⁾
▪ 1100	7:50	- ³⁾	7:30	- ³⁾
▪ 1300	8:17	- ³⁾	9:24	- ³⁾
▪ 1500	8:32	- ³⁾	11:32	- ³⁾

¹⁾ This time refers to the roof waterproofing sheet.
²⁾ Length of fire spread measured from the edge the projection of the gas burner on to the exposed specimen surface.
³⁾ Not been reached.

4.2.1.2 Measurements made after test

External fire spread / burnt length ¹⁾	Results [mm]		
	roof waterproofing sheet	fire barrier	thermal insulation
▪ left	149	145	119
▪ right	65	53	30
▪ forward	164	157	115
▪ backward	98	90	80

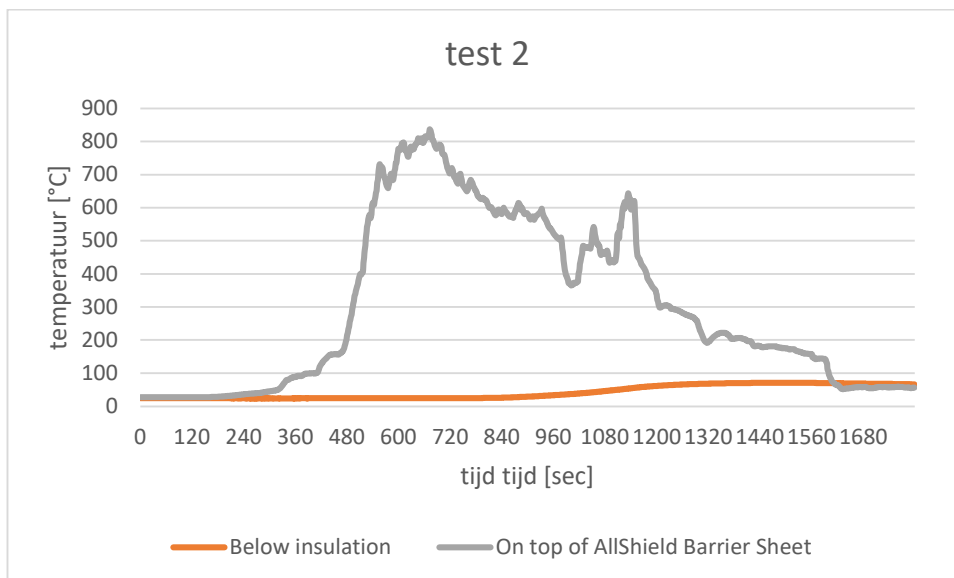
¹⁾ Length of fire spread and damaged area measured from the edge the projection of the gas burner on to the exposed specimen surface.

4.2.2 Temperature measurements, measured by Troned

4.2.2.1 Temperature rising during the test at the position near by the burner

Highest temperature measured after	Results [°C]	
	underneath insulation (sensor III A)	on top of fire barrier (sensor III B)
Start of the test	24,3	27,2
2 minutes	24,2	27,2
4 minutes	24,2	35,7
6 minutes	24,1	88,8
8 minutes	24,2	201,2
10 minutes	24,3	770,1
11 minutes	24,3	837,3
12 minutes	24,3	703,4
14 minutes	25,7	581,4
16 minutes	33,1	525,9
18 minutes	45,6	465
20 minutes	61,3	342,9
22 minutes	68,2	191,8
24 minutes	70,4	182,2
25 minutes	70,8	175,7
26 minutes	70,5	157,4
28 minutes	68,6	57,5
30 minutes	66,1	56,0

4.2.2.2 Graph of temperature rise during the test in °C



5 Discussion

The roof waterproofing sheet underneath the burner did catch fire after 1:44 (min:s) for test 1 and after 1:33 (min:s) for test 2. There is no significant difference.

The PV module of test 1 collapsed 3 minutes after the burner has been ignited, the PV module of test 2 collapsed 11 minutes after the burner has been ignited. This is with a probability bordering on certainty caused by the glass sheet which was broken for test 1 and still intact for test 2.

The fire spread measured above the fire barrier (roof waterproofing sheet) in comparison to the fire spread measured underneath the fire barrier (thermal insulation) is degraded for approximately 40% for test 1 and approximately 30% for test 2. This less degreasing in fire spread by test 2 is probably caused by the more intense fire which was present on test 2.

The burner has been turned off after 10:00. At both test specimens almost all the flames disappear fairly soon after the burner has been turned off. At test specimen 2 it took a little longer. At both tests only the rubber granulate feet underneath the mounting system keep on burning until they are extinguished.

At test 1 the highest temperature; 575,1 °C has been reached after 7 minutes. At test 2 the highest temperature; 837,3 °C has been reached after 11 minutes. The position of the temperature sensor compared to the burner is approximately the same for both tests, however the position compared to the layers is different. The temperature sensor which reached the highest temperature for test 1 is positioned on top of the insulation and underneath the fire barrier and for test 2 this the sensor is positioned on top of the fire barrier and underneath the roof waterproofing sheet. So a comparison between the temperature measured at this position between the two tests cannot be given.

For this investigation a burner has been used as defined in CLC/TR 50670. The burner has been positioned below one of the PV panels in order to combine the effects of burning of the PV panels with the effects of the fire performance of roofs.

Remarks:

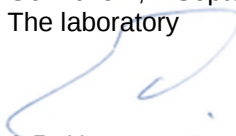
The results are only related to the investigated samples, products and/or systems. Kiwa BDA Testing is not liable for interpretations or conclusions that are made in consequence of the results obtained.

The reported test results have not been corrected with the uncertainty of measurements (simple evaluation). The uncertainty of measurement can be retrieved at Kiwa BDA Testing.

Sampling was not performed by Kiwa BDA Testing, so no judgement can be given with regard to the origin and representativeness of the samples.

Gorinchem, 2 September 2024

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Construction Products Regulation (EU, No 305/2011)



Member

I Photo report of the test

Fire test 1

(four DM405M10-54HBB PV modules with a broken sheet of glass)

Photo 1

The PV modules have been positioned on the test specimen.



Photo 2

The gas burner has been ignited.



Photo 3

The roof waterproofing sheet is burning.



Photo 4

The fire is spreading in the right direction



Photo 5

The PV module is collapsed after 3 minutes.



Photo 6

The fire is spreading more to the right direction.



Photo 7

The burner is turned off after 10 minutes.



Photo 8

Only the rubber granulate feet are still burning.



Photo 9

The fire is extinguished.



Photo 10
Overview of the burnt roof
waterproofing sheet.



Photo 11
Overview of the burnt fire
barrier.



Photo 12
Overview of the burnt
thermal insulation.



Photo 13

Overview of the burnt depth of the thermal insulation.



Photo 14

Detail of the burnt depth of the thermal insulation.



Fire test 2

(two DM405M10-54HBB PV modules with a broken sheet of glass +
one PV 60-TSM6-270 PV module with a hole sheet of glass)

Photo 15

The PV modules have been positioned on the test specimen.



Photo 16

The gas burner has been ignited.



Photo 17

The roof waterproofing sheet is burning.



Photo 18

The fire is spreading in the backward direction.



Photo 19

The fire is spreading in the forward direction.



Photo 20

The fire is spreading in the right direction.



Photo 21

The fire is spreading further in all directions.



Photo 22

The PV module in front of the PV module were underneath the burner is located is collapsed after 8 minutes.



Photo 23

The PV module next to the PV module were underneath the burner is located is collapsed after 9 minutes.



Photo 24

The burner is turned off after 10 minutes.



Photo 25

The PV module is collapsed after 11 minutes.



Photo 26

The fire is slowly decreasing.



Photo 27

Only the rubber granulate feet are still burning.



Photo 28

The fire is extinguished.



Photo 29

Overview of the burnt roof waterproofing sheet.



Photo 30
Overview of the burnt fire
barrier.



Photo 31
Overview of the burnt
thermal insulation.



Photo 32
Overview of the burnt depth
of the thermal insulation.



Photo 33

Detail of the burnt depth of the thermal insulation.



II Positions of the thermocouples and burner

