



Verification Report

PVStop


IN20160117UK03E

1 August 2017

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Signature 

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Position Operations Manager, Verification

Date 1 August 2017

Signature 

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1. Introduction

This verification report summarises information relevant to the verification of PV Stop. The verification was conducted by BRE Global on behalf of Solar Developments Pty Ltd. The work was conducted in accordance with the methodology and procedures described in the EU Environmental Technology Verification Pilot Programme General Verification Protocol, version 1.2 – July 27th 2016. This work was within the scope of BRE Global's UKAS accreditation to ISO/IEC 17020:2012.

1.1. Name of technology and unique identifier of the technology being verified

PVStop, manufactured by Spraylat International Ltd. on behalf of Solar Developments Pty Ltd.

1.2. Name and contact of proposer

Jim Foran
Solar Developments Pty Ltd
Wakefield Business Park
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NSW 2158
Australia
+61 2 9652 5000
jim@pvstop.com.au

1.3. Name of Verification Body

BRE Global Ltd.
Bucknalls Lane
Watford
WD25 9XX
+44 (0)3333 218811
etv@bre.co.uk

1.4. Organisation of verification including experts, and verification process

Verification Body: BRE Global

Internal Expert: Dr John Holden

External Expert: Dr Colin Cunningham

Test Body: BRE National Solar Centre

Internal Expert: Chris Coonick (Mrs)

Proposer: Solar Developments Pty Ltd.

Internal Experts: Jim Foran

Luke Williams

1.5. Deviations from the specific verification protocol

It has not been possible to identify a test laboratory capable of measuring the DC current flowing upstream from a DC source to the nozzle of the PVStop application device. Consequently the relevant performance claim within the Specific Verification Protocol (When tested using procedures in accordance with EN 3 – 7:2004 Annex C, but using a DC voltage of 1200VDC instead of an AC voltage of 35kV to simulate the electrical parameters of the PV arrays on which PVStop will be applied, the DC current flowing upstream from the PV array to the nozzle of the PVStop application device will not exceed 'z'ADC) could not be verified.

2. Description of the technology and application

2.1. Summary description of the technology

PVStop is a black sprayable/rollable/brushable water based polymer. The application of PVStop to PV modules will restrict light from reaching the PV cells thereby reducing the PV system's ability to generate electricity. This reduces the risk of electric shock through direct or indirect contact with PV modules.

2.2. Intended application (matrix, purpose, technologies, technical conditions)

Matrix: Solar photovoltaics.

Purpose: Inhibit solar photovoltaic function.

Technologies: Solar PV modules.

Technical conditions: Application in accordance with manufacturer's instructions.

2.3. Verification parameters definition

2.3.1. Initial Performance Claim

PVStop applied according to the manufacturer's instructions to a solar PV array consisting of 6 x 260W PV modules with a nominal electrical output of 1.56kW/225V_{oc}/9.12A_{sc} (at STC) experiencing nnn^1Wm^{-2} of solar radiation will restrict the amount of light falling on the PV modules thereby inhibiting their ability to energise the PV system and consequently reducing its power/voltage/current below w^1kW , xx^1VDC and yy^1ADC respectively within s^1 seconds.

2.3.2. Performance parameters

- PV array initial power/voltage/current
- Time needed to apply PVStop according to manufacturer's instructions
- PV array power/voltage/current during application of PVStop
- DC current flowing upstream from PV array to PVStop discharge nozzle when tested in accordance with EN3-7:2004 Annex C but using 1200VDC. Not verified, see section 1.5.

¹ The magnitude of these parameters to be determine during testing phase

2.3.3. Operational parameters

- Ground mounted PV array specification
 - Number of modules
 - Module inclination relative to horizontal
 - Nominal PV array output (kW), V_{oc} and I_{sc}
- Inverter specification
 - Make and model
 - Operational parameters (electrical input and output)

2.3.4. Environmental parameters

- Solar radiation on PV array at time of application of PVStop
- Ambient temperature
- PV module solar cell temperature

2.3.5. Additional parameters

- Dispensing nozzle specification
- Installation, Maintenance and Use manuals
- Product Specification data sheet
- Product Health and Safety data sheet

3. Existing data

3.1. Accepted existing data

No existing data were accepted for the verification of PVStop. However it was noted that videos showing the application and flame retardant properties of PVStop are publicly available from the PVStop website (<http://www.pvstop.com.au/>)

4. Evaluation

4.1. Test site

Former London Fire Brigade fire station. Closed to public, open air.

4.1.1. Address

London Fire Brigade Southwark Training Centre
94 Southwark Bridge Road
London, UK
SE1 0EG

4.2. Tests

Tests were performed on Tuesday 18th April 2017 and Wednesday 19th April 2017. Weather conditions were clear, bright and dry with a calm or gentle breeze, with an ambient temperature of approximately 13°C.

The PV array used in the test comprised of 6 x Canadian Solar CS6P-260P 260W polycrystalline modules providing a theoretical maximum power output of 1560W under standard test conditions (STC - Solar irradiance of 1000 Wm^{-2} , ambient temperature of 25°C). Each module consisted of 3 banks of 20 polycrystalline silicon cells each protected by a bypass diode. The modules were arranged facing due south in a 1 x 6 array with each module oriented in portrait mode at 35° from horizontal. The total module area was $1.638\text{m} \times 0.992\text{m} \times 6 = 9.75\text{m}^2$. See below.



For these tests the PV array was connected to a Zeversolar Zeverlution 2000S 2.0kW grid inverter.

4.2.1. Test methods (incl. sampling methods)

PVStop was applied to a test PV array according to the manufacturer's instructions. See Appendix 1.

London Fire Brigade (LFB) personnel, trained and supervised in the use of PVStop by Solar Developments Pty Ltd, applied PVStop to the test PV array. This was witnessed by BRE Global and BRE National Solar Centre. Test parameters were recorded by BRE National Solar Centre and BRE Global.

4.2.2. Measuring equipment

The following calibrated equipment was used during the tests:

Seaward Solar Survey 200R: Irradiance, inclination, orientation, temperature

http://www.sewardsolar.com/downloads/survey_100_and_200r_datasheets_international_v1.3.pdf

Seaward PV150 Solar Installation Test Kit: PV voltage, current, power, data logger.

http://www.sewardsolar.com/downloads/pv150_test_kit_datasheet_international_v1.1.pdf

Calibration certificates may be found in Appendix 2

4.2.2.1. Additional equipment

The following uncalibrated equipment was used during the tests:

Fluke 381 Remote Display True-rms AC/DC Clamp Meter

<http://www.fluke.com/fluke/uken/electrical-test-tools/clamp-meters/fluke-381.htm?PID=70413>

Zeversolar Zeverlution 2000S Single Phase String Inverter

https://www.zeversolar.com/fileadmin/user_upload/pdf/datasheets_en/zeversolar_datasheet_single_phase_inverters_zeverlution_s_en.pdf

4.2.3. Type and number of samples

The PVStop used in these tests was supplied in 9 litre dispensers, see below.



Samples used for testing were selected at random by the manufacturer from stock. The batch number for these samples was 1702007. Additional samples from this batch have been retained by the manufacturer under their ISO 9001 quality procedures.

4.2.4. Operation conditions

Weather conditions were clear, bright and dry with a calm or gentle breeze, with a mean ambient temperature of approximately 13°C.

4.3. Calculation of verification parameters including determination of uncertainty

The verification parameters contained in the performance claim include:

- Irradiance
- DC voltage
- DC current
- Electrical Power

Each of these parameters was measured directly using the test equipment detailed in section 4.2.2.

Electrical power may also be determined by calculation using the equation:

$$P = V \times I$$

Where: P = Electrical Power

V = Voltage

I = Current

4.4. Evaluation of test quality

4.4.1. Control data

The measurement equipment used in this testing was calibrated by an accredited calibration laboratory. The calibration certificates are presented in appendix 2. These calibrations are traceable to national standards.

The parameters contained in the performance claim include:

- Irradiance
- DC voltage
- DC current
- Electrical Power

Sources of uncertainty in the measurement of these parameters arise from the accuracy of the measurement instruments, timing errors due to the refresh rates of the instrument display and changes in solar irradiance during the tests.

The manufacturer of the electrical measurement instruments states the instrument accuracy for the measurement of voltage and of current is $5\% \pm 2$ digits. The instrument displayed the measurement to 1 decimal place hence the uncertainty for both voltage and current measurement was $5\% \pm 0.2$ V/A as appropriate.

The respective calibration certificates confirmed that the instruments were functioning within this specification.

A back-up multimeter (Fluke 381) was also used to record DC voltage and current for the tests on day 2 (see section 4.4.3). The instrument accuracy stated by the manufacturer is $2\% \pm 5$ digits for the measurement of DC current and $1\% \pm 5$ digits for the measurement of DC voltage. The instrument displayed measurements to 1 decimal place hence the uncertainty for DC current measurement was $2\% \pm 0.5$ A and for DC voltage $1\% \pm 0.5$ V. This instrument was not calibrated.

Timing errors are considered to be, conservatively, 1s.

The change in solar irradiance (Wm^{-2}) during the tests was:

Time (s)	Solar Irradiance (Wm^{-2})	
	Test 1	Test 2
Start of test	763	951
6	764	941
10	764	913
20	761	922
30	759	914
End of test	763 (38s)	898 (47s)

4.4.2. Audits

Testing was witnessed by BRE Global (Dr John Holden)

4.4.3. Deviations

Although 6 tests were conducted the results from the 4 tests conducted on day one were not used for the verification of the performance claim since it was determined that the SEAWARD PV150 could measure either voltage or current, but not both simultaneously which compromised the data logged on day 1 of the testing. On day 2 a Fluke 381 device was used alongside the SEAWARD PV150 to log the voltage/current measurements as appropriate.

Also see Section 1.5

4.5. Verification results (verified performance claim)

4.5.1. Verification parameters

PVStop when applied, according to the manufacturer's instructions will restrict the amount of sunlight falling on an array of PV modules thereby reducing the electrical output of PV system

Test results indicate that the electrical output of the PV array was significantly reduced during the first 7 ± 1 seconds following the start of the application of PVStop.

In test 1 PVStop was applied according to the manufacturer's instructions to a solar PV array consisting of 6 Canadian Solar CS6P-260P 260W PV modules with a nominal electrical output of $1.56\text{kW}/225\text{V}_{\text{oc}}/9.12\text{A}_{\text{sc}}$ (at STC) experiencing between $759 - 764 \text{ Wm}^{-2}$ of solar radiation measured using the Seaward Solar Survey 200R. Under these conditions the output DC current of the array measured using the Seaward PV150 Solar Installation Test Kit was reduced from $6.7 \pm 0.5 \text{ ADC}$ to $0.0 \pm 0.2 \text{ ADC}$ in $7\text{s} \pm 1\text{s}$ from the start of the application of PVStop to the PV array. During the first $7\text{s} \pm 1\text{s}$ from the start of the application of PVStop the indicated output of the inverter reduced from 1125.3W to 0.0W . See figure 1 and figure 2

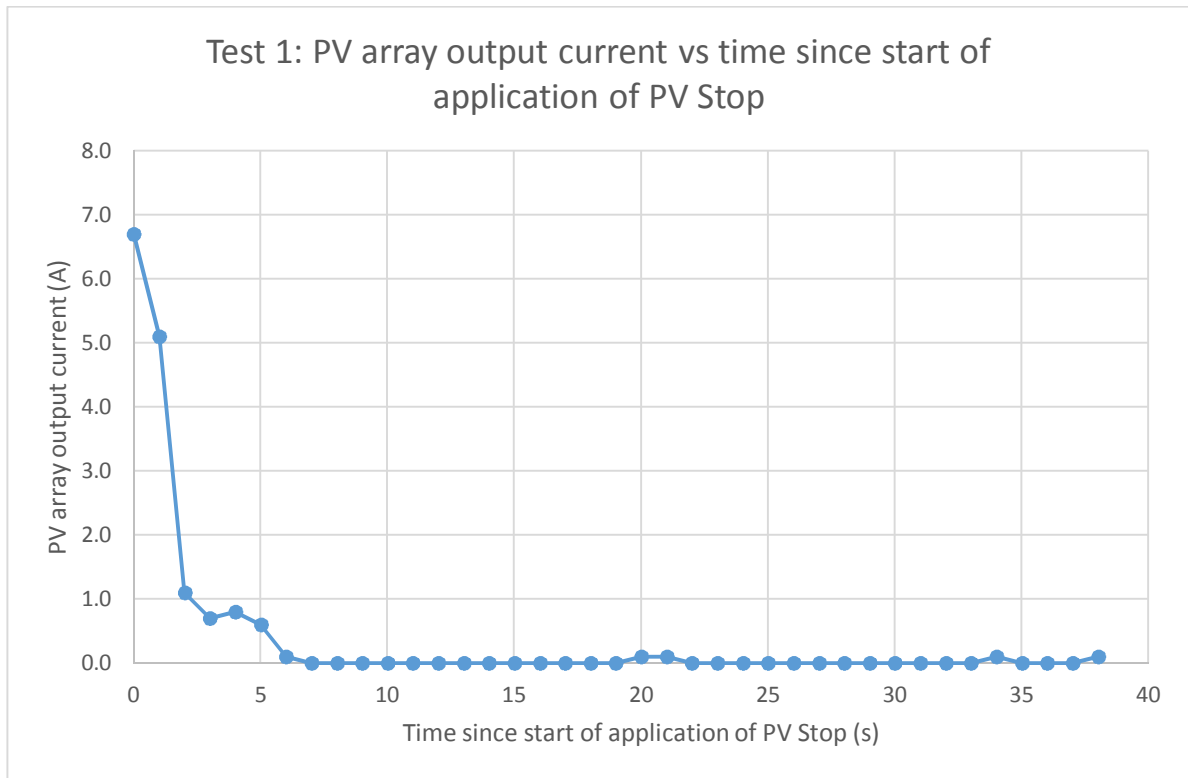


Figure 1 PV Array output vs time since start of application of PVStop

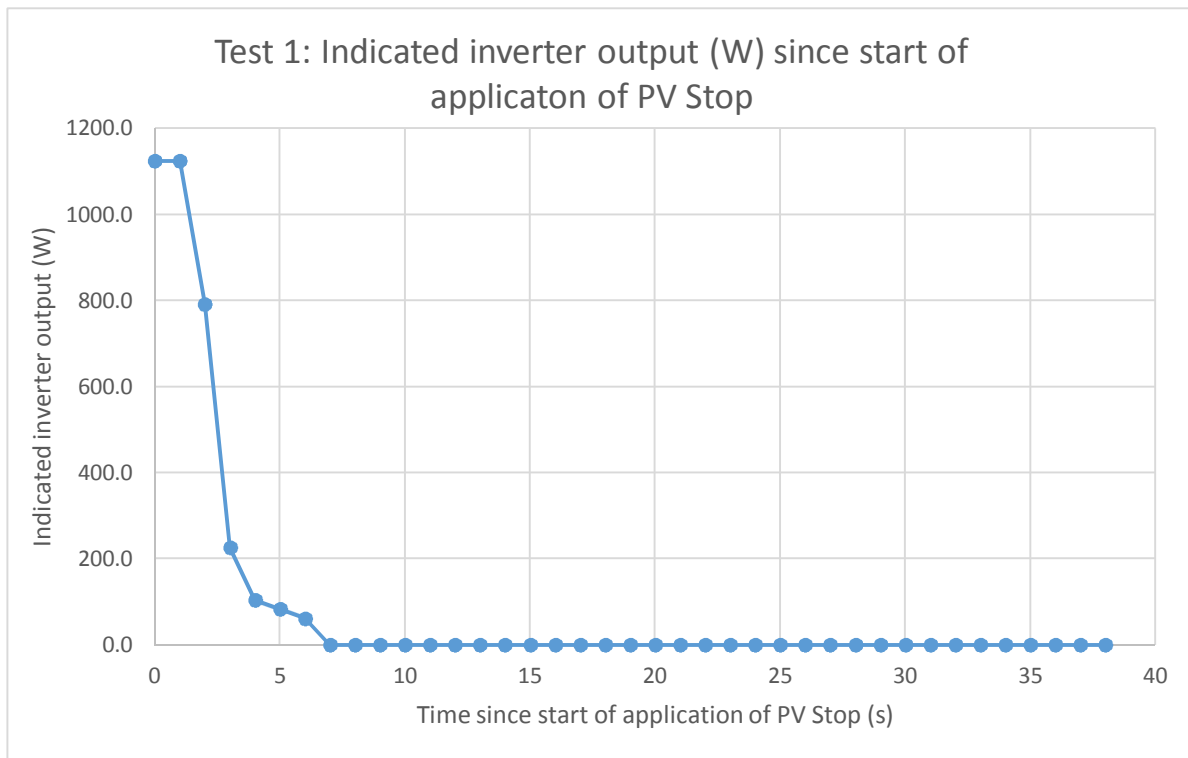


Figure 2 Indicated inverter output since start of application of PVStop

In test 2 using the same application process for PVStop and the same PV array, but this time experiencing between 898-951 Wm⁻² of solar radiation measured using the Seaward Solar Survey 200R, the DC voltage of the PV array measured using the Seaward PV150 Solar Installation Test Kit was reduced from 168.0 ± 8.6VDC to 72.0 ± 3.8 VDC in 4s ± 1s from the start of the application of PVStop.

It is worth noting that some residual DC voltage is to be expected following the application of PVStop. This is because, even small, areas of the modules not completely blocked from exposure to sunlight will give rise to low (ca. 0.5VDC) DC voltages which cumulatively can result in the residual DC voltage levels recorded. Such residual voltage should be considered alongside the associated DC current which, as seen in test 1, rapidly reduces to 0.0 ± 0.2 ADC. Since the output power of the PV array is the product of output current and voltage (I x V) the output power will also fall sharply if the either, or both, of the output current or voltage is rapidly reduced.

During the first 4s ± 1s from the start of the application of PVStop the indicated output of the inverter reduced from 1322.3W to 33.1W after which indicated output remained in the range 24.9 – 29.5W. See figure 3 and figure 4

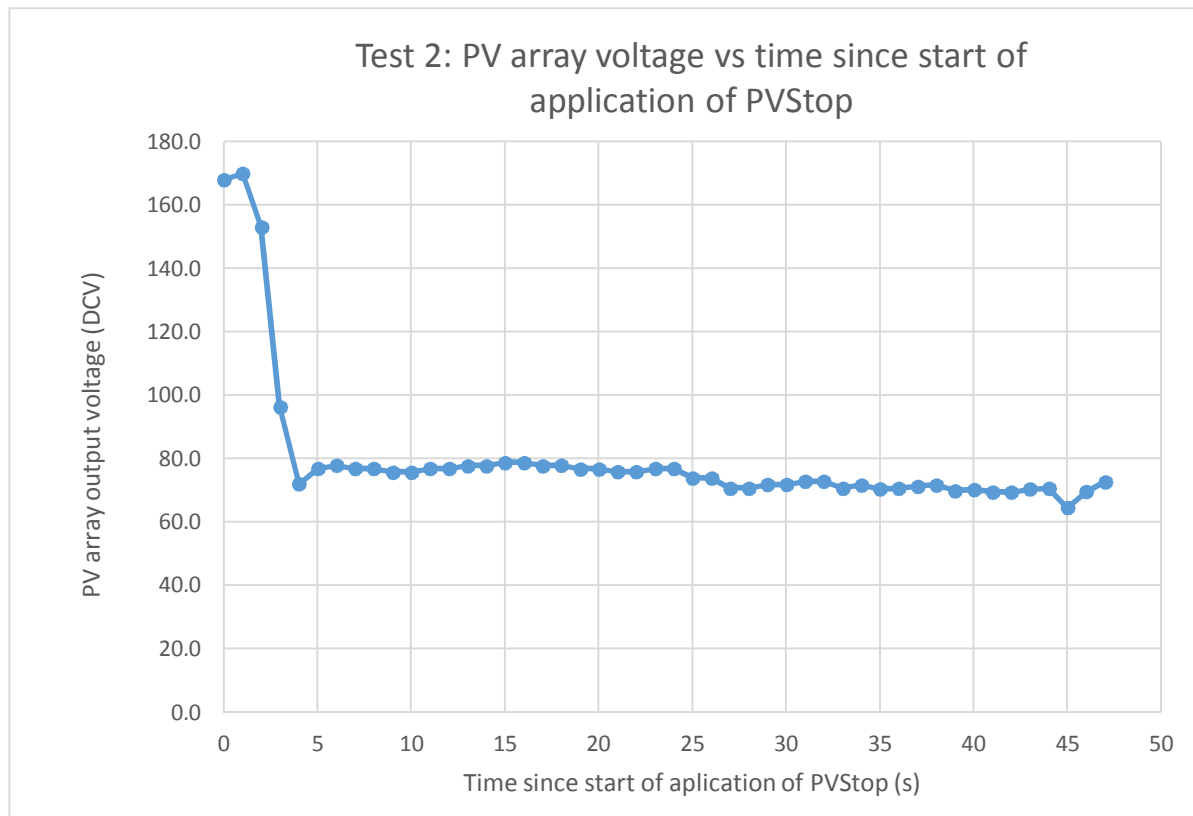


Figure 3 PV array voltage vs time since start of application of PVStop

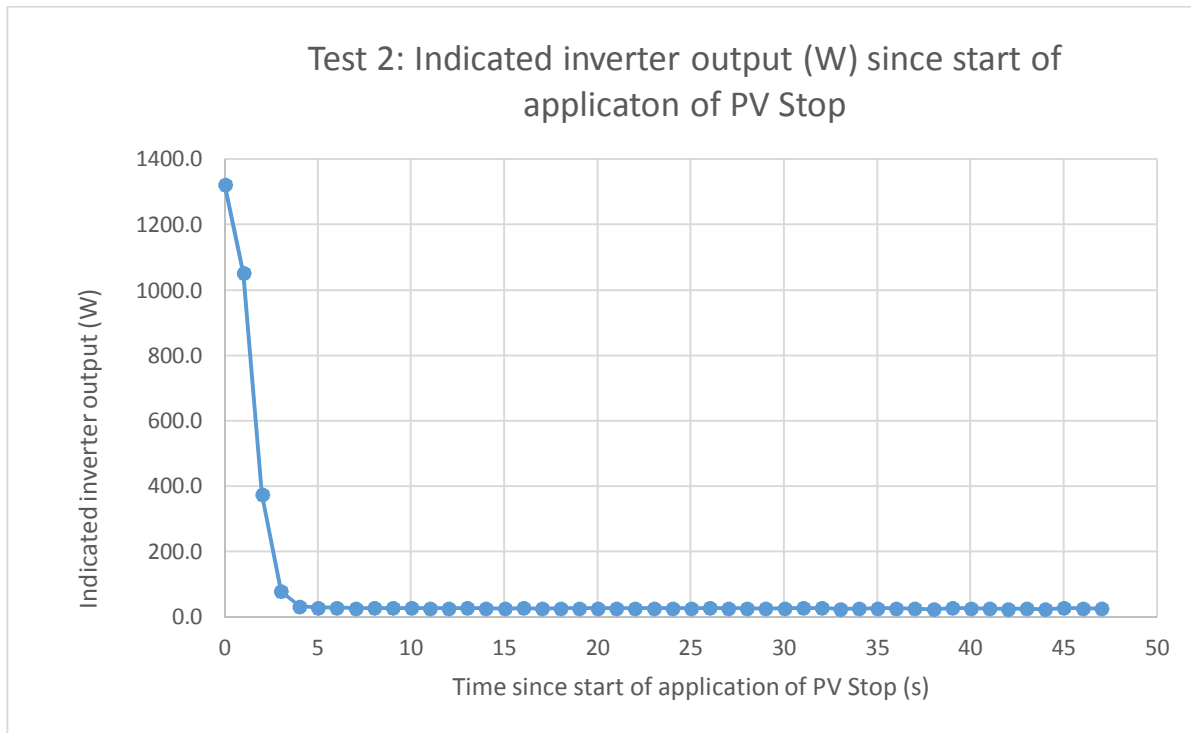


Figure 4 Indicated inverter output since start of application of PVStop

4.5.2. Additional parameters, with comments or caveats where appropriate

Solar radiation during the tests was recorded using a calibrated Seaward Solar Survey 200R instrument (see 4.4.2). The solar radiation recorded during the tests was:

Test 1: 759 – 764 Wm⁻² (average = 761.5)

Test 2: 898 - 951 Wm⁻² (average 924.5)

The ambient temperature at the location during the tests (10:45 – 12:49) was reported to be 12.6 – 12.8°C, average = 12.7°C

<https://www.wunderground.com/personal-weather-station/dashboard?ID=ILONDON161%20-%20history/s20170419/e20170419/mdaily#history/s20170419/e20170419/mdaily>

The temperature of the solar cells within the PV modules may be determined from the ambient temperature from the equation:

$$T_{Cell} = T_{Air} + \frac{NOCT - 20}{80} S$$

Where:

T_{air} = ambient air temperature (see above)

NOCT = Nominal Operating Cell Temperature (from module manufacturer)

S = Incident solar radiation (in mWcm⁻²)

Using the above the cell temperature (T_{cell}) during the tests is calculated to be:

$$\text{Test 1: } T_{\text{cell}} = 12.7 + ((43-20)/80)*76.1 = 34.6^{\circ}\text{C}$$

$$\text{Test 2: } T_{\text{cell}} = 12.7 + ((43-20)/80)*92.4 = 39.3^{\circ}\text{C}$$

5. Quality assurance

This verification was conducted according to the documented procedures of BRE Global. These procedures fall within the scope of BRE Global's, Schedule of Accreditation to ISO/IEC 17020:2012 issued by the United Kingdom Accreditation Service (UKAS) and which includes internal and external review.

Appendix 1. PVStop application instructions**PVStop Application Instructions**

VERSION NUMBER: 1.2
LAST REVISION DATE: 03.04.17

- Ensure an appropriate risk assessment of the vicinity has been performed.
- Remove safety pull-pin from the pressure vessel, aim the hose nozzle at the solar PV array and depress the handle to commence spraying.
- Spray an initial band of coating horizontally across the centre of the solar PV array, ensuring some coverage is achieved on every solar panel (this renders the solar PV system electrically safe).
- Proceed to spray coating onto the remaining uncovered areas of the solar PV array with an even coating until all the panels are completely covered or until the extinguisher is completely empty (providing additional assurance that the solar PV array is electrically safe).
- The solar PV array is now electrically isolated.
- If possible, locate the solar PV system inverter LCD display to confirm that the PV system is no longer producing power (note that not all PV system inverter types feature an LCD display).

Additional Information

- Please refer to the following youtube clip for a demonstration of the procedure for applying the coating to a PV array <https://youtu.be/y3h-DskL2Uc>
- For more information on the procedure for applying the coating, please visit our website www.pvstop.com.au and click on the “videos” page. These instructional videos answer the most commonly asked questions about the product.
- **NOTE:** Covering the solar panels with PVStop blocks the light from reaching the solar cells so that the system cannot produce electricity.
- Avoid spraying the coating too thickly in any one spot, this slows the drying time of the coating.
- PVStop is safe to apply to wet, burning or damaged solar PV panels.

- In a scenario involving fire, PVStop acts as a fire retardant and can be utilised to extinguish burning or fire damaged solar PV panels. The coating will encase the solar PV panels and prevent toxic nano-particles from being released and is also equally effective during salvage operations.
- At an ambient temperature of 25°C the coating is touch dry and waterproof in approximately 4 minutes.
- After 12 hours the coating is completely dry and can be peeled off the solar PV array easily to reactivate the solar PV system (we advise that the PV system owner contact a qualified electrical contractor to re-activate the solar PV system).
- Once removed from the solar PV system, the dry coating can be rolled into a ball and disposed of in normal garbage waste.
- The coating is UV resistant and can be left on the solar PV system for up to 12 months without deterioration.
- Any overspray can be removed from surrounding surfaces utilising a high pressure water blaster.



Appendix 2. Calibration Certificates

CERTIFICATE OF CALIBRATION

ISSUED BY SEAWARD ELECTRONIC LIMITED
 DATE OF ISSUE 04 April 2017
 CERTIFICATE NUMBER SEA019186/2R / 1



Bracken Hill
 South West Ind. Estate
 Peterlee
 Co. Durham
 SR8 2SW

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Approved Signatory

M. HUNTINGTON

Telephone: 0191 5878737 Fax: 0191 5860227 email: info@calibrationhouse.com

Requested By:	BRE NATIONAL SOLAR CENTRE EDEN PROJECT ST BLAZEY PL24 2SG
Order Number:	
Manufacturer:	SEAWARD ELECTRONIC
Model:	PV150
Description:	SOLAR INSTALLATION TESTER
Serial Number:	31G-0478
Asset ID:	
Seaward Reference:	115003
Temperature:	20.0°C
Humidity:	49 %RH
Date Received:	03 April 2017
Calibration Date:	04 April 2017
Calibration Category:	A: WITHIN SPECIFICATION AT THE POINTS TESTED, NO ADJUSTMENT NECESSARY

The ambient temperature and relative humidity throughout the calibration were 20 +/-2 degrees and 50% +/-20% RH

The unit was calibrated by connecting to an automatic test fixture which applied various load resistance values to simulate test conditions. Clamp measurement by by mV simulation. All measurements were gathered electronically.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a confidence level of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory

CERTIFICATE OF CALIBRATION

ISSUED BY CALIBRATIONHOUSE

DATE OF ISSUE 07/04/2017 CERTIFICATE NUMBER SEA019288/2R / 1



Seaward Electronic Limited
 11, Bracken Hill
 South West Ind. Estate
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 SR8 2SW
 Telephone: 0191 5878737 Fax: 0191 5184666
 e-mail: service@calibrationhouse.com

CALIBRATED BY
M. HUNTINGTON
 PAGE 1 of 3 PAGES

Requested By:	BRE NATIONAL SOLAR CENTRE EDEN PROJECT ST BLAZEY PL24 2SG
Order Number:	
Manufacturer:	SEAWARD ELECTRONIC
Model:	SOLAR SURVEY 200R
Description:	IRRADIANCE METER
Serial Number:	31G-0864
Customer/Asset ID:	
Seaward Reference:	115004
Date Received:	03 April 2017
Calibration Date:	07 April 2017
Calibration Category:	A: WITHIN SPECIFICATION AT THE POINTS TESTED, NO ADJUSTMENT NECESSARY

The measurements reported in this certificate were carried out using equipment whose measured values are traceable to UK National Standards, where these exist.

All procedures employed and management controls are in conformance with BS EN ISO9001: 2008, Seaward Electronic Limited certificate no. Q05356.

The ambient temperature and relative humidity throughout the calibration were 21 +/-2 degrees and 30-50% RH44

Approved Signatory

CERTIFICATE OF CALIBRATION

ISSUED BY SEAWARD ELECTRONIC LIMITED
DATE OF ISSUE 06 April 2017
CERTIFICATE NUMBER SEA019264/2R / 1



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PAGE 1 of 2 PAGES

Approved Signatory
 M. HUNTINGTON

Telephone: 0191 5878737 Fax: 0191 5860227 email: info@calibrationhouse.com

Requested By:	BRE NATIONAL SOLAR CENTRE EDEN PROJECT ST BLAZEY PL24 2SG
Order Number:	
Manufacturer:	SEAWARD ELECTRONIC
Model:	SOLAR AC/DC CURRENT CLAMP
Description:	CLAMP METER
Serial Number:	54003623
Asset ID:	
Seaward Reference:	115005
Temperature:	20.0°C
Humidity:	40 %RH
Date Received:	03 April 2017
Calibration Date:	06 April 2017
Calibration Category:	A: WITHIN SPECIFICATION AT THE POINTS TESTED, NO ADJUSTMENT NECESSARY

The ambient temperature and relative humidity throughout the calibration were 20 +/-2 degrees and 50% +/-20% RH

The unit was tested by applying varying test values at appropriate points throughout each range by means of a multifunction calibrator and multi turn coil. The resulting output was measured using a digital multimeter.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a confidence level of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory