Fraunhofer ISE
TestLab PV Modules

FRAUNHOFER-INSTITUTE FOR SOLAR ENERGY SYSTEMS, ISE

REPORT FUE14260

Mechanical load test on PV-Modules with 0° and 20° inclination in combination with PowAR snap S mounting system from supplier ARaymond Energies

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FUE14260

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Freiburg, 31 July 2014

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Content

1
Preliminary Remarks

1.1
Description

The purpose of the specific mechanical load test with the PowAR snap S mounting system was to determine the ability of the mounted module to withstand the specified static load in push-down and pull-up direction. To simulate real conditions, two mounting configurations (0° and 20° inclination angle) were tested. The test-setup was defined by the customer ARaymond Energies and exceeds the requirements of the standard IEC 61215 with respect to the inclination angle
Before and after the mechanical load test, the performance of the PV module was measured in acc. to the IEC 61215 standard and an electroluminescence image was taken.

1.2
Summary

The tested modules and the PowAR snap S attachments withstood the mechanical load test without malfunction or any other failure which could impact the save operation of the modules and the substructure. No frame-deformation, broken cells or delamination of the backsheet could be detected.

The performance measurement showed a small performance loss at all three tested modules after the mechanical load test.

The occurrence of cell cracks is typical for the mechanical load test. In the delivered condition, two modules already showed several macro cracks. During the mechanical load test, the existing cell cracks have become more intensive and partly inactive cell areas were caused. Only very few new additional cracks have occurred during the mechanical load test.
At the end an «extreme load test" was carried out on both modules with the 20° inclination mounting configuration. Both modules withstood a load of +6000 Pa and -5800 Pa without damage of the modules and breakage of the clamps.

2
Definitions

2.1
Specification of Test Samples

	Module 1	Module 2	Module 3
Manufacturer	YINGLI Solar	YINGLI Solar	YINGLI Solar
Type	YL250P-29b	YL245PT-29B	YL245P-29B
Ser. No.	122302051903	120503151443	121509025462
Technology	60 poly-Si	60 poly-Si	60 poly-Si
nominal P_{mpp} [W]	250	245	245
TLPV-ID	FUE14260 M2	FUE14260 M5	FUE14260 M4
Condition	new	new	new

Table 1: Sample description

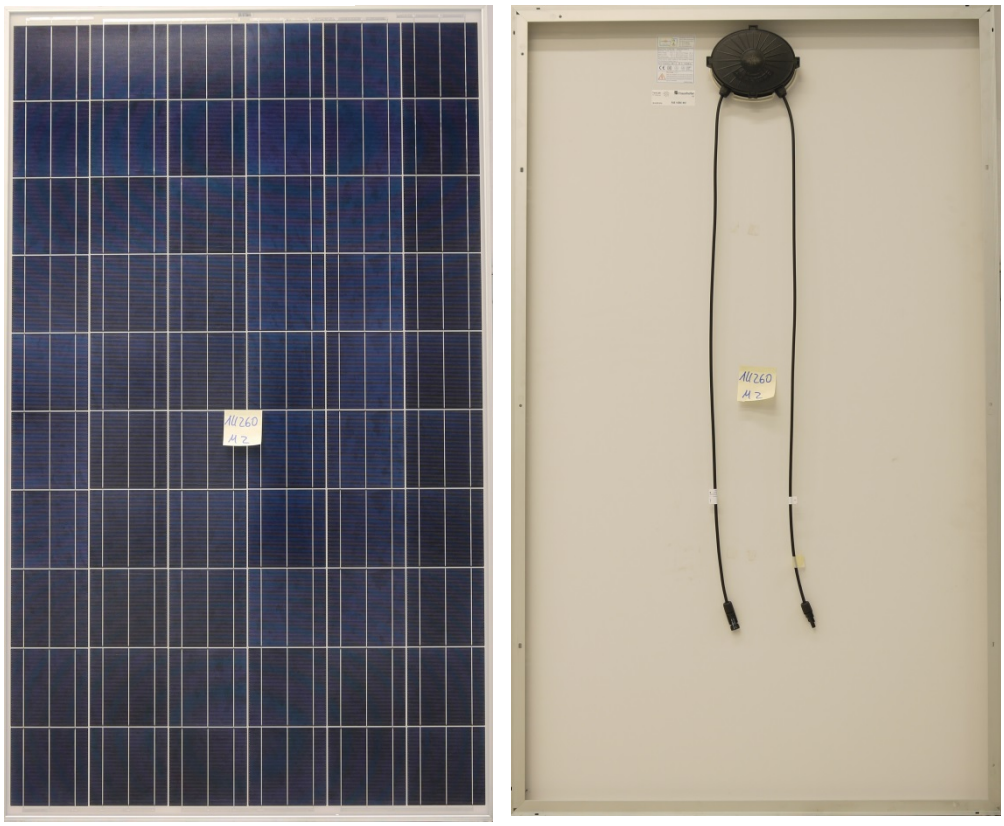


Figure 1/2: Representative front and rear side photography of module M2

2.2
Characterization Measurements

Characterization measurements are conducted before and after stress tests. These measurements enable an evaluation of the module's resistivity against the applied stresses.

2.2.1
Visual Inspection According to IEC61215:2005, Step 10.1

A photograph is taken of each module under an illumination of 1000 lux and more. The inspection is performed with respect to failures defined in IEC61215:2005 step 10.1.2 and other abnormalities.

2.2.2
Performance at STC According to IEC 60904 (-1 and -3)

The specific module parameters are determined by taking an I-V-curve by means of a pulsed solar simulator at standard test conditions (STC):

Irradiation: 1000 W/m²
Module temperature: 25 °C
Spectrum of solar simulator: AM 1.5
Class of solar simulator (according to IEC 60904-9): AAA

The measured values will be compared to the specifications given on the data sheet.

2.2.3
Electroluminescence Imaging

An electroluminescence (EL) image is taken while applying a current to the module and collecting the emitted radiation from the module.

EL images can reveal inhomogenities and defects like micro cracks on the cell or defective electrical interconnections.

2.3 Test Sequence

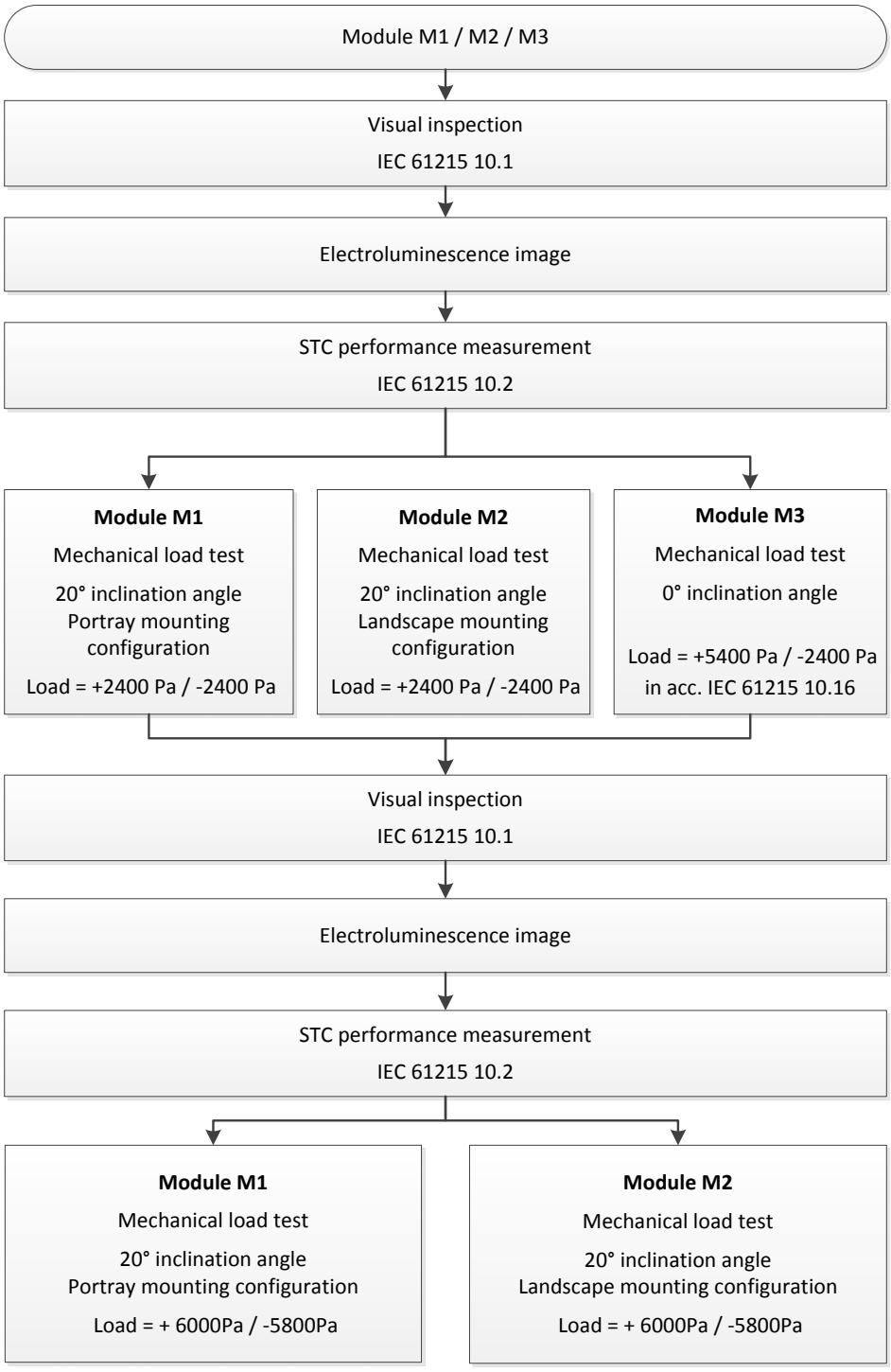


Figure 2 – Test sequence

2.4
Mechanical Load Test

2.4.1
Test-Setup - Mechanical Load Test with 20° Inclination Angle (Portray Configuration)

Figure 3/4: Test setup – 20° inclination (portray configuration)

First, PowAR™ Snaps were slipped into the defined position on the module frame. Then, the modules were clipped into the strut.

2.4.2
Test-Setup - Mechanical Load Test with 20° Inclination Angle (Landscape Configuration)

Figure 5/6: Test setup – 20° inclination (portray configuration)

First, PowAR™ Snaps were slipped into the defined position on the module frame. Then the modules were clipped into the strut. As visible above, to avoid slipping down, two stoppers (mounting brackets) were mounted on the bottom side of the frame.

2.4.3
Test-Setup - Mechanical Load Test with 0° Inclination angle

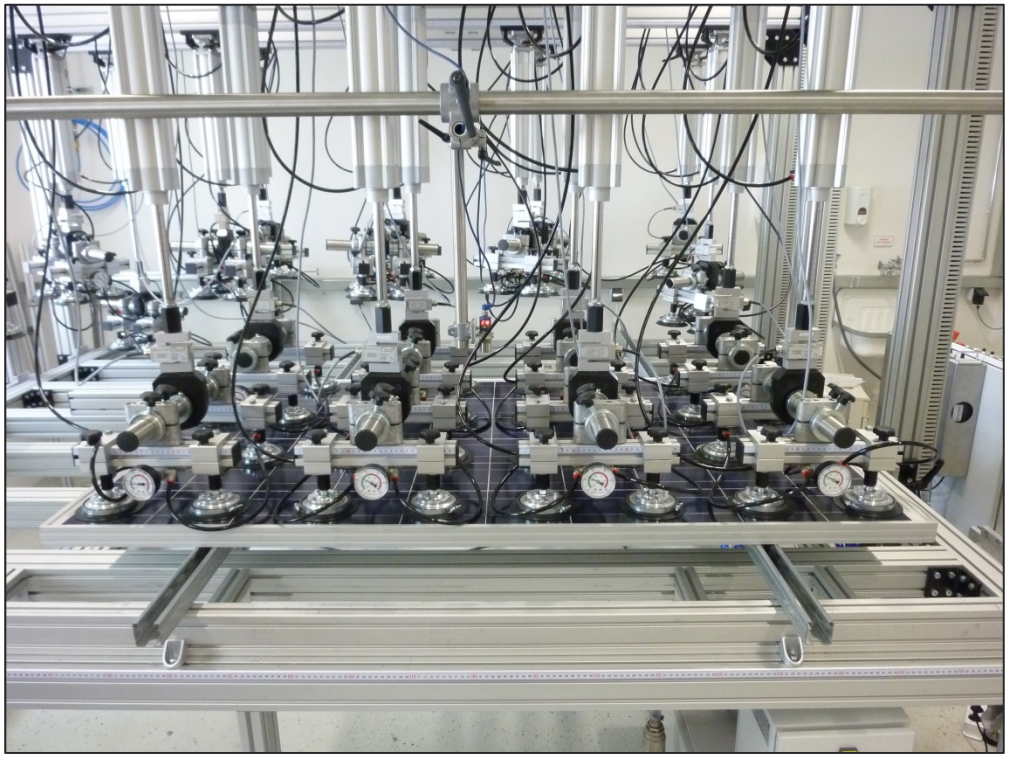


Figure 7 – Test-Setup with 0° Inclination

Figure 8 – View from bottom side during application of 5400 Pa load

2.4.4
Applied Mechanical Load Parameter

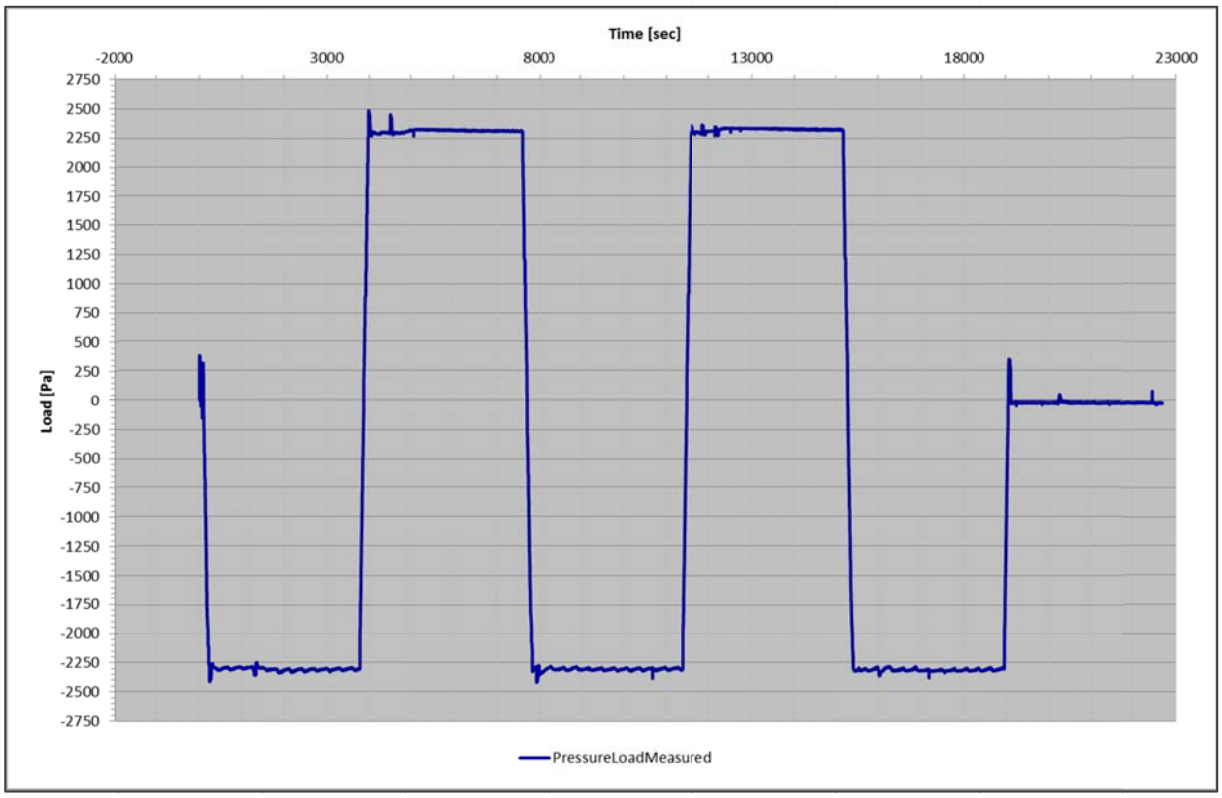


Diagram 1 – Applied load on module M1

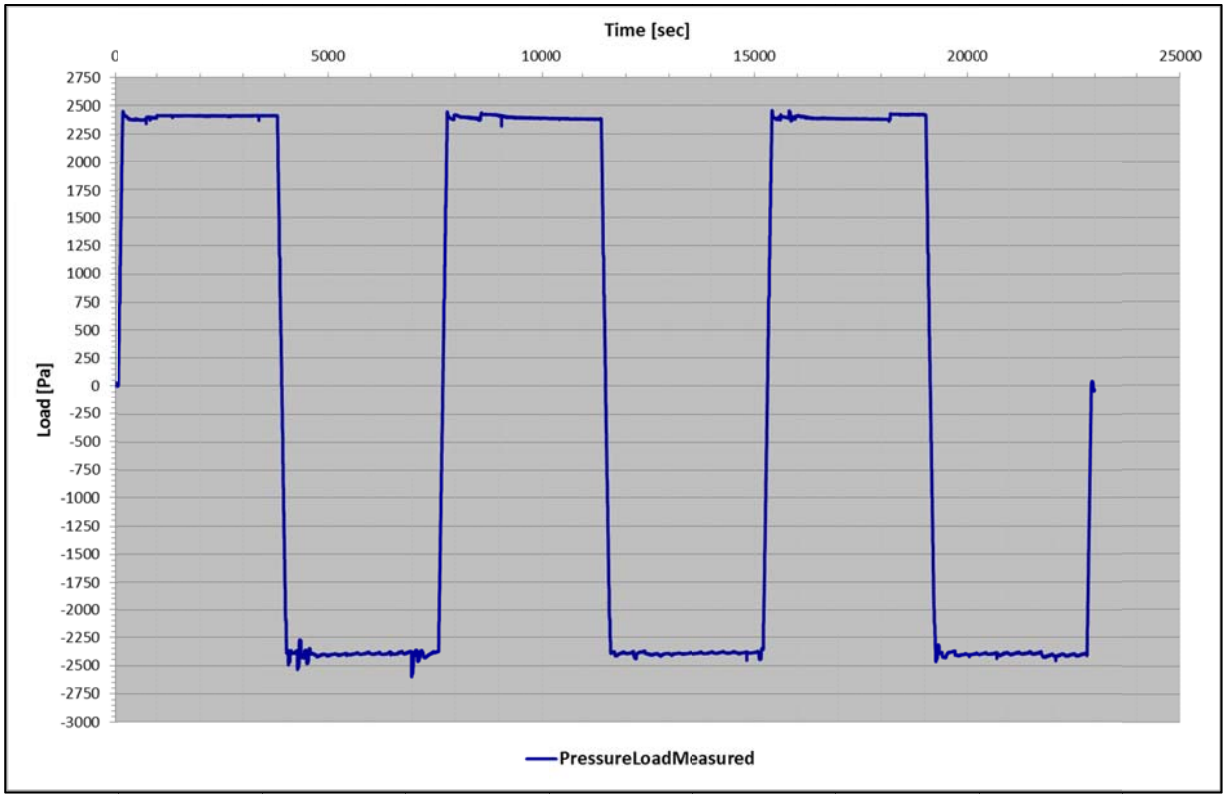


Diagram 2 – Applied load on module M2

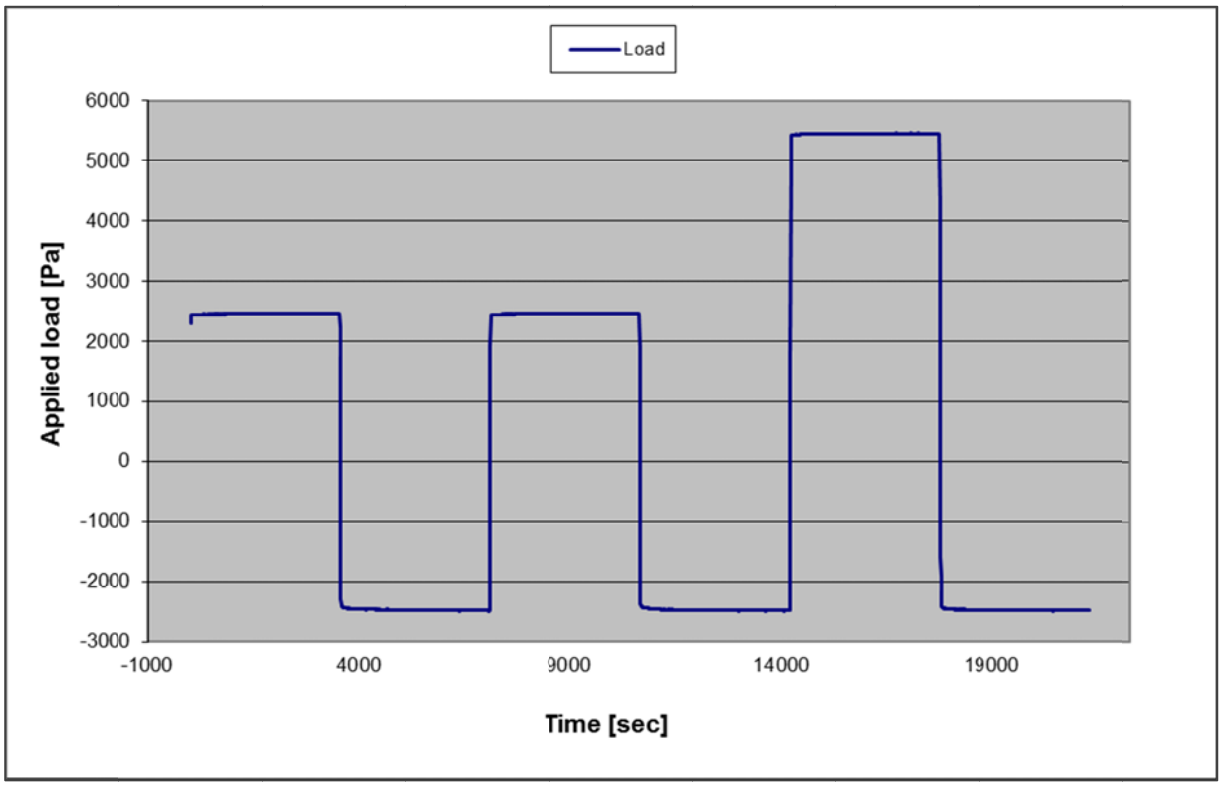


Diagram 3 – Applied load on module M3

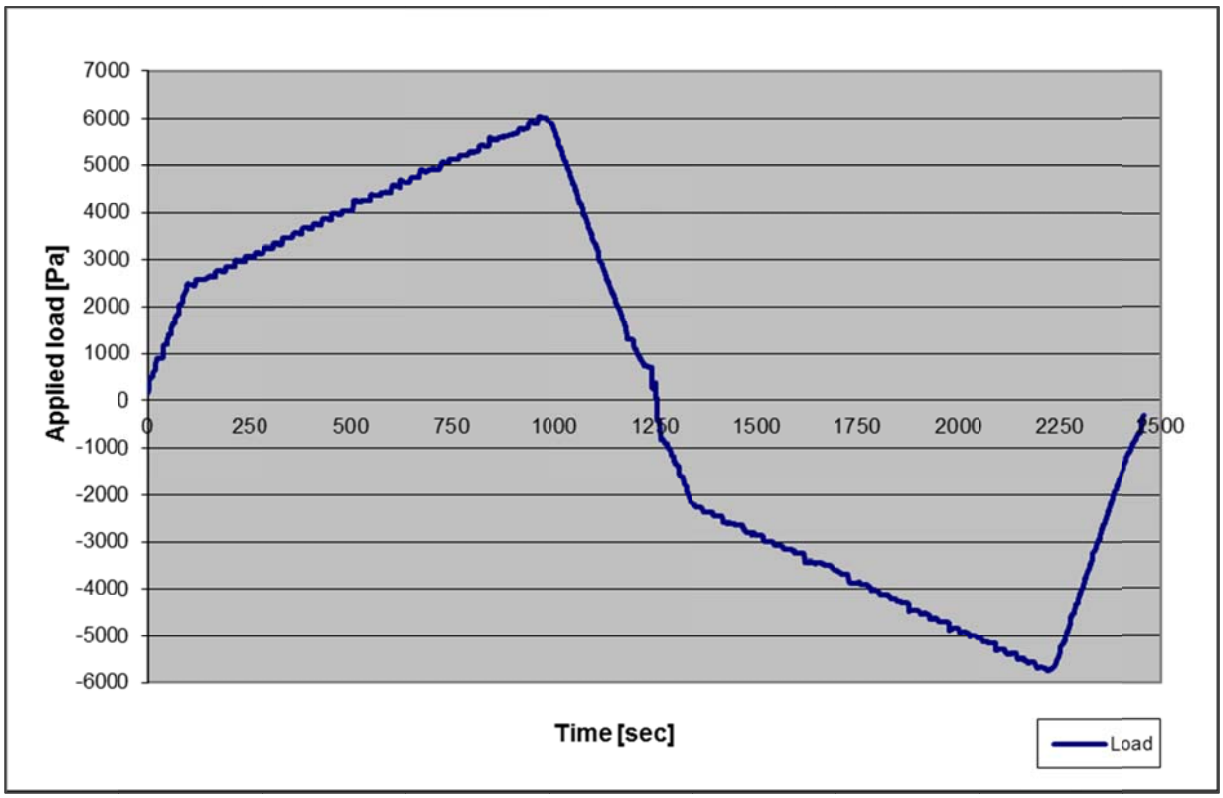


Diagram 4 – Applied load on module M1

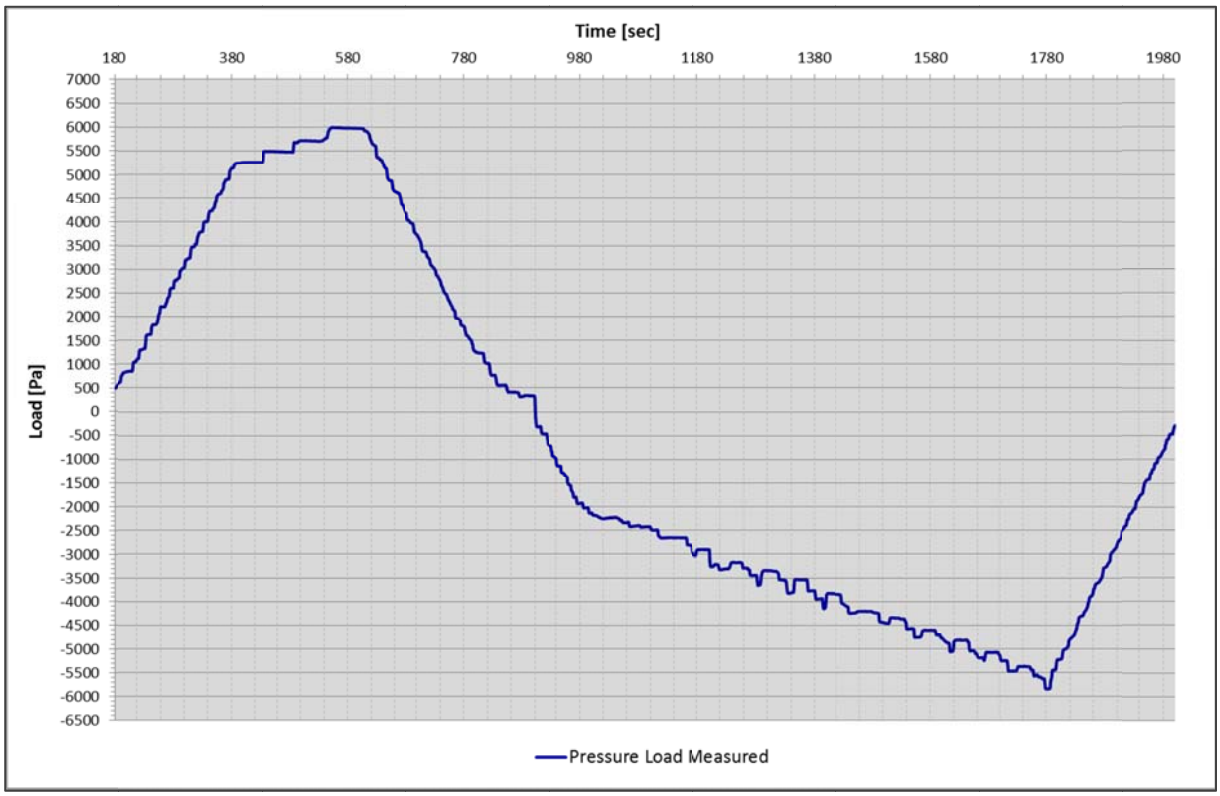


Diagram 5 – Applied load on module M2

3
Results

3.1
Visual Inspection

At the beginning and after each stress test, a visual inspection was performed. Each inspection is documented with a picture of the front and the rear side of the sample. The requirements of the standard IEC 61215 10.1 have been fulfilled before and after mechanical loading. No frame-deformation, broken cells or delamination of the backsheet could be detected.

3.2
Performance at STC

The following table shows the measured performance data before and after each stress test. The deviation of the final measurement to the initial measurement is given.

The performance measurement was done with an absolute accuracy of ±2.5 %.

Module 1	Isc [A]	Uoc [V[	Impp [A]	Umpp [V]	Pmpp [W]	FF [%]	Eta [%]
Initial	8,839	37,711	8,201	29,850	244,806	73,443	14,987
After ML	8,856	37,718	8,144	29,711	241,978	72,440	14,813
Difference [%]	0,19%	0,02%	-0,70%	-0,47%	-1,16%	-1,37%	-1,16%

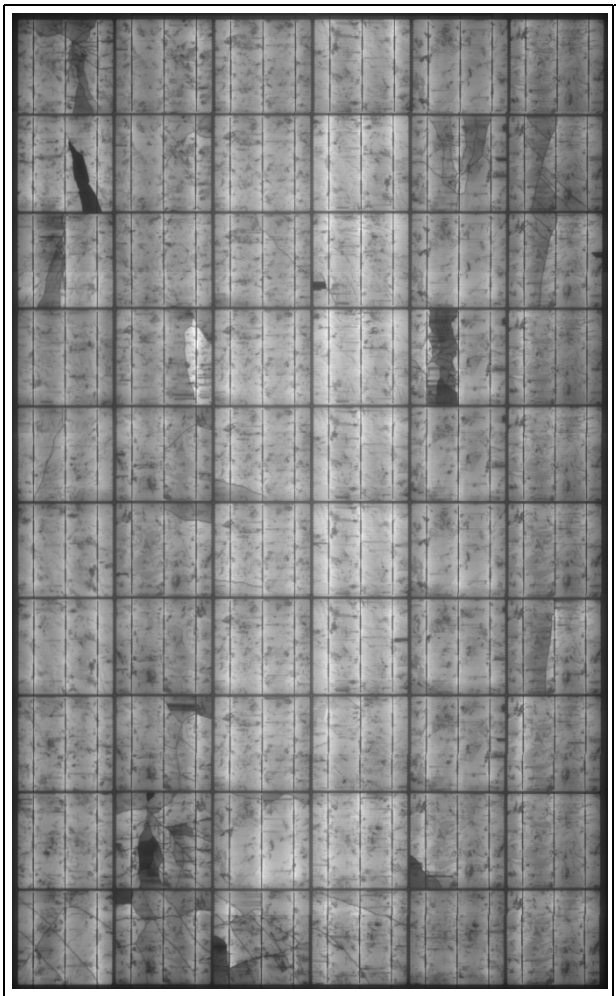
Module 2	Isc [A]	Uoc [V[	Impp [A]	Umpp [V]	Pmpp [W]	FF [%]	Eta [%]
Initial	8,764	37,392	8,158	29,800	243,096	74,177	14,882
After ML	8,709	37,339	8,119	29,773	241,726	74,330	14,798
Difference [%]	-0,63%	-0,14%	-0,48%	-0,09%	-0,56%	0,21%	-0,56%

Module 3	Isc [A]	Uoc [V[	Impp [A]	Umpp [V]	Pmpp [W]	FF [%]	Eta [%]
Initial	8,832	37,780	8,208	29,739	244,085	73,148	14,942
After ML	8,828	37,596	8,160	29,507	240,784	72,547	14,740
Difference [%]	-0,05%	-0,49%	-0,58%	-0,78%	-1,35%	-0,82%	-1,35%

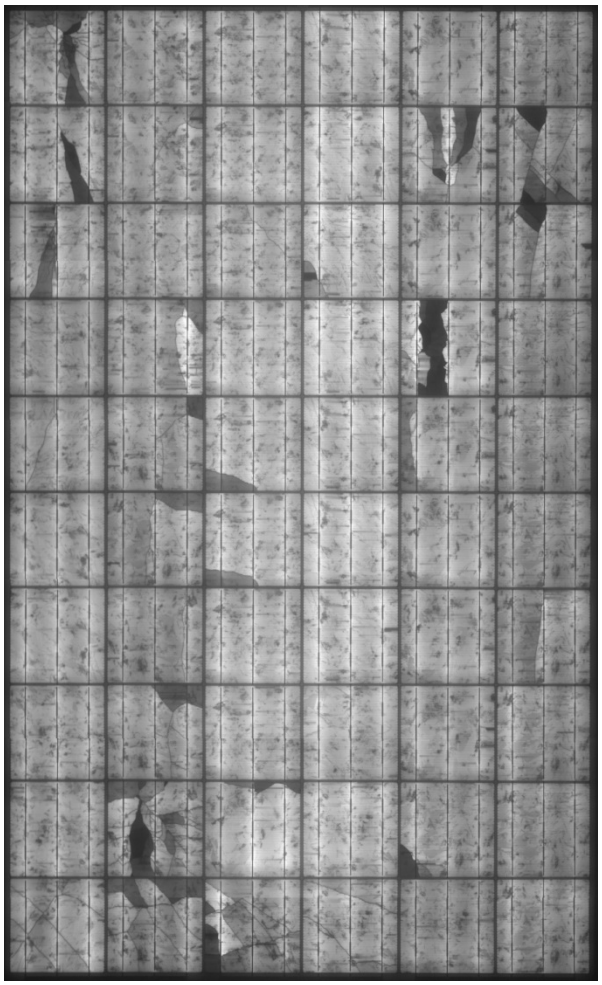
The performance measurement shows a small performance decrease at all three tested modules. In accordance to the IEC 61215 standard, the performance loss caused by the mechanical load test should not exceed 5 %.

3.3 Electroluminescence Imaging

In order to identify cell defects due to the mechanical load test, electroluminescence images have been made before and after the test.



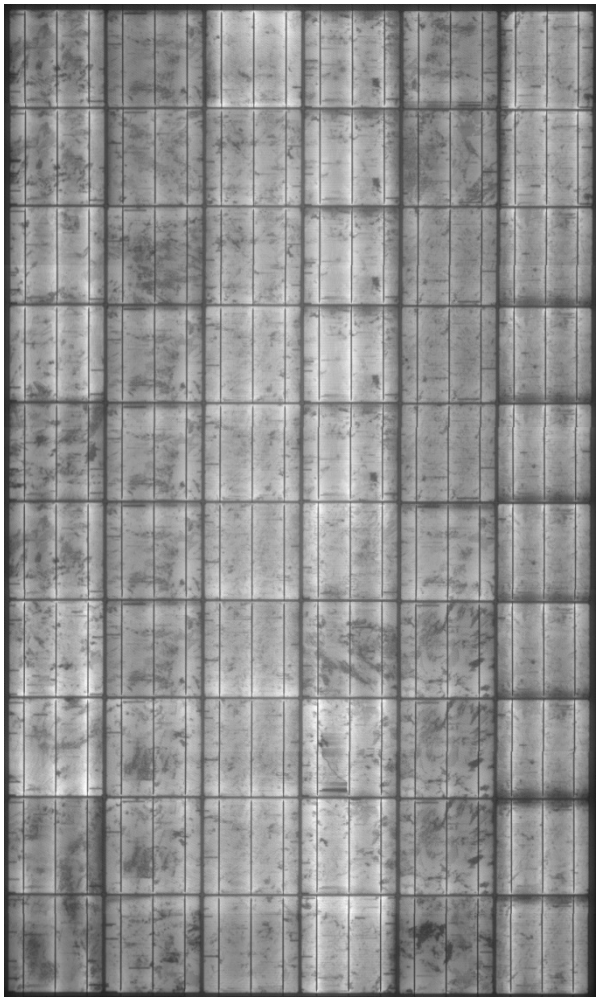
Module M1 - Before mechanical load test



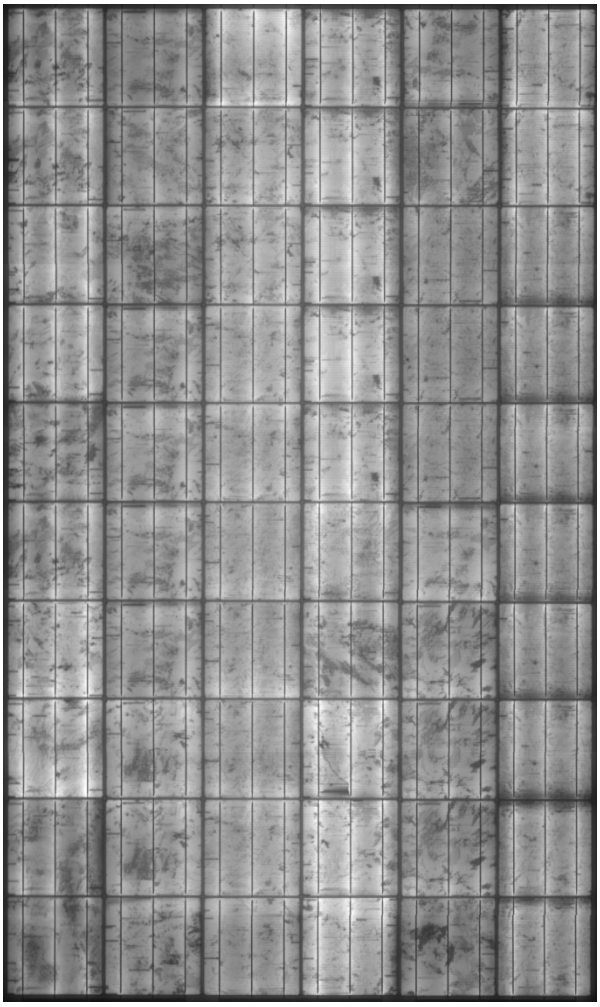
Module M1 - After mechanical load test

Figure 9/10: Electroluminescence images - Module M1

In the delivered condition, the module showed already several macro cracks and cell breakages. As visible in the picture above, during the angular mechanical load test with 20° inclination, the existing cell cracks have become more intensive and in some parts inactive cell areas were caused. Only very few new additional cracks have occurred during the mechanical load test.



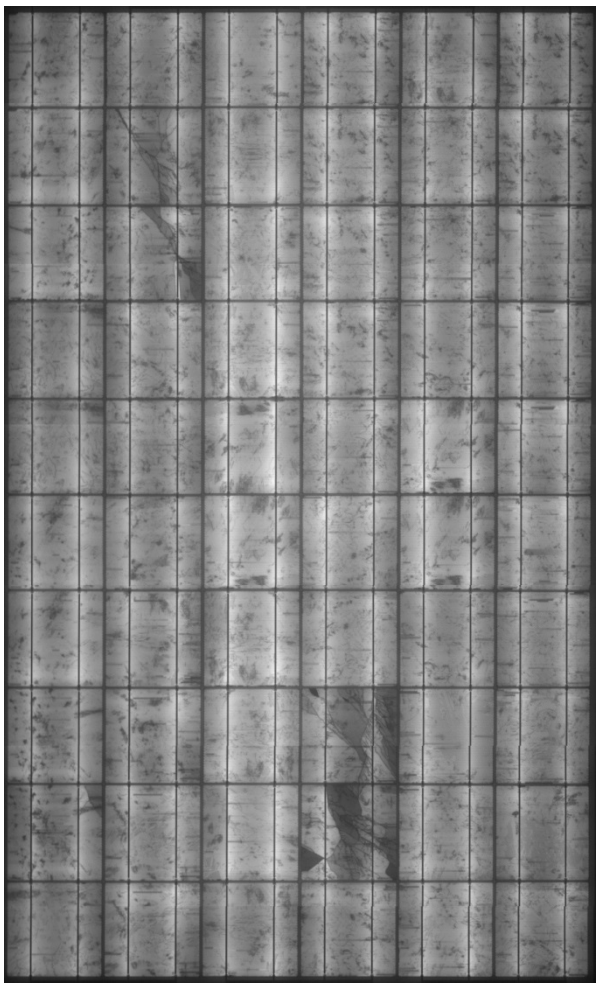
Module M2 - Before mechanical load test



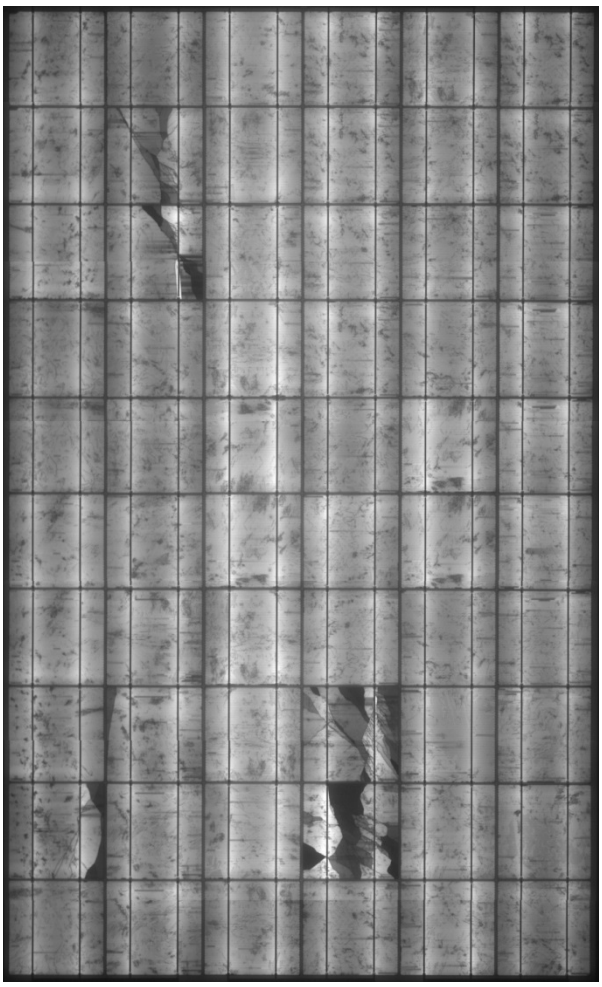
Module M2 - After mechanical load test

Figure 11/12: Electroluminescence images - Module M2

During the mechanical load test with 20° inclination and the load of +/- 2400 Pa, no visible cracks have occurred.



Module M3 - Before mechanical load test



Module M3 - After mechanical load test

Figure 13/14: Electroluminescence images - Module M3

In the delivered condition, the module showed already several macro cracks. As visible in the picture above, during the angular mechanical load test with 20° inclination, the existing cell cracks have become more intensive and in some parts inactive cell areas were caused. Only very few new additional cracks have occurred during the mechanical load test.

4 Annex

4.1
Technical drawing - PowAR snap S