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TUV Rheinland (India) Pvt. Ltd.
Product Safety &Quality

Test Report

Photovoltaic module Testing for
Resistivity to Potential induced Degradation(PID)

TÜV Report No. 19630765.001

Bangalore, APRIL 2016

Certificate No. T-1543

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Test report no.: *Prüfbericht - Nr.:*	**19630765.001**		
Client **(Customer no. and address):** *Auftraggeber* *(Kunden-Nr. u. Adresse):*	410949 Renewsys India Pvt Ltd.Division: Hyderabad, Fab City (SEZ), Plot No.6,Survey #114/P, Srinagar Village, Maheswaram, R.R District Hyderabad -501359. India		
Test item: *Gegenstand der Prüfung:*	Photovoltaic (PV) Module(s)	**Date of receipt:** *Eingangsdatum:*	29-03-2016
Module type designation: *Modultypen-Bezeichnung:*	**DESERVE-3M6-310**		
Order no.: *Auftragsnummer:*	1803132069	**Quotation no.:** *Angebotsnummer:*	402031537 dtd 23.03.2016
Testing location: *Prüfort:*	TUV Rheinland(India) Pvt.Ltd Plot No.17B,Electronic city, Phase II, Industrial Area,Begur Hobli, Bangalore(south)-560 100,India Tel: +91 80 3923 4301		
Test specification: *Prüfgrundlage:*	IEC TS 62804 – 1 :Test methods for the detection of potential-induced degradation – Part 1: Crystalline silicon with following severities - Climatic conditions: 60°C and 85% RH - Duration: 96 hours		
Test result: *Prüfergebnis:*	Results Enclosed		

compiled by/*erstellt:*		**reviewed by**/*kontrolliert:*	
20-04-2016	K. Ganesh Kamath	20-04-2016	Kamalaksha.CS
Date *Datum*	**Title/Name** *Titel/Name*	**Date** *Datum*	**Title/Name** *Titel/Name*

This test report relates to the listed test samples. Without permission of the test centre this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any safety mark on this or similar products.

Dieser Prüfbericht bezieht sich nur auf die gelisteten Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.

Address/es of the manufacturing site/s:

Name / Description:	Renewsys India Pvt Ltd.Division: Hyderabad
Street:	Fab City (SEZ), Plot No.6,Survey #114/P
Postcode / City:	Srinagar Village, Maheswaram, R.R District Hyderabad -501359.
Country:	India
Type of production:	Solar Photovoltaic Modules

Contents

Summary of testing:

"According to the enquiry of the manufacturer for a testing against PID resistivity shall be performed according to IEC TS 62804 with following severities –

- Negative potential of the specified maximum system voltage between the shorted output terminals and the frame(ground), - 1000V DC
- Climatic conditions: 60°C and 85% RH
- Duration: 96 hours

Before and after the PID test, Visual inspection, maximum power determination, wetleakage current test and documentation by electroluminescence imaging shall be performed.

In line with the international standard for PV module type approval testing EN IEC 61215, two modules will be tested. One additional module will be used as a reference sample.

Pass Criteria:

A module design shall be judged to have passed the PID test , if each test sample meets all the following criteria:

- The degradation of maximum output power does not exceed 5%.
- No evidence of a major visual defect (as defined in IEC 61215:2005)

All presented results are only valid for the exact tested module type and design (cell type, encapsulation material, glass type)

Summary of test locations:

All tests were performed at TUV Rheinland (India) Pvt Ltd, Bangalore.

Summary of deviations from the standard:

- NA

General information:

Abbreviations used in the report:	
Impp	– Maximum power point current
Isc	– Short circuit current
Pmpp	– Maximum power
STC	– Standard Test Conditions
Vmpp	– Maximum power point voltage
Voc	– Open circuit voltage
FF	– Fill factor
Possible test case verdicts:	
- test case does not apply to the test object ..... :	N/A
- test object does meet the requirement ..... :	Passed (P)
- test object does not meet the requirement ..... :	Failed (F)
Date(s) of performance of tests ..... :	From: 30-03-2016 to 15-04-2016

Module group assignment:

TUV No #	Sample S/N	Remarks / constructional characteristics
1803132069-01	1152952	Module type: DESERV - 3M6 - 310 Cell: DMEGC_ DMTP156 - 3bb Multicrystalline EVA : Renewsys_ CONSERV A 360.2 14 FC Back Sheet: Renewsys_ PRESERV A - 190WN Superstrate: Dongguan CSG
1803132069-02	1152955	
1803132069-03	1152953	

Tables:

Visual inspection (Initial) (10.1):

Test date [DD/MM/YYYY]	Sample #	Nature and position of initial findings	—
30-03-2016	1803132069-01	No major visual defects found	P
30-03-2016	1803132069-02	No major visual defects found	P
30-03-2016	1803132069-03	No major visual defects found	P
Supplementary information: None			

Maximum power determination (Initial) (10.2):

Module temperature [°C]		Corrected to 25					—
Irradiance [W/m²]		1000					—
Test date [DD/MM/YYYY]	Sample #	Pmpp [W]	Vmpp [V]	Impp [A]	Voc [V]	Isc [A]	FF [%]
31-03-2016	1803132069-01	313.6	37.52	8.35	45.78	8.97	76.3
31-03-2016	1803132069-02	313.3	37.00	8.46	45.61	8.99	76.3
31-03-2016	1803132069-03	312.9	37.01	8.45	45.63	8.97	76.3
Supplementary information: None							

Wet leakage current test (Initial) (10.15):

Test voltage Applied[V_{DC}]		1000			—
Solution resistivity [Ω cm]		< 3,500			
Solution temperature [°C]		22 ± 3			
Test date [DD/MM/YYYY]	Sample #	Measured [MΩ]	Area [m²]	Result* [MΩ * m²]	—
31-03-2016	1803132069-01	3520.0	1.93	6793.6	P
31-03-2016	1803132069-02	4700.0	1.93	9071.0	P
31-03-2016	1803132069-03	3150.0	1.93	6079.5	P
Supplementary information: None * Minimum requirement acc. to the standard is 40 MΩ*m².					

Ground continuity test (Initial, MST 13):

		Maximum over-current protection rating[A]		15		
		Current applied [A]		37.5		—
		Location of Ref grounding point		Right side Longer frame		—
Test date [DD/MM/YYYY]	Sample No	Position in test sequence	Location	Voltage [mV]	Resistance [mΩ]	—
31-03-2016	1803132069-01	CONTROL	Ref- Adjacent frame 1	119.0	3.17	P
			Ref- Adjacent frame 2	151.3	4.03	P
			Ref- Opposite frame	175.6	4.68	P
31-03-2016	1803132069-02	PID	Ref- Adjacent frame 1	126.8	3.38	P
			Ref- Adjacent frame 2	143.6	3.83	P
			Ref- Opposite frame	149.8	3.99	P
31-03-2016	1803132069-03	PID	Ref- Adjacent frame 1	198.1	5.28	P
			Ref- Adjacent frame 2	210.6	5.62	P
			Ref- Opposite frame	181.0	4.83	P
Supplementary information: None						

Performance of PID Test:

Test date	11-04-2016 to 15-04-2016	
Method	Climatic chamber	
Module temperature [°C]	60	
Relative humidity [%]	85	
Grounding Polarity	+ve	
Sample	Applied voltage [V]	Duration[Hrs]
1803132069-02	-1000	96
1803132069-03	-1000	96
Supplementary information: None		

Visual inspection after PID Test:

Test date [DD/MM/YYYY]	Sample #	Nature and position of findings	-
15-04-2016	1803132069-02	No major visual defects found	P
15-04-2016	1803132069-03	No major visual defects found	P
Supplementary information: None			

Maximum power determination after PID Test:

Module temperature [°C]		Corrected to 25							-
Irradiance [W/m²]		1000							-
Test date [DD/MM/YYYY]	Sample #	Pmpp [W]	Vmpp [V]	Impp [A]	Voc [V]	Isc [A]	FF [%]	Degradation [%]	-
15-04-2016	1803132069-02	314.1	37.48	8.38	45.70	9.03	76.1	0.0	P
15-04-2016	1803132069-03	314.6	37.04	8.49	45.76	9.01	76.3	0.0	P
Supplementary information: Initial measurements were considered for calculating degradation									

Wet leakage current test (Initial) (10.15):

Test voltage Applied[V_{DC}]		1000			—
Solution resistivity [Ω cm]		< 3,500			
Solution temperature [°C]		22 ± 3			
Test date [DD/MM/YYYY]	Sample #	Measured [MΩ]	Area [m²]	Result* [MΩ * m²]	—
15-04-2016	1803132069-02	351.0	1.93	677.4	P
15-04-2016	1803132069-03	314.0	1.93	606.0	P
Supplementary information: None * Minimum requirement acc. to the standard is 40 MΩ*m².					

Result:

1. The degradation of maximum output power were not exceed 5%
2. There is no evidence of a major local degradation in electroluminescence inspection.

There is no Potential Induced degradation determined according to pass criteria

Annex 1: Statement of the estimated uncertainty of the test verdicts:

- Electrical performance rating is outside the scope of IEC 61215:2005 qualification testing. The verdicts of performance rating are only related to the test samples that were subjected to the tests. They cannot be generalised to the modules from the series production.
- Pmax measurement:2.45% with a coverage factor k=2
- Current measurement:2.27% with a coverage factor k=2
- Voltage measurement:1.39% with a coverage factor k=2
- Relative measurements were performed with a flash type solar simulator.
- The accuracy of measurement reproduction with the solar simulator is less than ±1%.

Annex 2: Measuring software:

Program name	Version no.	Date	Application
SLAB industrial _IO_V2_1_1	V2.1	SEP 2009	Operating software for pulsed simulator
S!MPATI.exe	4.02	-	Operating software for chambers

Annex 3: Measurement at STC:Initial

1803132069-01

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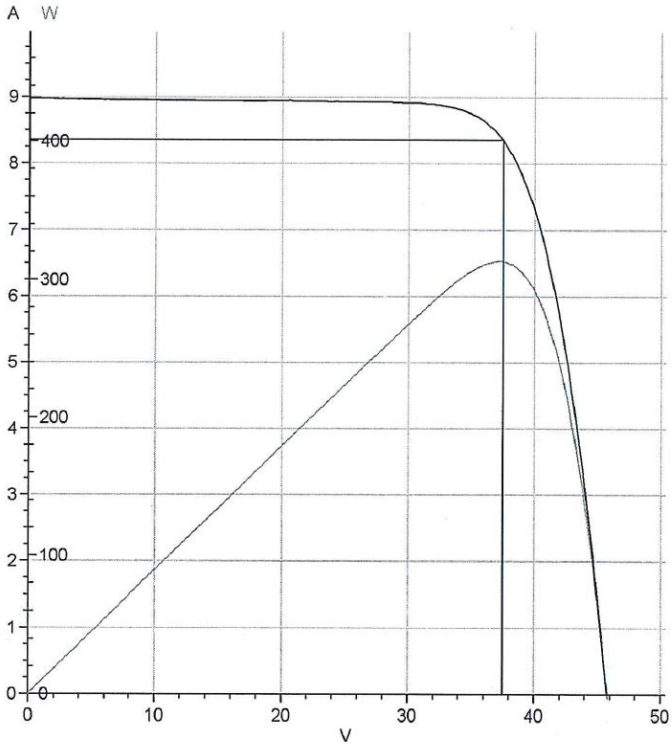
Performance measurement

PASAN SLAB Tester - STC + SM V2.4.4 31-03-16 15:49



Measurement Data (Temp. compensated results)

PASAN Tester version	2.4.4		Operator	1803132069-01 Initia	
Module ID Code	1152952		Serial number		
Standard temperature	25.0	°C	Monitor Cell	002-2010	
Mean Irradiance	1.004	kW/m²	Calibration Value	32.200	mV/(kW/m²)
Module Temp.	26.6	°C	Mon. Cell Temp.	26.6	°C
Mask	NO-MASK 1.000	-	Cell Area	243.360	cm²
Module Area	19354.500	cm²	Cells in Parallel	1	
Cells in Series	72		Measurement irradiance	1.000	kW/m²
Isc	8.977	A	Voc	45.785	V
Imp	8.358	A	Vmp	37.523	V
Pmax	313.620	W	Reference vlt 1	0.000	V
Reference vlt 2	0.000	V	Power ar ref 1	-1.000	W
Power ar ref 2	-1.000	W	Current at ref 1	0.000	A
Current at ref 2	0.000	A	Fill Factor	76.306	%
Cell Efficiency	17.899	%	Module Efficiency	16.204	%
Shunt res.	478.819	Ohm	Serie res.	0.568	Ohm

31/3/16

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1803132069-02

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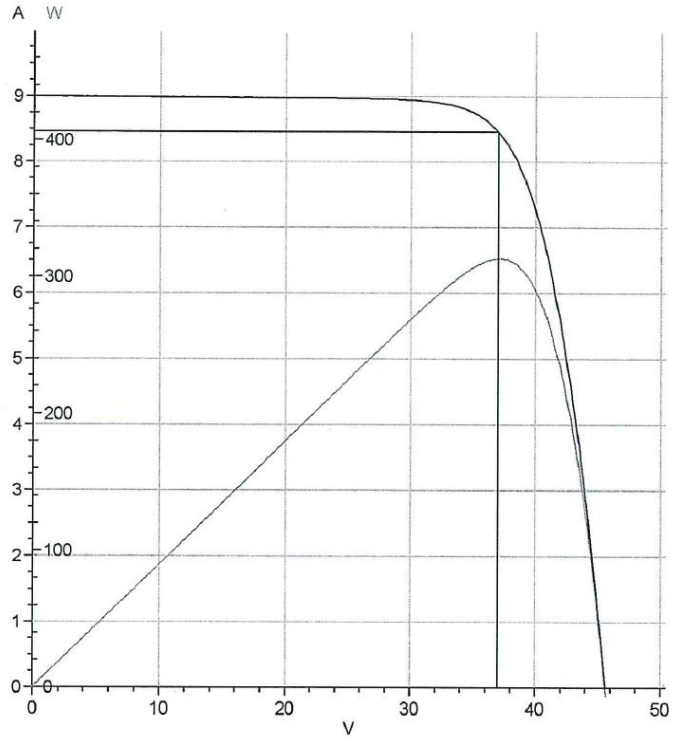
Performance measurement

PASAN SLAB Tester - STC + SM V2.4.4 31-03-16 15:57



Measurement Data (Temp. compensated results)

PASAN Tester version	2.4.4		Operator	1803132069-02 Initia	
Module ID Code	1152955		Serial number		
Standard temperature	25.0	°C	Monitor Cell	002-2010	
Mean Irradiance	1.004	kW/m²	Calibration Value	32.200	mV/(kW/m²)
Module Temp.	23.4	°C	Mon. Cell Temp.	23.4	°C
Mask	NO-MASK 1.000	-	Cell Area	243.360	cm²
Module Area	19354.500	cm²	Cells in Parallel	1	
Cells in Series	72		Measurement irradiance	1.000	kW/m²
Isc	8.999	A	Voc	45.617	V
Imp	8.467	A	Vmp	37.002	V
Pmax	313.310	W	Reference vlt 1	0.000	V
Reference vlt 2	0.000	V	Power ar ref 1	-1.000	W
Power ar ref 2	-1.000	W	Current at ref 1	0.000	A
Current at ref 2	0.000	A	Fill Factor	76.320	%
Cell Efficiency	17.881	%	Module Efficiency	16.188	%
Shunt res.	914.283	Ohm	Serie res.	0.553	Ohm

31/3/16

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1803132069-03

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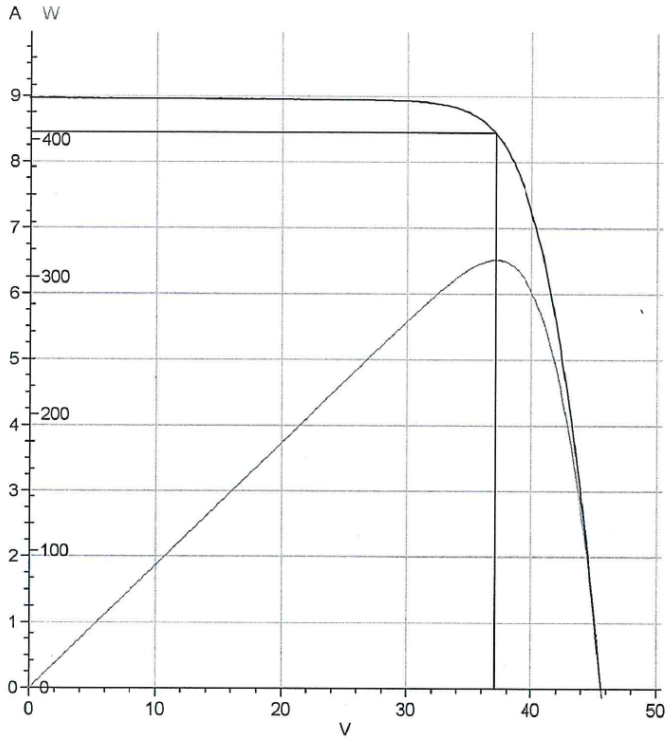
Performance measurement

PASAN SLAB Tester - STC + SM V2.4.4 31-03-16 16:02



Measurement Data (Temp. compensated results)

PASAN Tester version	2.4.4		Operator	1803132069-03 Initia	
Module ID Code	1152953		Serial number		
Standard temperature	25.0	°C	Monitor Cell	002-2010	
Mean Irradiance	1.004	kW/m²	Calibration Value	32.200	mV/(kW/m²)
Module Temp.	23.5	°C	Mon. Cell Temp.	23.5	°C
Mask	NO-MASK 1.000	-	Cell Area	243.360	cm²
Module Area	19354.500	cm²	Cells in Parallel	1	
Cells in Series	72		Measurement irradiance	1.000	kW/m²
Isc	8.974	A	Voc	45.632	V
Imp	8.452	A	Vmp	37.018	V
Pmax	312.882	W	Reference vlt 1	0.000	V
Reference vlt 2	0.000	V	Power ar ref 1	-1.000	W
Power ar ref 2	-1.000	W	Current at ref 1	0.000	A
Current at ref 2	0.000	A	Fill Factor	76.409	%
Cell Efficiency	17.857	%	Module Efficiency	16.166	%
Shunt res.	974.054	Ohm	Serie res.	0.558	Ohm

31/3/16

Measurement at STC: After PID Test:

1803132069-02

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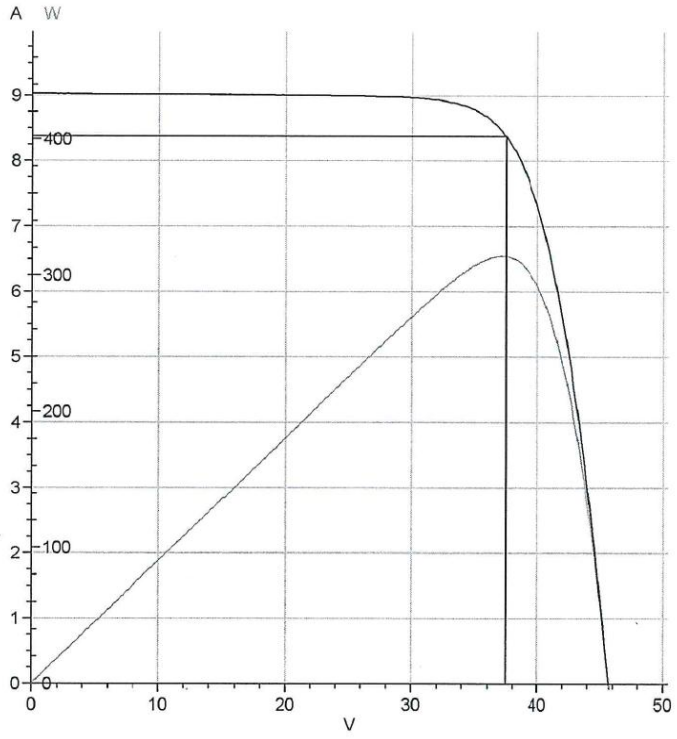
Performance measurement

PASAN SLAB Tester - STC + SM V2.4.4 15-04-16 16:28



Measurement Data (Temp. compensated results)

PASAN Tester version	2.4.4		Operator	1803132069-02 Af PID	
Module ID Code	1152955		Serial number		
Standard temperature	25.0	°C	Monitor Cell	002-2010	
Mean Irradiance	1.004	kW/m²	Calibration Value	32.200	mV/(kW/m²)
Module Temp.	26.4	°C	Mon. Cell Temp.	26.4	°C
Mask	NO-MASK 1.000	-	Cell Area	243.360	cm²
Module Area	19354.500	cm²	Cells in Parallel	1	
Cells in Series	72		Measurement irradiance	1.000	kW/m²
Isc	9.033	A	Voc	45.706	V
Imp	8.381	A	Vmp	37.481	V
Pmax	314.119	W	Reference vlt 1	0.000	V
Reference vlt 2	0.000	V	Power ar ref 1	-1.000	W
Power ar ref 2	-1.000	W	Current at ref 1	0.000	A
Current at ref 2	0.000	A	Fill Factor	76.085	%
Cell Efficiency	17.927	%	Module Efficiency	16.230	%
Shunt res.	1121.986	Ohm	Serie res.	0.559	Ohm

15/4/16

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1803132069-03

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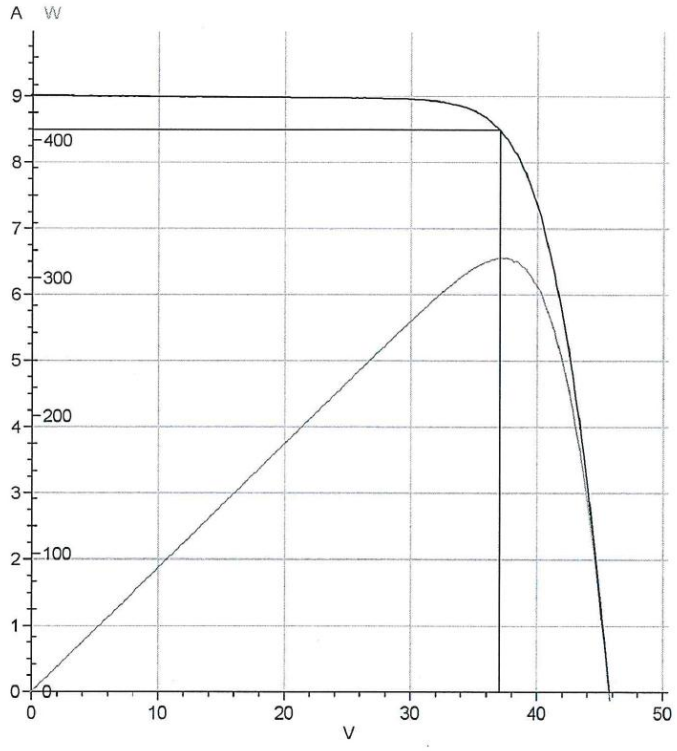
Performance measurement

PASAN SLAB Tester - STC + SM V2.4.4 15-04-16 16:23



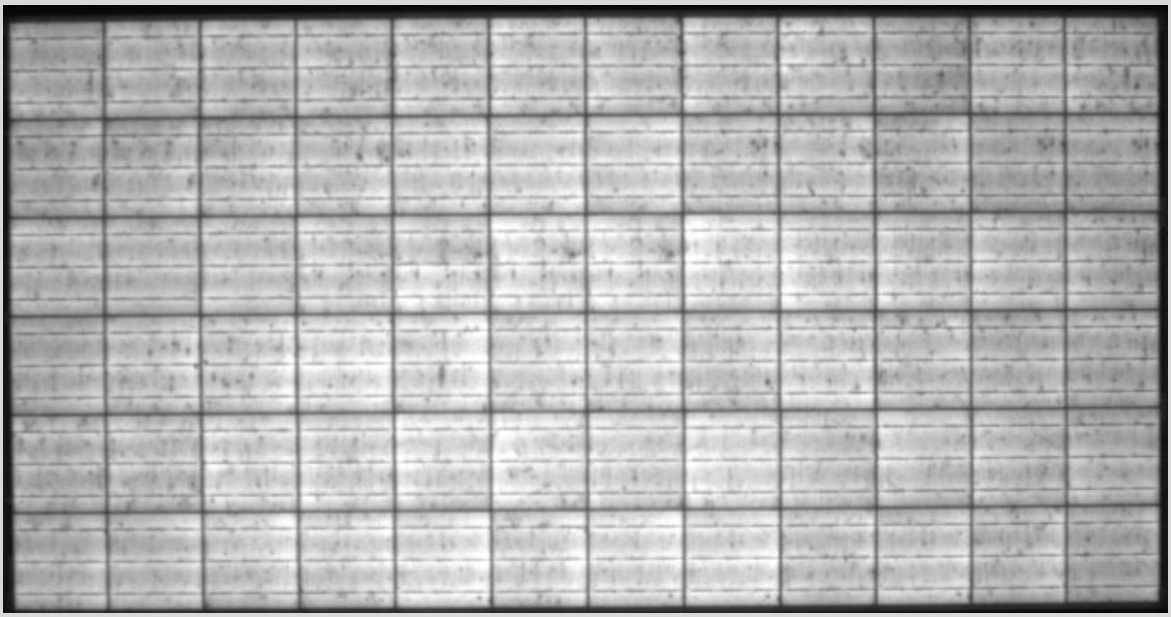
Measurement Data (Temp. compensated results)

PASAN Tester version	2.4.4		Operator	1803132069-03 Af PID	
Module ID Code	1152953		Serial number		
Standard temperature	25.0	°C	Monitor Cell	002-2010	
Mean Irradiance	1.004	kW/m²	Calibration Value	32.200	mV/(kW/m²)
Module Temp.	27.0	°C	Mon. Cell Temp.	27.0	°C
Mask	NO-MASK 1.000	-	Cell Area	243.360	cm²
Module Area	19354.500	cm²	Cells in Parallel	1	
Cells in Series	72		Measurement irradiance	1.000	kW/m²
Isc	9.010	A	Voc	45.768	V
Imp	8.491	A	Vmp	37.047	V
Pmax	314.572	W	Reference vlt 1	0.000	V
Reference vlt 2	0.000	V	Power ar ref 1	-1.000	W
Power ar ref 2	-1.000	W	Current at ref 1	0.000	A
Current at ref 2	0.000	A	Fill Factor	76.280	%
Cell Efficiency	17.953	%	Module Efficiency	16.253	%
Shunt res.	662.365	Ohm	Serie res.	0.557	Ohm

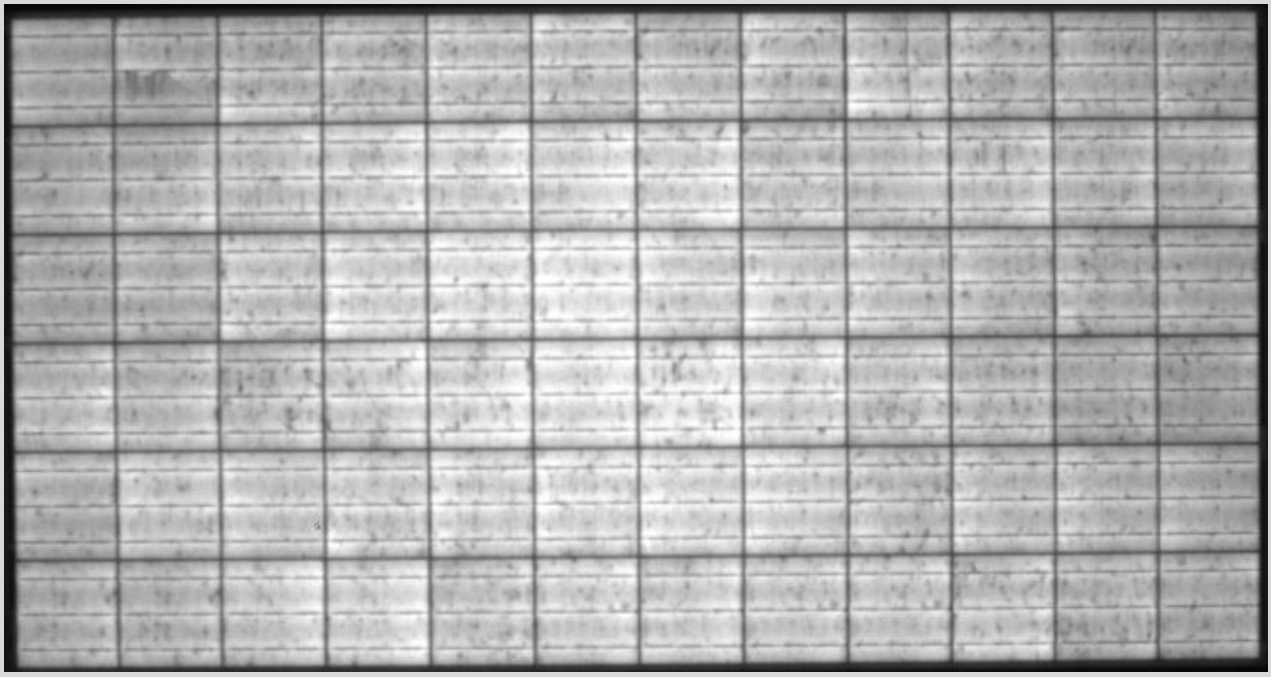
Annex 4: EL Image of Test samples:

1803132069-02_Initial

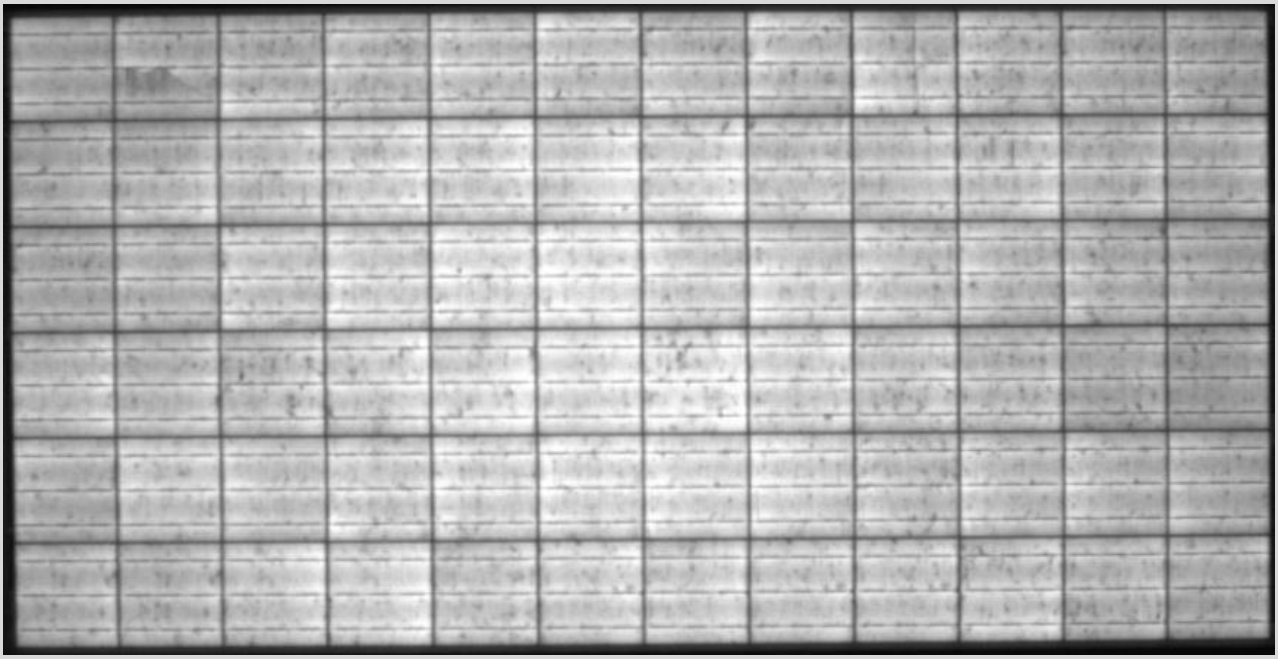
1803132069-02_after PID



1803132069-03 - Initial



1803132069-03 – After PID



1803132069-01 – Control Module

Annex 5: Pictures of Test Samples :

DESERV - 3M6 - 310	
	
Fig.1:Front view of the module	Fig.2:Rear view of the module

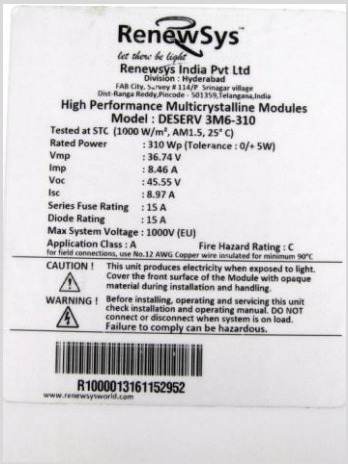
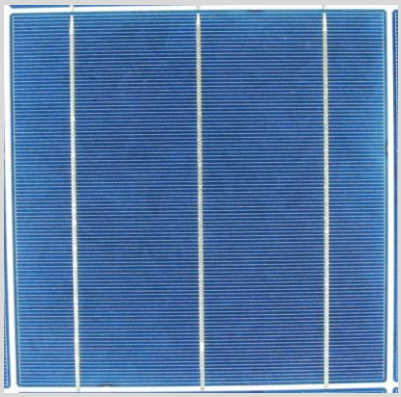

	

Fig.3:Detail view of the Type label	Fig.4: Detail view of Solar Cell
	
Fig.5:detail view of the Junction Box	Fig.6: detail view of Serial number