CEA I PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | Tongwei

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Date: 13 September 2023
Form Version: V1.4

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1. INTRODUCTION

As part of CEA's engagement in developing and supervising PV Magazine's test program at Gsola, CEA has developed a testing protocol and flowchart, a scoring system, a methodology and a reporting structure that it will be used to run this program. This report presents the test results and scoring grades for this product.

2. SCORING SYSTEM

2.1. Test flowchart and protocol

The following is a high-level flowchart of the testing procedure, describing the steps, and tests to be followed. Detailed checklists have been delivered to Gsola, that will also serve as records of the process.

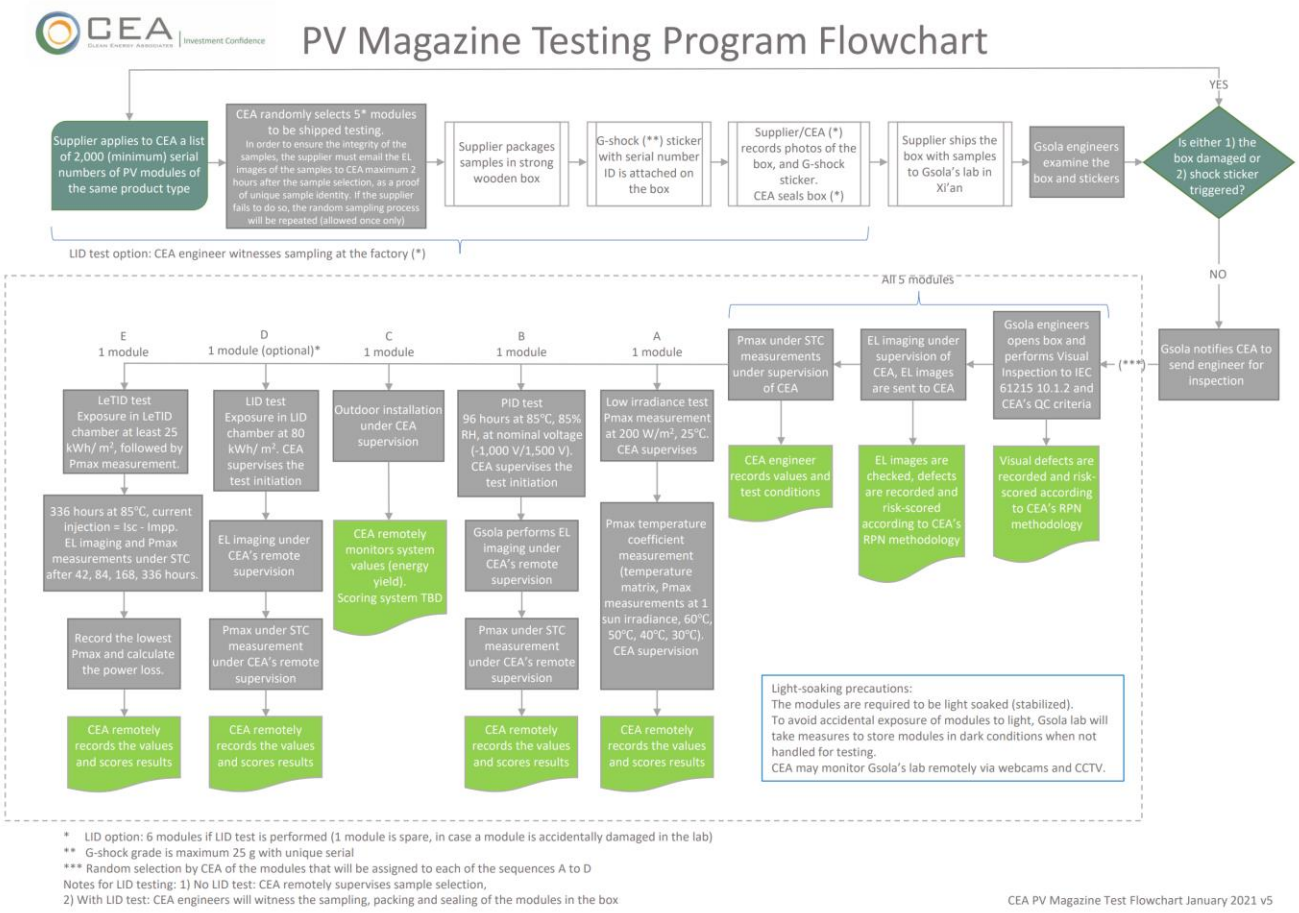


Figure 1 Test flowchart

2.2. Scoring methodology

For every product, 5 samples have been shipped to Gsola's lab to conduct the tests and inspections according to the above flowchart.

The following table describes the inspections and tests that have been applied on all products:

Table 1 Test/inspection grading system overview

	Test/inspection	# of samples	Method	Values	Average grade weight	Grades
1	Visual inspection	5	Inspection	RPN Scores	10%	1-100
2	EL image inspection	5	Inspection	RPN Scores	10%	1-100
3	Low irradiance efficiency loss	1	Test	%	25%	1-100
4	Pmax Temperature coefficient	1	Test	%/°C	25%	1-100
5	PID loss	1	Test	%	30%	1-100
6	LID loss (optional)	1	Test	%	NA	1-100
7	LeTID	1	Test	%	NA	1-100
8	Outdoor installation and yield measurement	1	Energy Yield Monitoring	Periodic kWh/kWp	NA	NA

Notes:

1. The RPN scoring method has been developed by CEA and is used to evaluate and create risk scores of Visual and EL defects.
2. The weights are used to calculate the average grade for tests 1-5.

A number within the 1-100 range will be used to grade the results, so that the overall ranking of the products will reflect general industry practices and requirements:

Table 2 Detailed scoring system

	Grade range:	100	90	80	70	60	50	40	30	20	10	0
1	Visual inspection (RPN scores)	0	0.74	2.20	4.39	7.30	10.94	15.30	20.39	26.20	32.74	≥ 40
2	EL image (RPN scores)	0.00	2.03	4.62	7.75	11.43	15.65	20.43	25.75	31.62	38.03	≥ 45.00
3	Low irradiance loss	≤ -2.00%	-0.02%	1.78%	3.41%	4.87%	6.16%	7.27%	8.21%	8.98%	9.58%	≥ 10.00%
4	Pmax Temp. coefficient	≥ -0.300%	-0.343%	-0.382%	-0.417%	-0.448%	-0.475%	-0.498%	-0.517%	-0.532%	-0.543%	≤ -0.550%
5	PID loss	≤ 0.0%	0.7%	1.6%	2.7%	4.0%	5.5%	7.2%	9.1%	11.2%	13.5%	≥ 16.0%
6	LID loss (optional)	≤ -0.50%	0.35%	1.20%	2.05%	2.90%	3.75%	4.60%	5.45%	6.30%	7.15%	≥ 8.00%
7	LeTID	≤ 0%	0.30%	0.60%	0.90%	1.20%	1.50%	1.80%	2.10%	2.40%	2.70%	≥ 3.00%

Notes:

1. The Visual and EL Inspection RPN scores will be divided by the number of samples, to normalize the score, as the total number of samples may vary.
2. The correspondence of the scores/test results to the grades follows a binomial or linear relationship, anchored to certain key values that are generally accepted and employed in the PV industry. For example, a PID loss of 5%,

which is the pass/fail threshold of the related IEC standard, will give a grade close to 50. In this sense, grades below 50 indicate a product performance that is below a generally acceptable threshold.

The scoring system shown in Table 2 is preliminary, and will be adjusted as the testing program develops, in order to better reflect the products standing per industry standards.

3. TEST DETAILS

A sample lot consists of 5 modules, one of which has been used as a spare for the chamber and outdoor testing, in case a module is accidentally damaged during handling at the lab. Refer to Table 3 and Table 4 for test sample and product information.

Table 3 Test sample information

Sample #	Serial number
1	DY6HMPM22908000600
2	DY6HMPM22908000414
3	DY6HMPM22908000388
4	DY6HMPM22908000583
5	DY6HMPM22908000307

Table 4 Product information

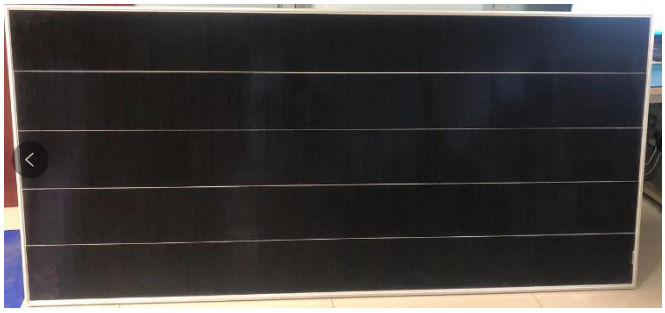
Model	TH545 PMB6 58SDC
Cell technology	Bifacial Mono PERC
Cell number	345
Cell format	210 × 35 mm
Number of busbars	Shingling
Junction box	IP68 rated
Laminate construction	Framed glass/glass
Bifaciality ratio	65%

Figure 2 Product nameplate

3.1. Visual inspection

All 5 modules of each product sample lot have undergone visual inspection, according to CEA's quality criteria for visual inspection. The defects found has been evaluated according to CEA's scoring system. The scoring system is a modified version of CEA's proprietary RPN (risk priority number) system, based on the formula RPN score = Severity x Detectability.

Table 5 Product picture

Front Side	Rear Side
	

The following table shows the visual inspection results, normalized for the number of tested modules:

Table 6 Visual inspection results

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
Visual inspection	None	None	None	None	None	0	100

3.2. EL image Inspection

The same sample lot was inspected for EL defects.
Table 7 shows the EL inspection results normalized for the number of tested modules. Visual and EL inspection scores are shown below in

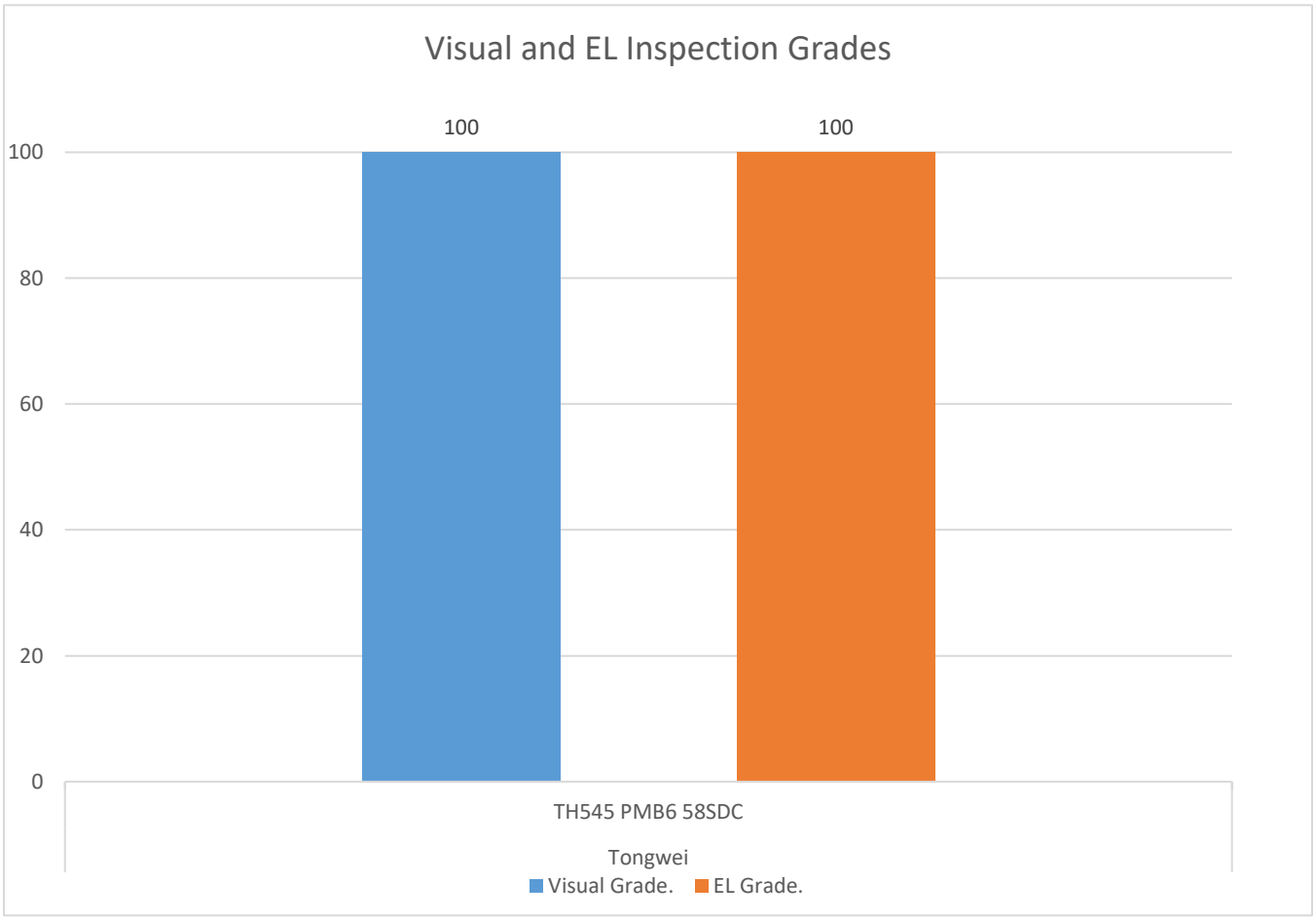


Figure 3.

Table 7 EL image inspection results

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

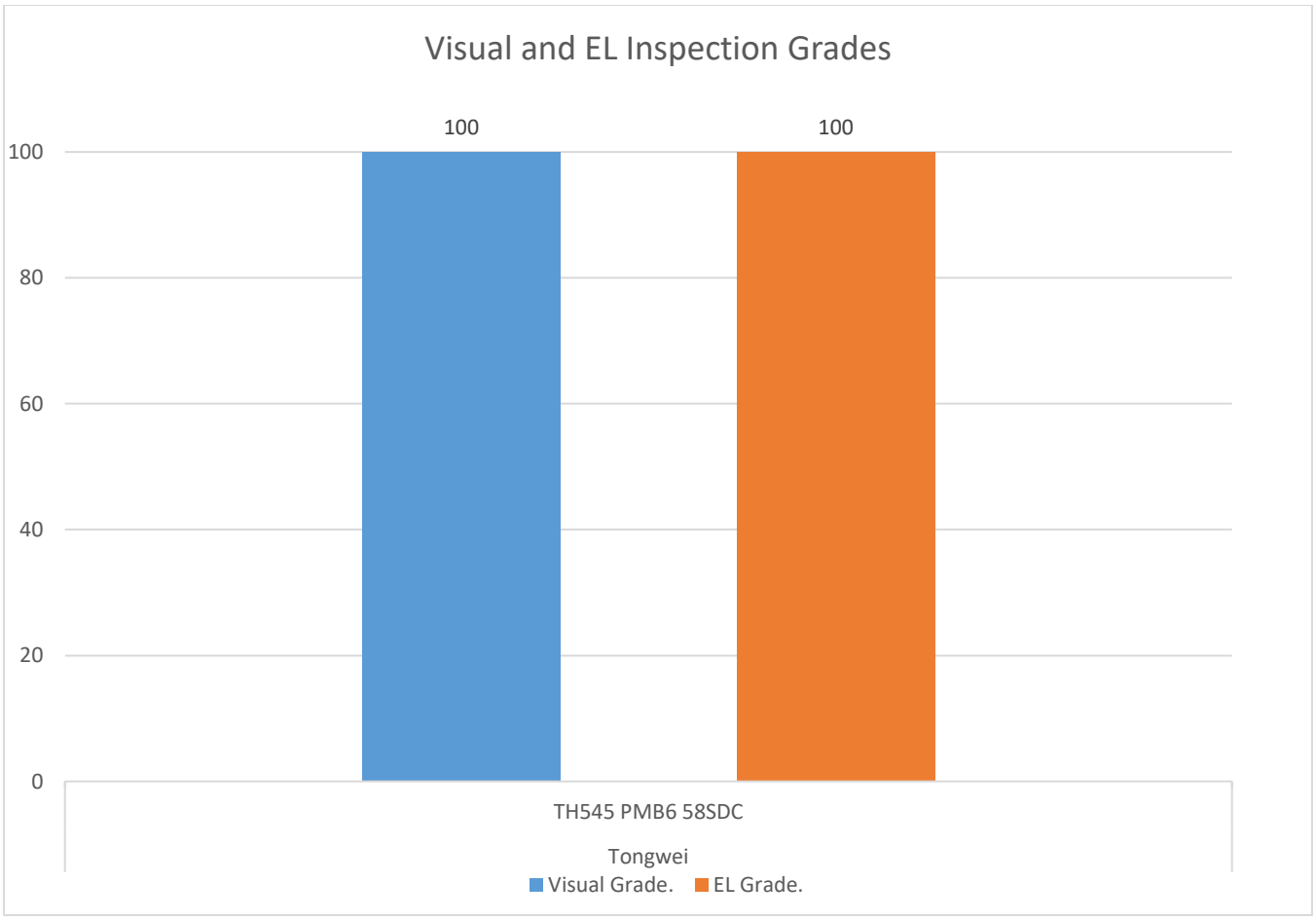


Figure 3 Visual and EL inspection results

3.3. Low irradiance efficiency loss test

The efficiency loss is calculated by the following formula:

Efficiency loss = 1- [(Pmax at low irradiance conditions / Pmax at STC) * (1,000/200)]

Table 8 and Figure 4 show the low irradiance efficiency test results for the front side.

Table 8 Low irradiance test results

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side low irradiance efficiency loss (%)	2.30%					76

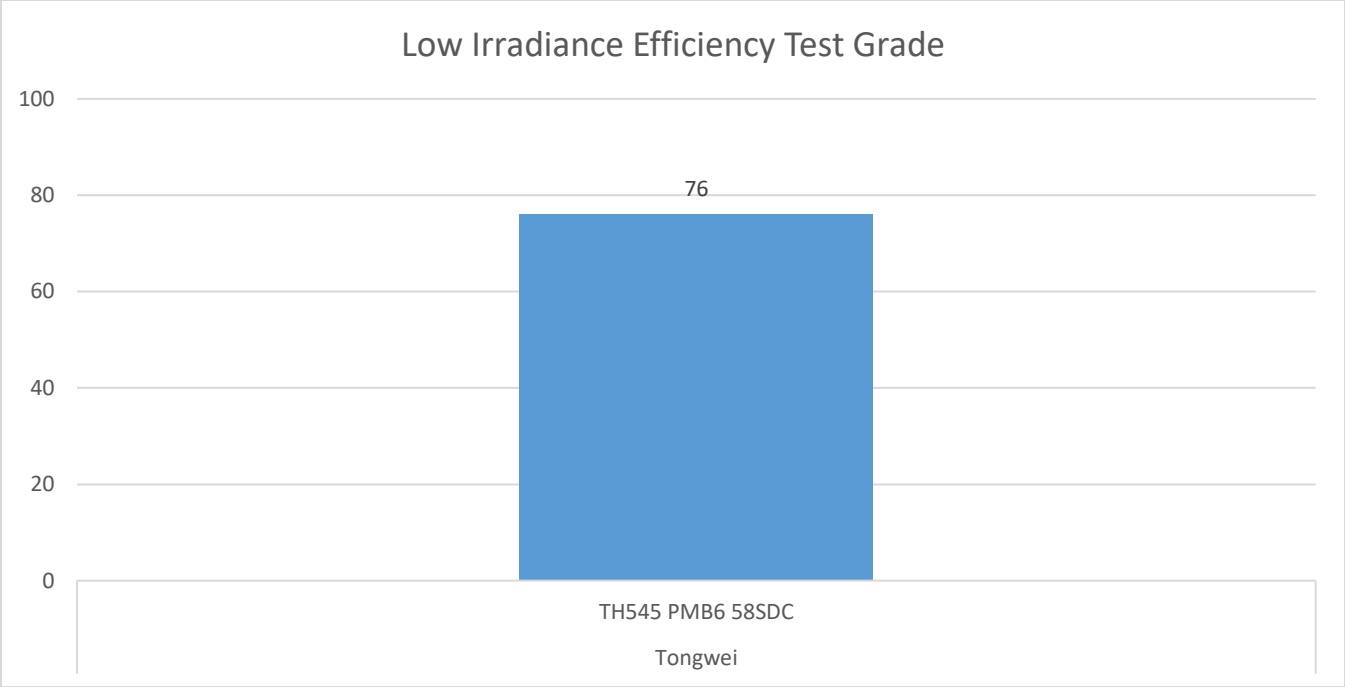


Figure 4 Low irradiance test result

3.4. Pmax temperature coefficient test

Table 9 and Figure 5 depict the Pmax temperature coefficient test results.

Table 9 Pmax temperature coefficient test result

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.359%					86

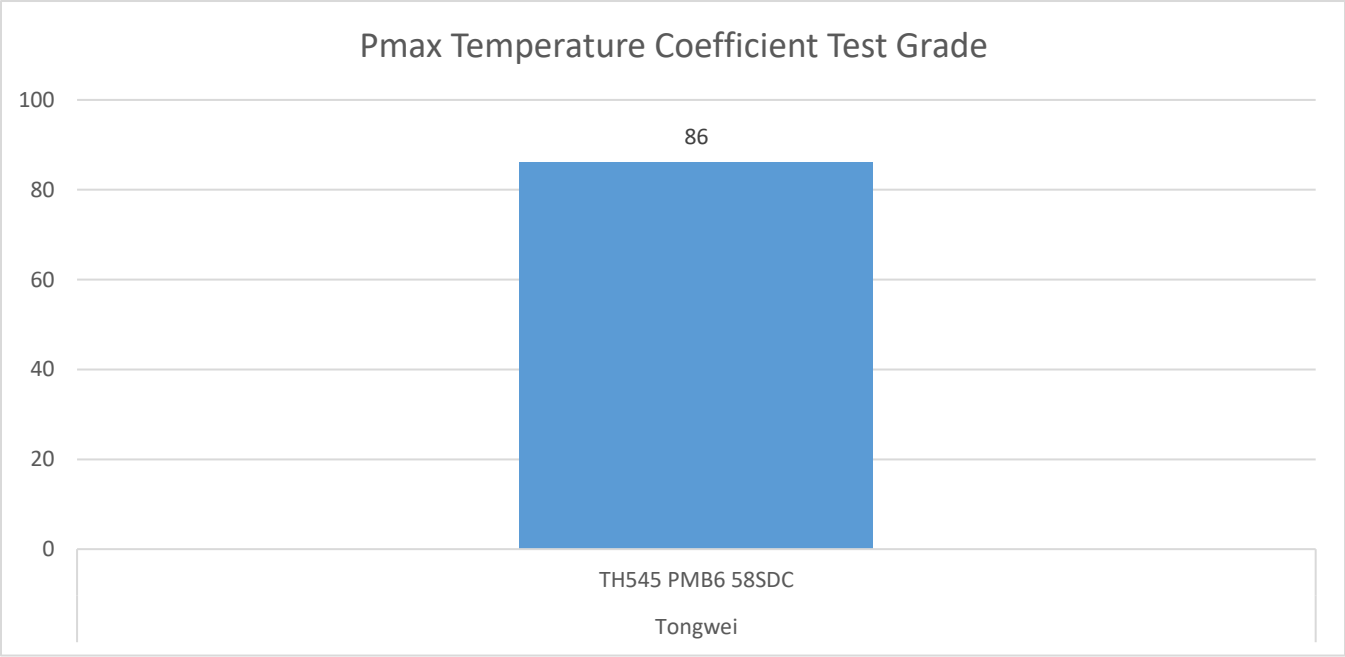


Figure 5 Pmax temperature coefficient test result

3.5. PID loss test

Table 10 and Figure 6 depicts the PID loss test results for the front side at **1500 V**:

Table 10 PID loss test result

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)					1.04%	86

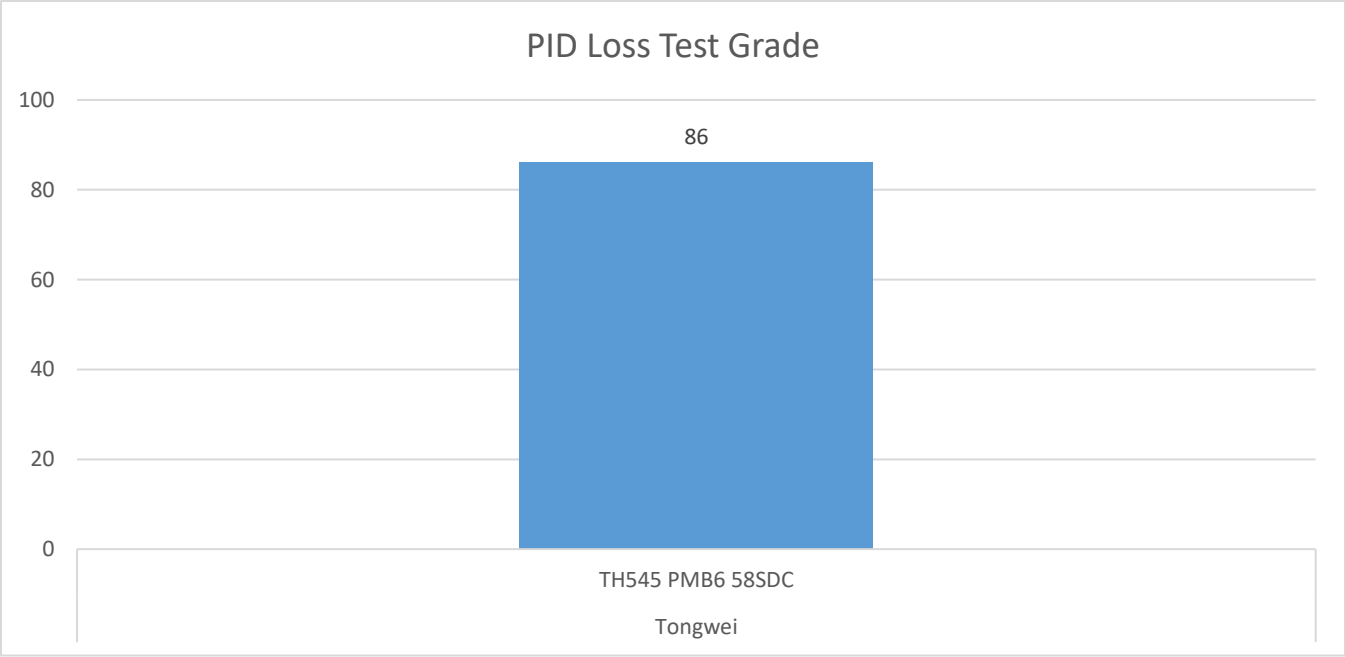


Figure 6 PID loss test result

3.6. LID loss test

Table 11 and Figure 7 depicts the LID loss test results for the front side:

Table 11 LID loss test result

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LID loss (%)				0.93%		83

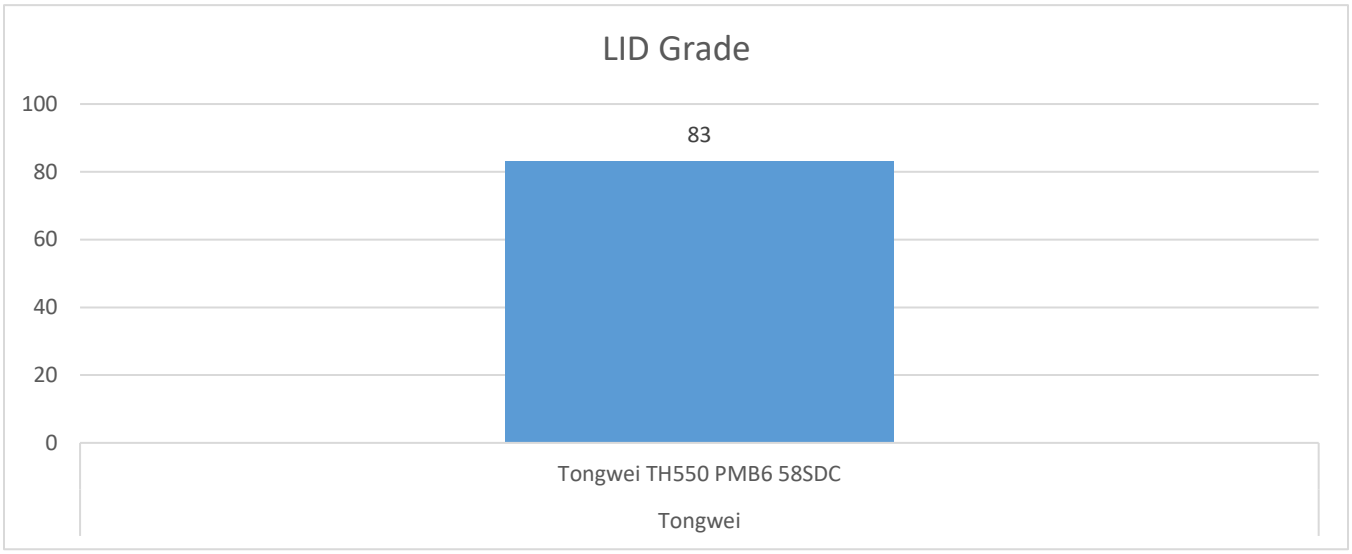


Figure 7 LID loss test result

3.7. LeTID loss test

Table 12 and Figure 6 depicts the LeTID loss test results:

Table 12 LeTID loss test result

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LeTID loss (%)	0.054%					98

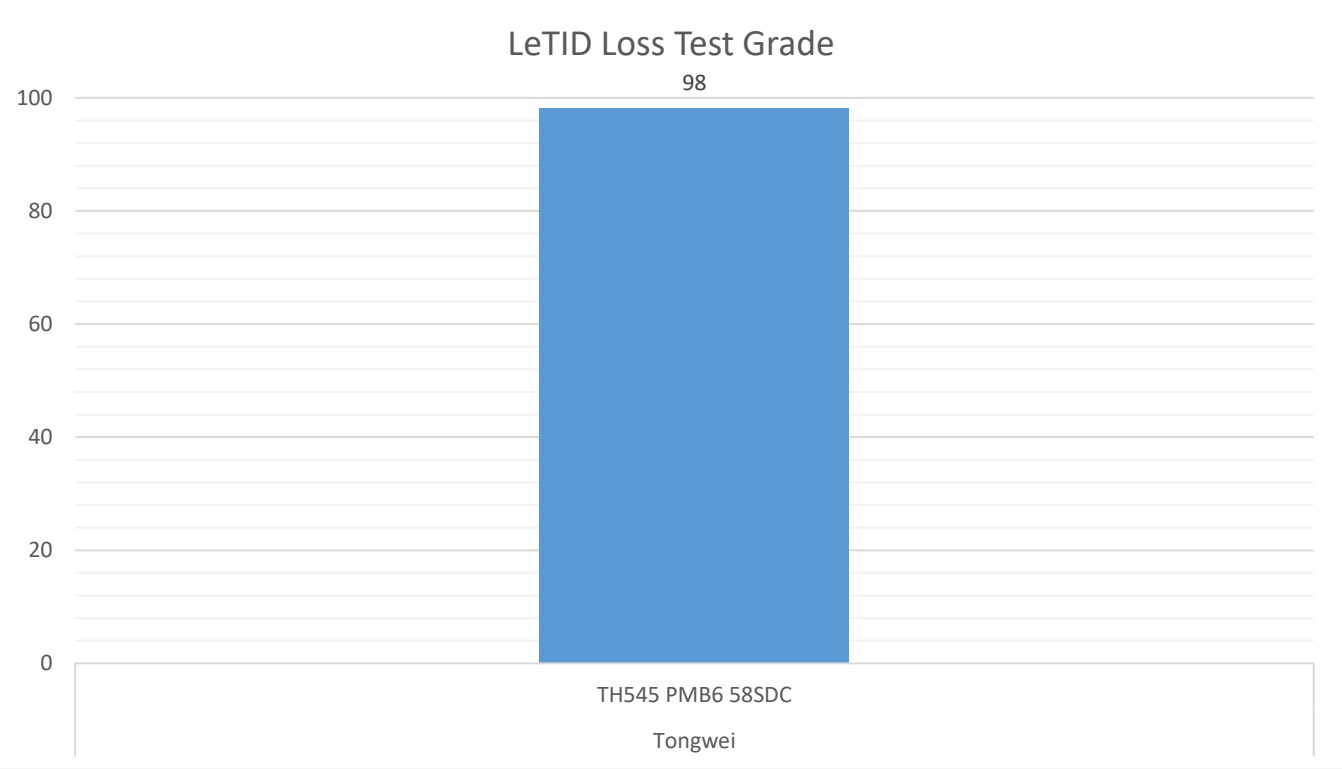


Figure 8 LeTID loss test result

3.8. Bifaciality ratio

The bifaciality ratio test result is not graded. We list the results here for informational purposes. The table below shows the bifaciality ratio results:

Table 13 Bifaciality ratio test results

TH545 PMB6 58SDC	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
Bifaciality ratio (%)	65.9	65.6	66.0	65.6	65.2	65.9

The bifaciality ratio is calculated from the following formula:

Bifaciality ratio = (Pmax rear surface / Pmax front surface) * 100%

3.9. Score overview

Figure 9 shows the overview of the test scores. Figure 10 shows the average score.

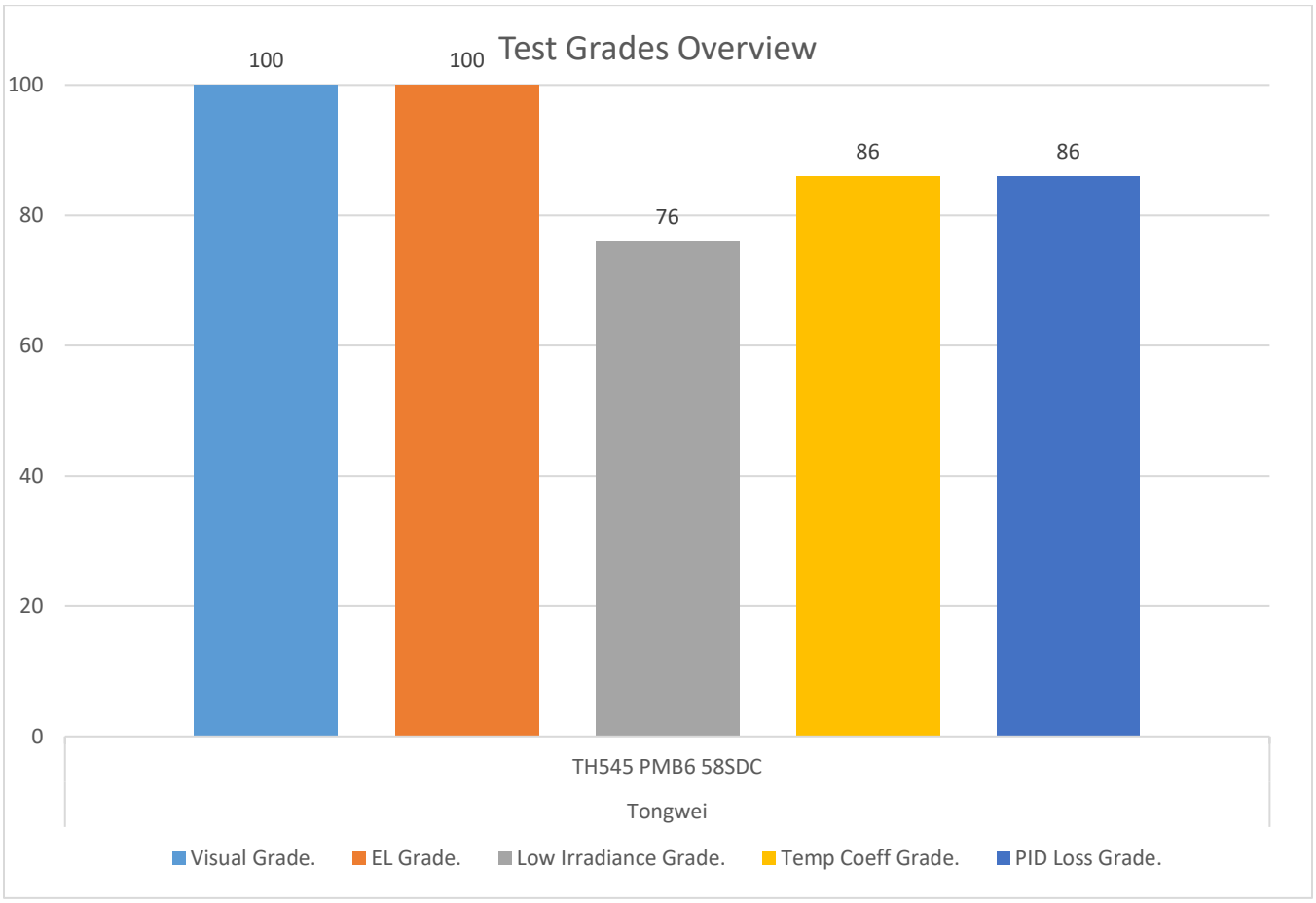


Figure 9 Test results overview

NOTE: The Average grade does **NOT** include the LID test, as it is optional and not performed for all products.

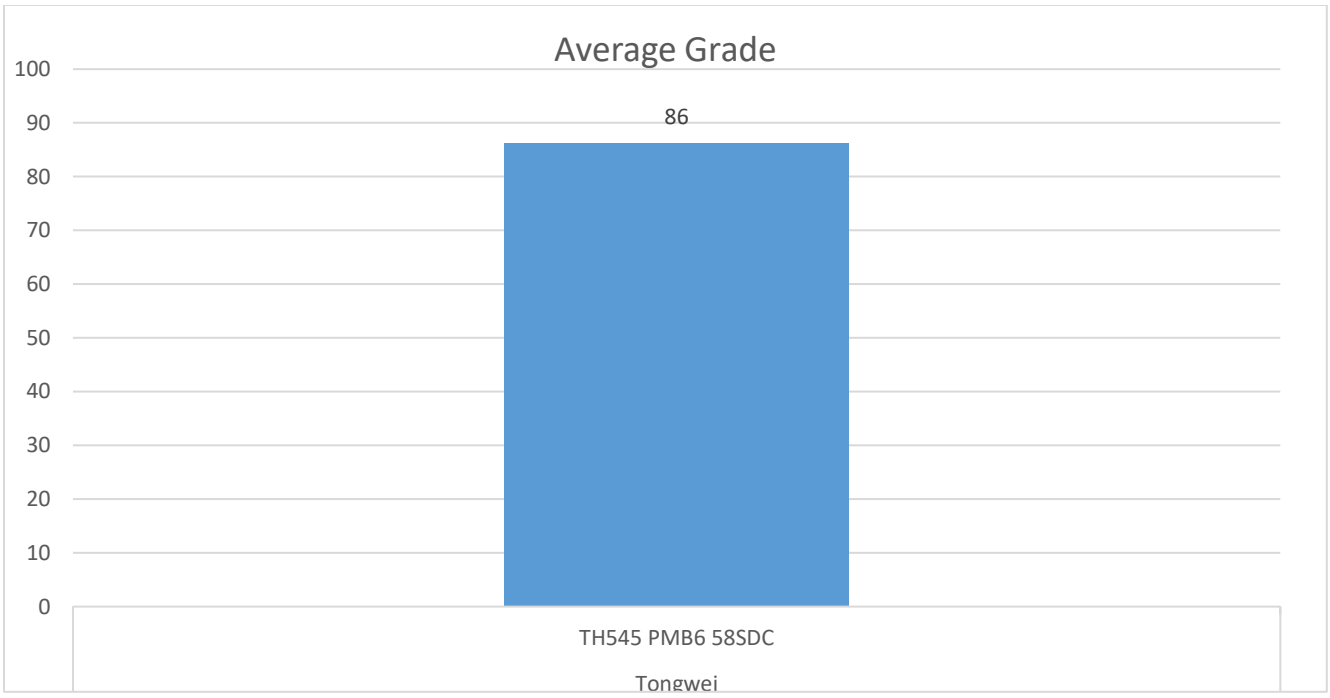


Figure 10 Average test grade

Appendix 1 – TH545 PMB6 58SDC Datasheet

Shingled bifacial module

TH530~555PMB6 58SDC

Features of Module

Shingling Technology
Innovative structure, low-temperature adhesive bonding, high-density layout.

Beautiful Appearance
Uniform layout, better aesthetic.

Superior Safety and Reliability
No hidden welding crack, low operating temperature, high pressure resistance.

Low System Cost
High module efficiency, reducing system cost.

Low Hot Spot Risk
Parallel circuit design reduces shading loss.

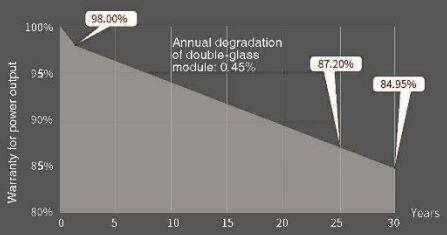
Low Shading Loss
Full parallel arrangement brings high effective power generation hours.

Eco-friendly
Adhering to green philosophy, no fluorine and low lead.

Linear Power Output Warranty

15 15-year warranty for materials.

30 30-year warranty for linear power output.



Quality Management System and Product Certification

IEC61215/61730、IEC62804(PID)、IEC61701(Salt)、
IEC62716 (Ammonia)、IEC60068-2-68(Sand)
ISO 9001:2015 / quality management system
ISO 14001:2015 / environmental management system
ISO 45001:2018 / occupation health safety management system
ISO 50001:2011 / energy management system
IEC TS 62941—2016 / PV industry quality management system

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Electrical Characteristics at Standard Test Conditions(STC)

Module Type:TH *** PMB6-58SDC	555	550	545	540	535	530
Maximum Power-Pm [W]	555	550	545	540	535	530
Open Circuit Voltage-Voc [V]	47.2	47.1	47.0	46.9	46.8	46.7
Short Circuit Current-Isc [A]	15.07	14.97	14.86	14.76	14.65	14.55
Maximum Power Voltage-Vm [V]	39.2	39.1	39.0	38.9	38.8	38.8
Maximum Power Current-Im [A]	14.17	14.07	13.98	13.89	13.79	13.67
Module Efficiency-η [%]	21.2	21.0	20.9	20.7	20.5	20.3

Temperature Characteristics

Maximum Power-Pm [W]	416	413	409	405	401	398
Open Circuit Voltage-Voc [V]	44.9	44.8	44.7	44.6	44.5	44.4
Short Circuit Current-Isc [A]	12.14	12.06	11.97	11.89	11.80	11.72
Maximum Power Voltage-Vm [V]	37.3	37.2	37.1	37.0	37.0	36.9
Maximum Power Current-Im [A]	11.17	11.09	11.01	10.94	10.86	10.78

1. Standard Test Conditions [STC]: irradiance 1000 W/m²; AM 1.5; ambient temperature 25°C according to EN 60904-3;
2. Nominal Module Operating Temperature (NMOT): Irradiance 800W/ m²; wind speed 1m/s, ambient temperature 20°C.
3. Tolerance of Pm: 0~+5W, Measuring uncertainty of power: ±3%. Performance deviation of Voc [V], Isc [A], Vm [V] and Im [A]: ±3%.
4. Bifaciality: Glazing 70%±5%

Electrical characteristics with different rear side power gain (reference to 545W front)

Power Gain-PG	5%	10%	15%	20%	25%	30%
Maximum Power-Pm [W]	572	600	627	654	681	709
Open Circuit Voltage-Voc [V]	47.0	47.0	47.0	47.1	47.1	47.1
Short Circuit Current-Isc [A]	15.61	16.35	17.09	17.84	18.58	19.32
Maximum Power Voltage-Vm [V]	39.0	39.0	39.0	39.1	39.1	39.1
Maximum Power Current-Im [A]	14.77	15.48	16.18	16.88	17.59	18.29

Mechanical Characteristics

Dimensions	2384 × 1096 × 30mm
Weight	32.0 ± 0.3kg
Front Glass	tempered glass, 2.0mm
Frame	Anodized aluminum profile
Cells	Mono-crystalline solar cell
Cell Orientation	345 (69*5)
Junction Box	IP68, three diodes
Cable	4mm², +500mm/-1000(V), +220mm/-180mm(H), be customized by customer
Packaging	36pcs/box; 720pcs/40'HQ; 1008 pcs/flat car

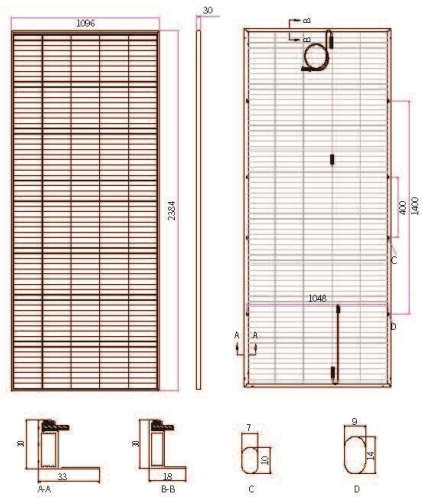
Temperature Characteristics

NMOT	42.3°C (± 2°C)
Temperature Coefficient of Voc	-0.27% / °C
Temperature Coefficient of Isc	0.04% / °C
Temperature Coefficient of Pm	-0.34% / °C

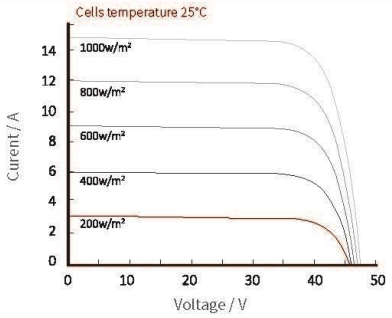
Maximum Ratings

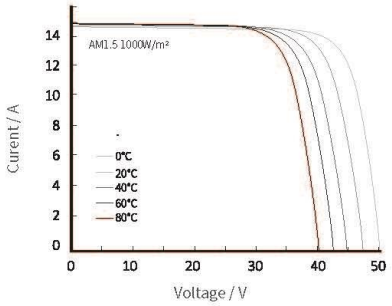
Maximum System Voltage [V]	DC 1500
Series Fuse Rating [A]	30
Surface Load Capacity [Pa]	Front5400 / Back2400
Temperature Range [°C]	– 40 ~ + 85
Withstanding Hail	Maximum diameter of 25 mm with impact speed of 23 m/s

Drawings



I-V Curve





Declaration:
With the technical progress and product updates, there exists a deviation between the technical parameter of the TW Solar's future products and the technical parameter in this specification, The TW Solar reserves the right to adjust the technical parameter at any time without notifying the customers, TW Solar reserves the final right of interpretation.

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