

CEA | PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | TW SOLAR

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TABLE OF CONTENTS

1. INTRODUCTION	3
2. SCORING SYSTEM	3
2.1. Test flowchart and protocol.....	3
2.2. Scoring methodology	4
2.3. Selection methodology	5
3. TEST DETAILS	5
3.1. Visual inspection	6
3.2. EL image Inspection	7
3.3. Low irradiance efficiency loss test	8
3.4. Pmax temperature coefficient test	10
3.5. PID loss test.....	11
3.6. LeTID loss test	12
3.7. Bifaciality ratio	13
3.8. Score overview.....	14
Appendix 1 – DAS-DH144PA-570 Datasheet.....	16

Table 1 Test/inspection grading system overview.....	4
Table 2 Detailed scoring system	4
Table 3 Test sample information	5
Table 4 Product information.....	5
Table 5 Product picture	6
Table 6 Visual inspection results.....	6
Table 7 EL image inspection results.....	7
Table 8 Low irradiance test results	8
Table 9 Pmax temperature coefficient test result	10
Table 10 PID loss test result.....	11
Table 11 LeTID loss test result	12
Table 12 Bifaciality ratio test results.....	13
Figure 1 Test flowchart	3
Figure 2 Product nameplate	6
Figure 3 Visual and EL inspection results	8
Figure 4 Low irradiance test result	9
Figure 5 Pmax temperature coefficient test result.....	10
Figure 6 PID loss test result.....	11
Figure 7 LeTID loss test result	12
Figure 8 Test results overview	14
Figure 9 Average test grade.....	15

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.

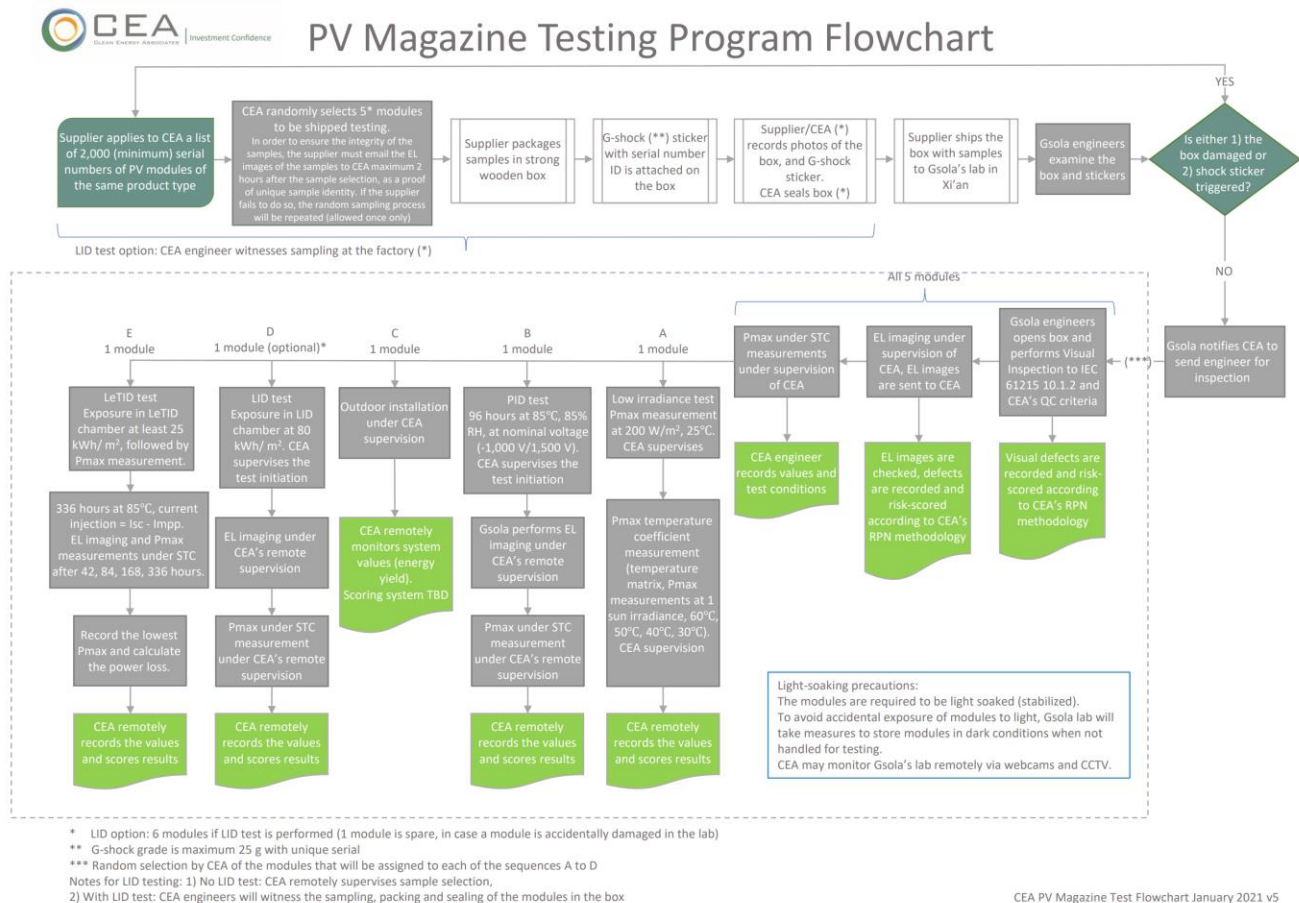


Figure 1 Test flowchart

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.

2.3. Selection methodology

We follow three testing sample selection methods:

- 1: Sample randomly selected by CEA from a large production lot
- 2: Sample purchased from the market by CEA
- 3: Sample provided by supplier, without random selection

The Tongwei TWMND-72HD565 testing samples were selected according to method 3.

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	N604202304070287
2	N604202304070301
3	N604202304070329
4	N604202304070322
5	N604202304070333

Table 4 Product information

Model	Tongwei TWMND-72HD565
Cell technology	N Type
Cell number	144
Cell format	182x182 mm
Number of busbars	16
Junction box	IP68, 3 diodes
Laminate construction	Glass
Bifaciality ratio	80%

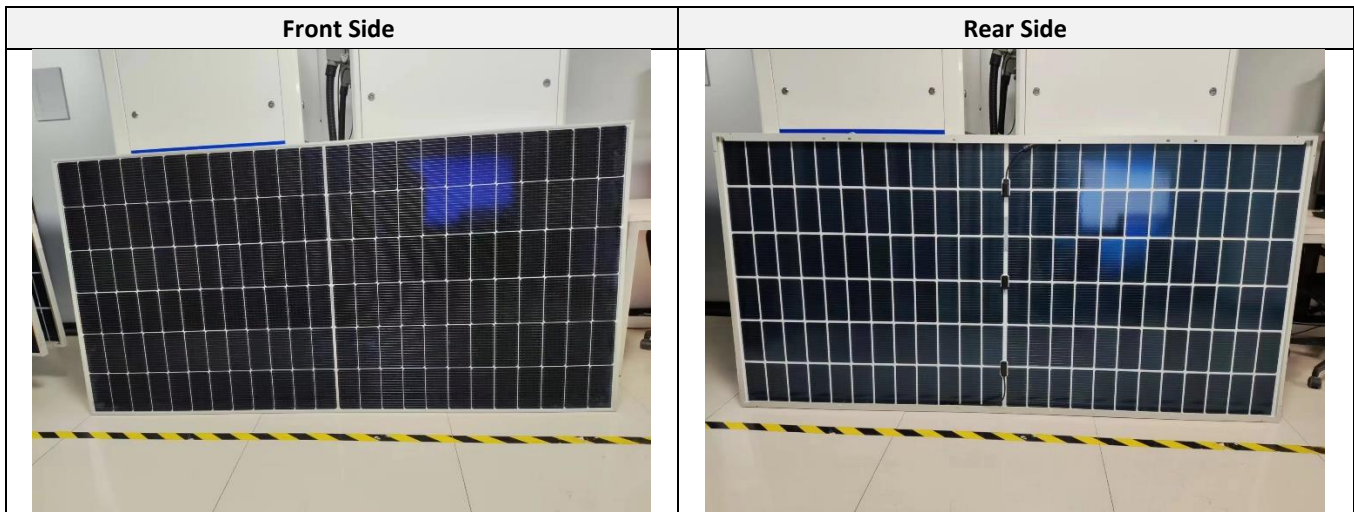


Figure 2 Product nameplate

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 $RPN\ score = Severity \times Detectability$.

Table 5 Product picture



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

Table 6 Visual inspection results

TONGWEI TWMND-72HD565	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

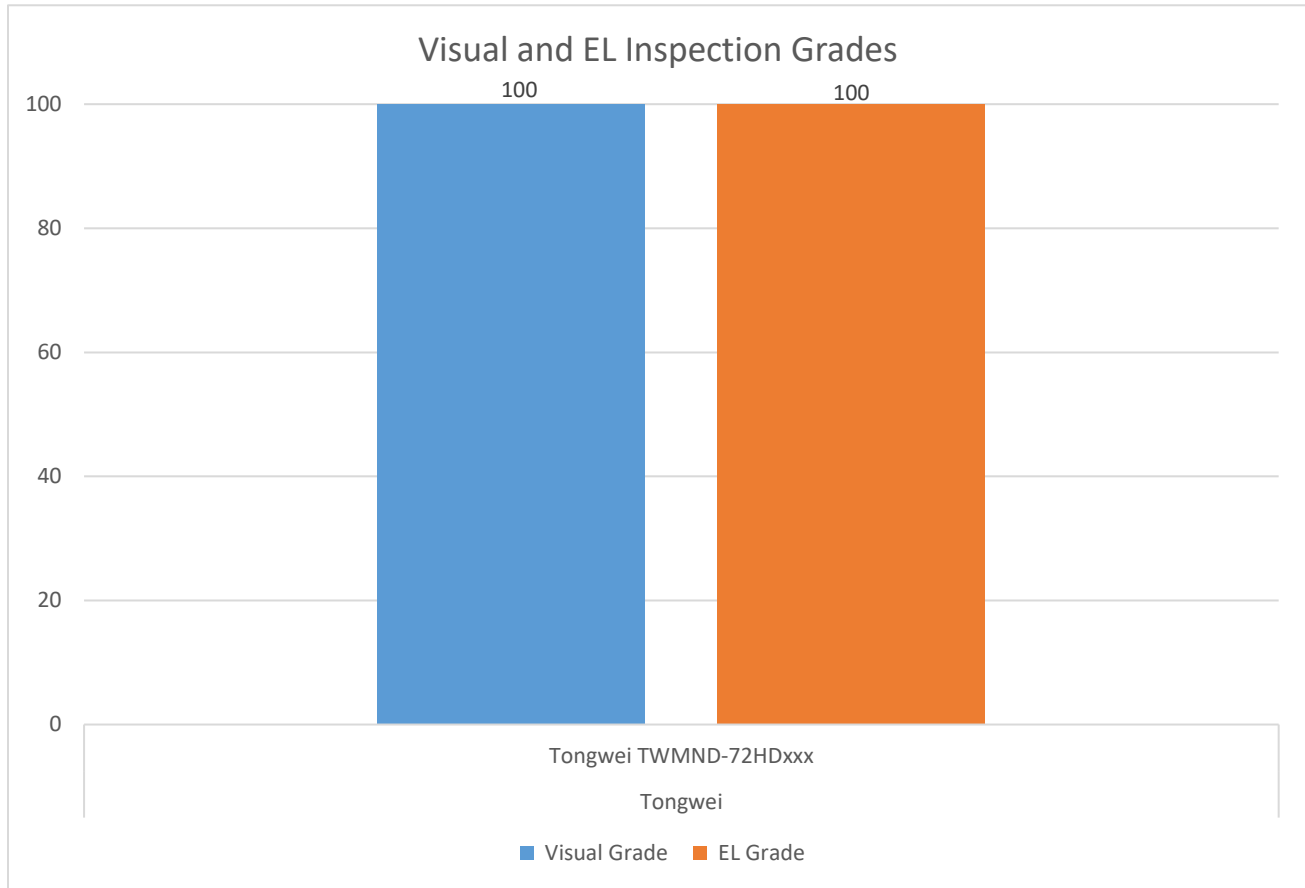


Figure 3.

Table 7 EL image inspection results

TONGWEI TWMND-72HD565	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

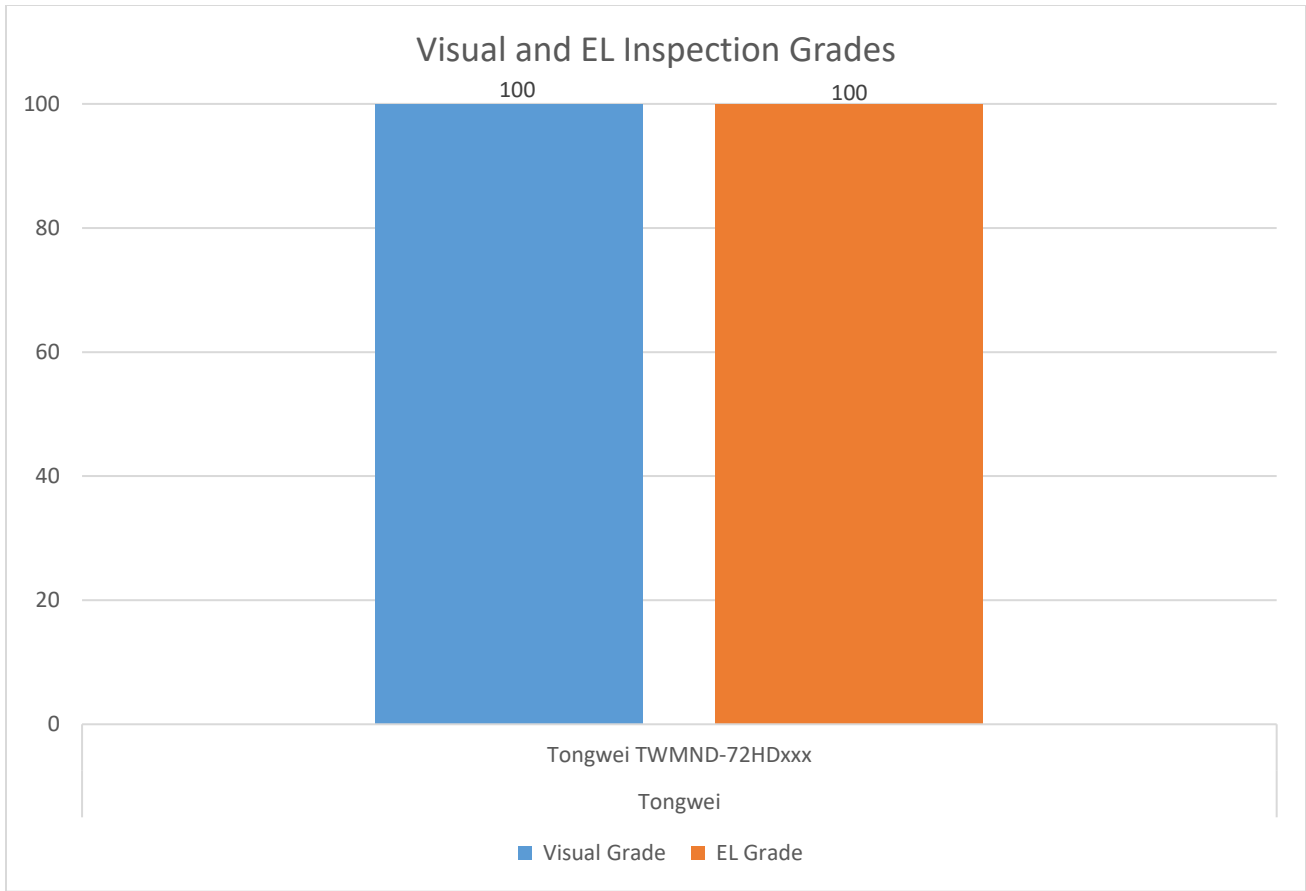


Figure 3 Visual and EL inspection results

3.3. Low irradiance efficiency loss test

The efficiency loss is calculated by the following formula:

$$\text{Efficiency loss} = 1 - \left[\left(\frac{\text{Pmax at low irradiance conditions}}{\text{Pmax at STC}} \right) * \left(\frac{1,000}{200} \right) \right]$$

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

Table 8 Low irradiance test results

TONGWEI TWMND-72HD565	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side low irradiance efficiency loss (%)	4.3%					64

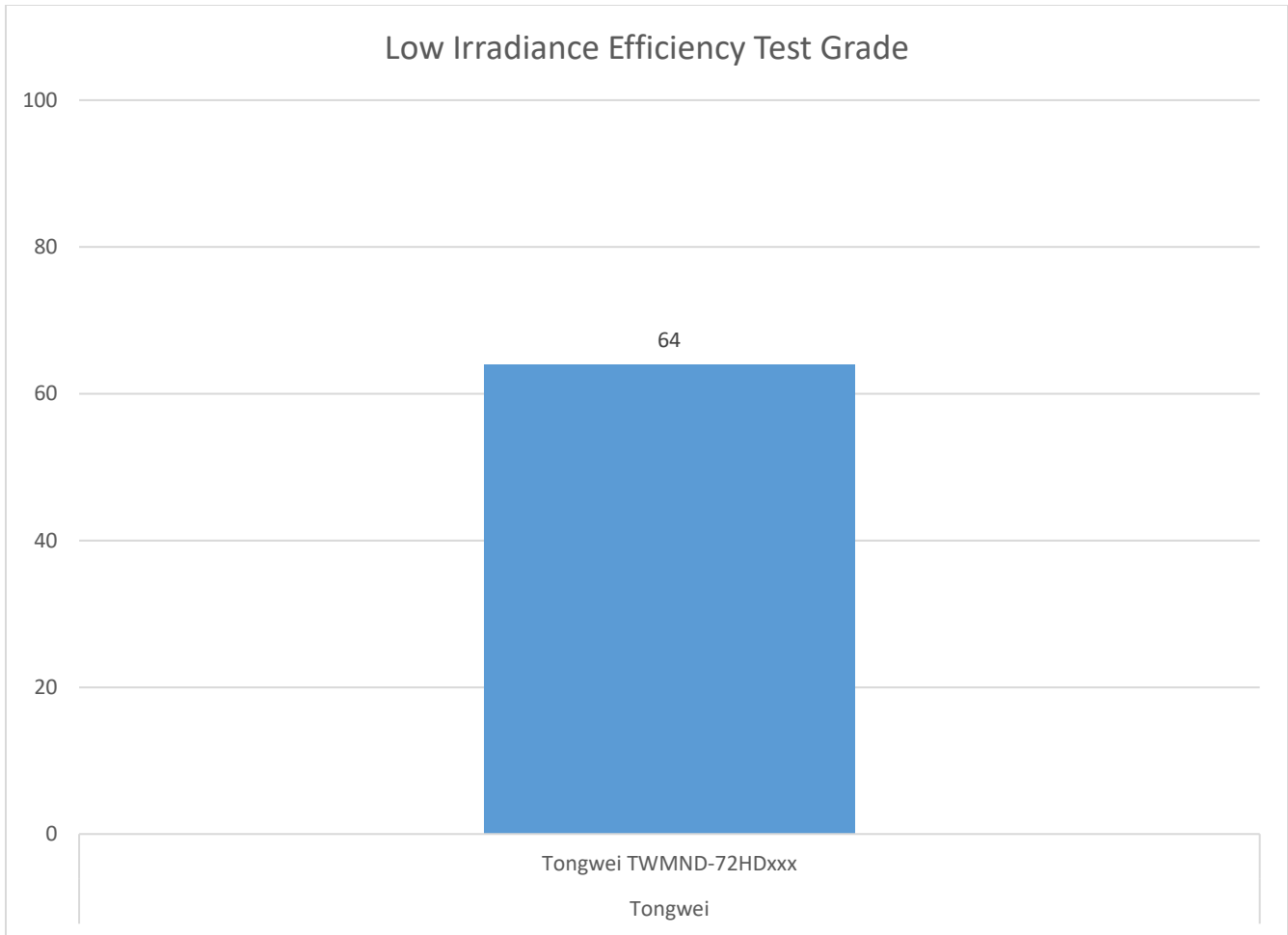


Figure 4 Low irradiance test result

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

TONGWEI TWMND-72HD565	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.297%					100

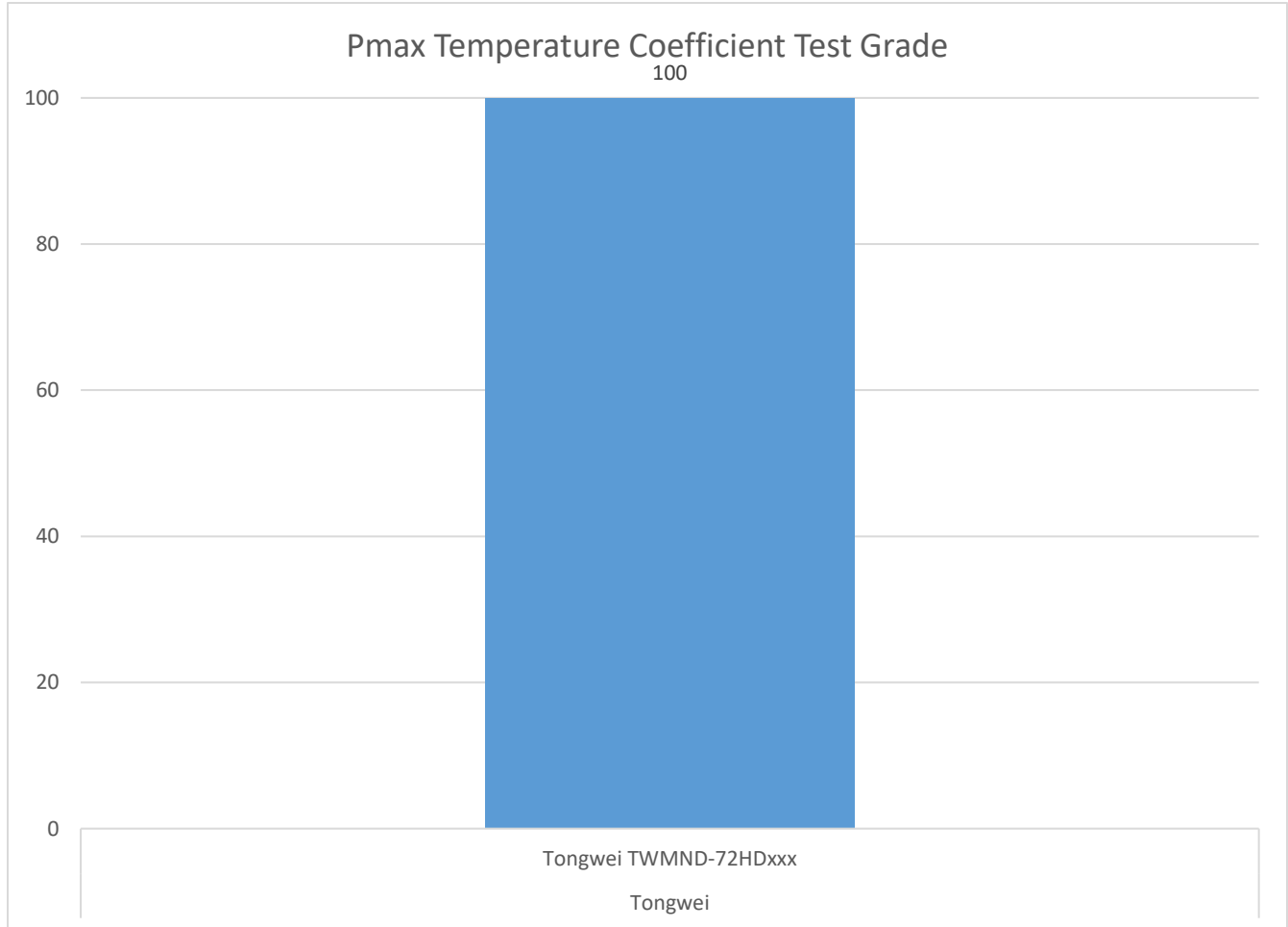


Figure 5 Pmax temperature coefficient test result

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

TONGWEI TWMND-72HD565	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)		1.14%				85

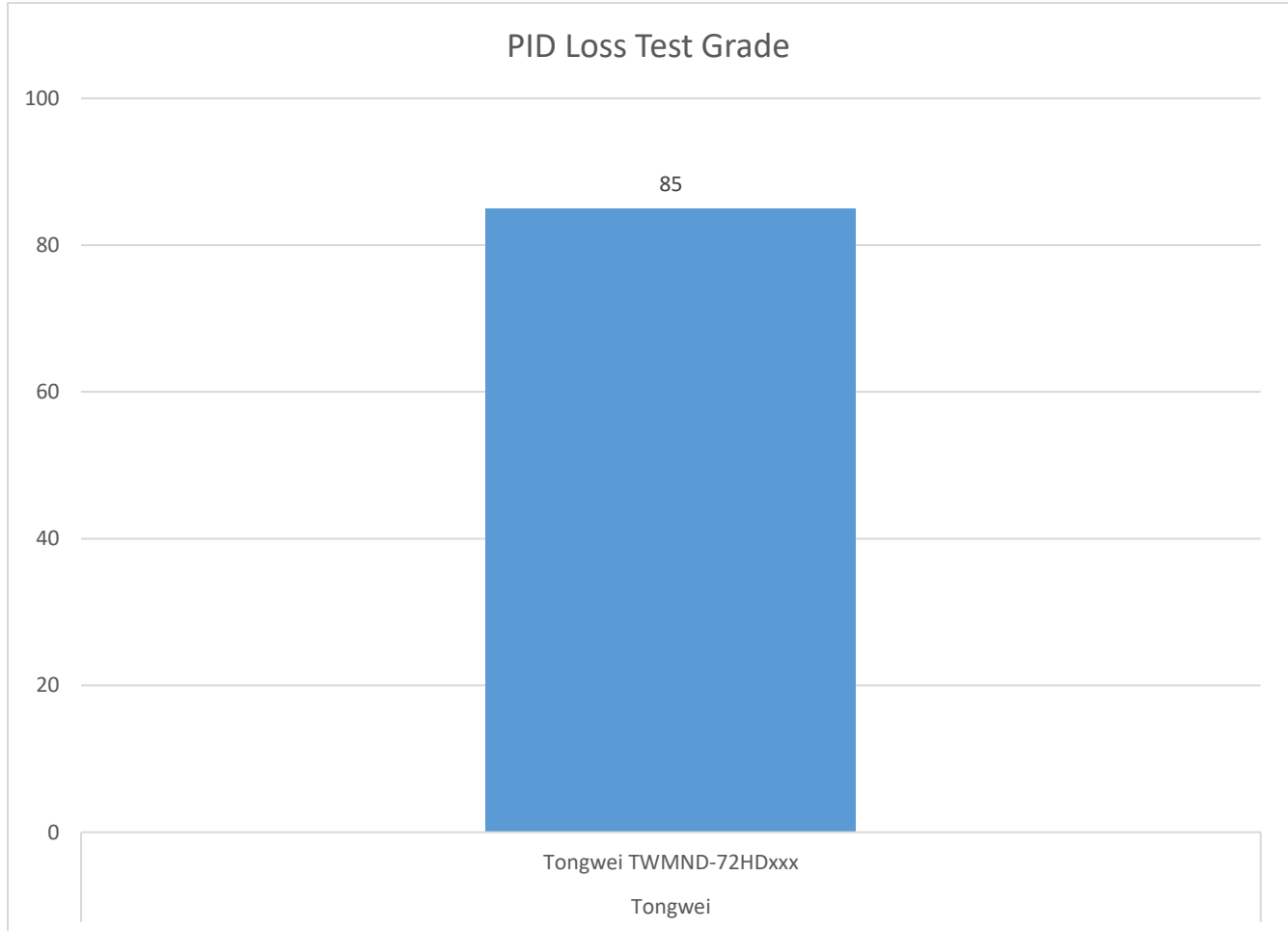


Figure 6 PID loss test result

3.6. LeTID loss test

Table 11 and Figure 6 depicts the LeTID loss test results:

Table 11 LeTID loss test result

TONGWEI TWMND-72HD565	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LeTID loss (%)						



Figure 7 LeTID loss test result

3.7. 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 12 Bifaciality ratio test results

TONGWEI TWMND-72HD565	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
Bifaciality ratio (%)	75.43%	75.70%	75.34%	74.87%	74.99%	75.27%

The bifaciality ratio is calculated from the following formula:

$$\text{Bifaciality ratio} = (\text{Pmax rear surface} / \text{Pmax front surface}) * 100\%$$

3.8. Score overview

Figure 8 shows the overview of the test scores. Figure 9 shows the average score.

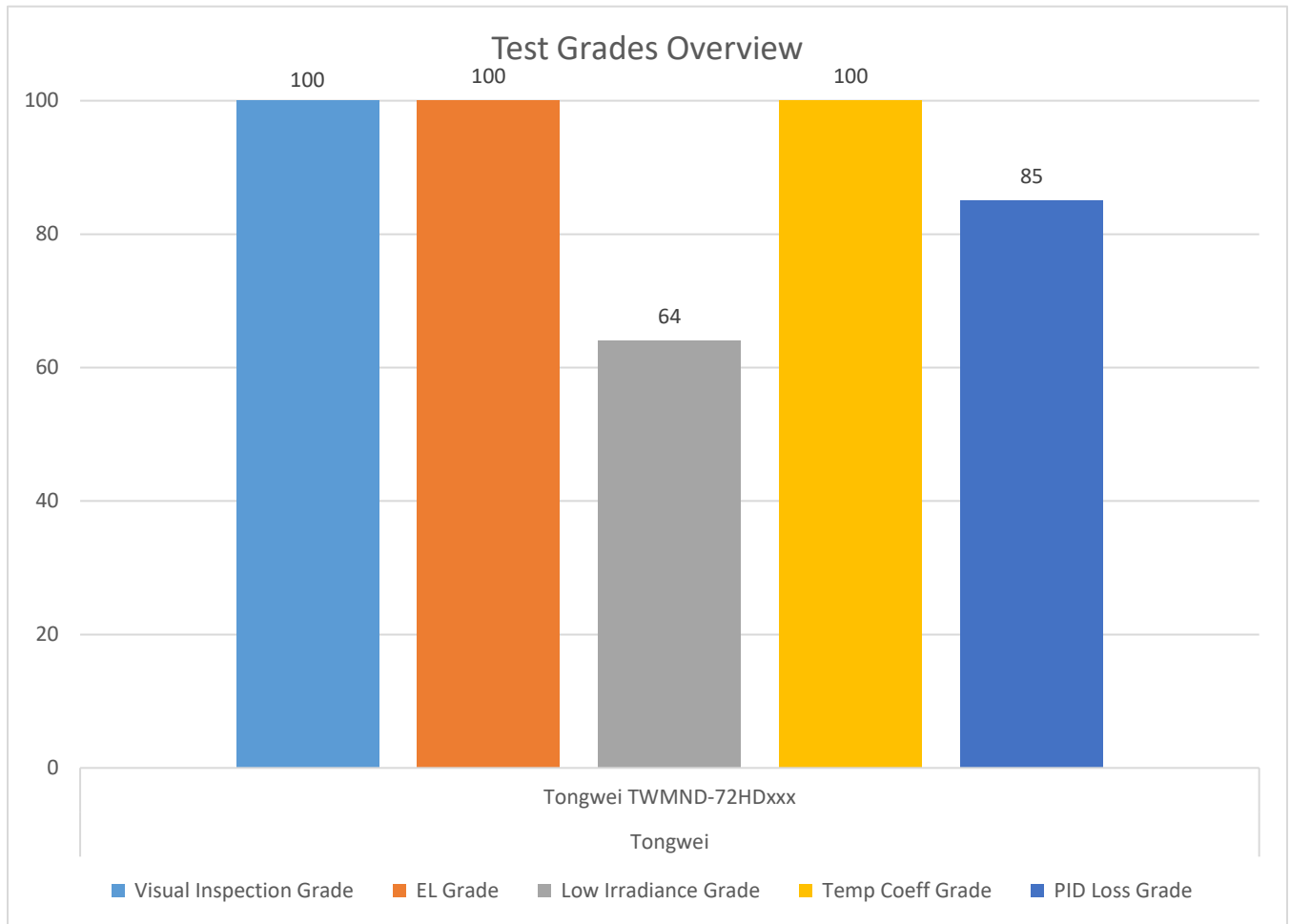


Figure 8 Test results overview

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

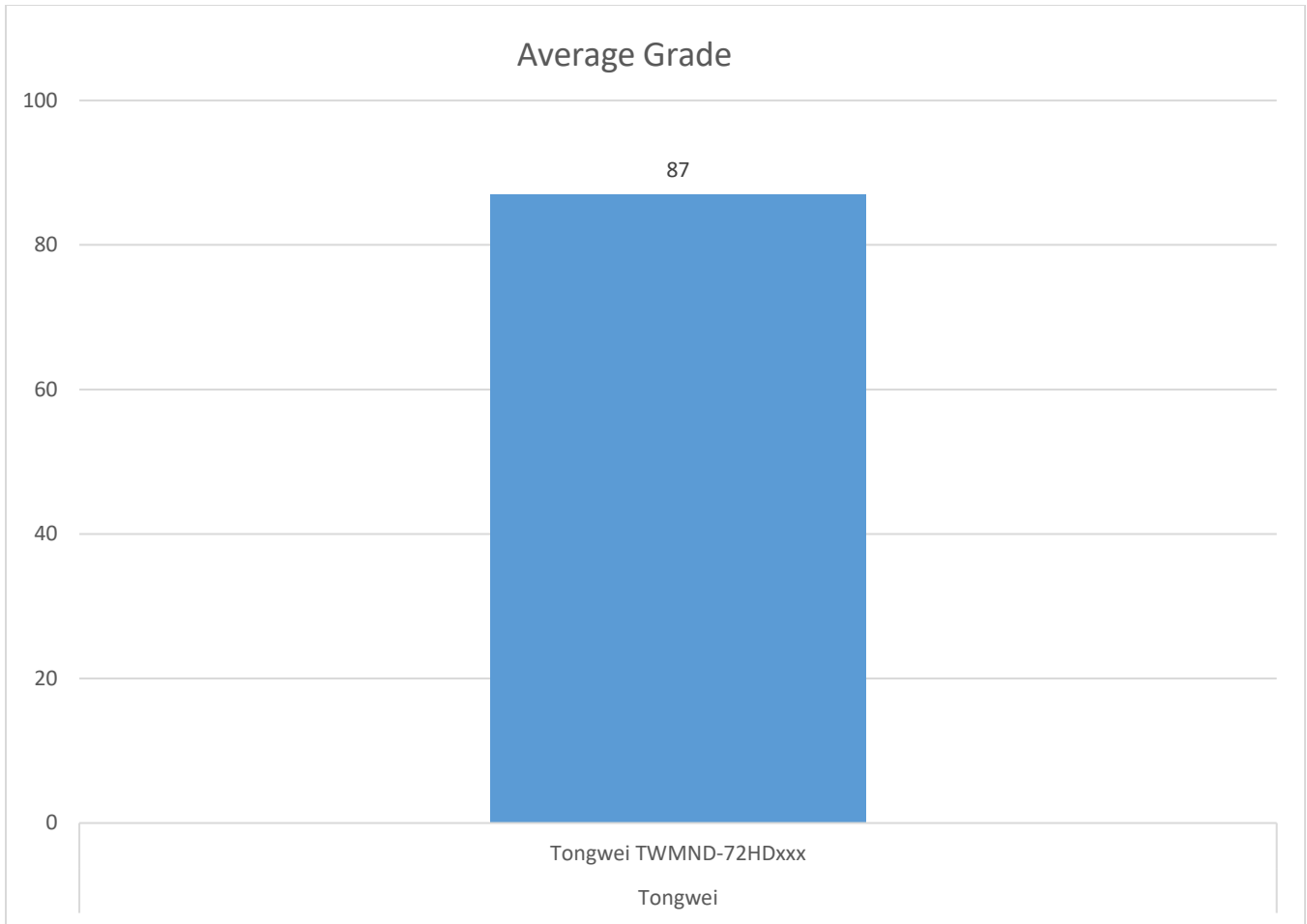


Figure 9 Average test grade

Appendix 1 – DAS-DH144PA-570 Datasheet



TW solar-M-PM-T5017/A1

182TOPCon- Half-cell Bifacial Module(72)

Product Feature



High Power Output
Low LCOE



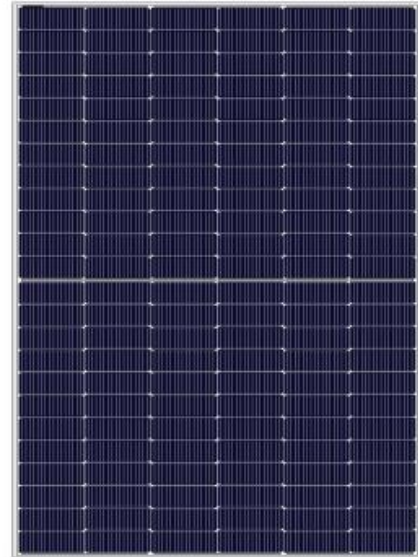
Maximum Power
up to 580W+



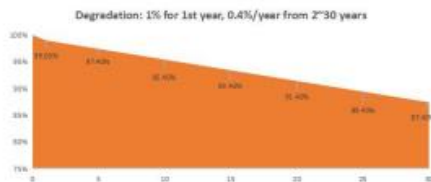
High Reliability



Low Degradation



Linear Warranty



12 year Warranty for Material and Processing



30 year Warranty for Linear Power output

Management System certification

ISO9001: 2015/Quality Management System
 ISO14001: 2015/Environmental Management System
 ISO45001: 2018/Occupational Health and Safety Management System
 IEC62941: 2019/Quality system for PV module manufacturing

Product certification



Tongwei Solar (Hefei) Co., Ltd
 Made in China



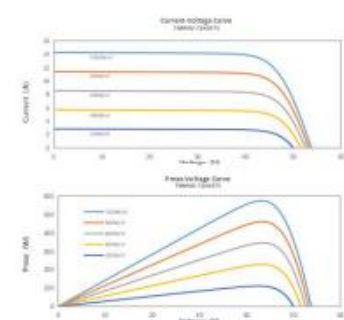
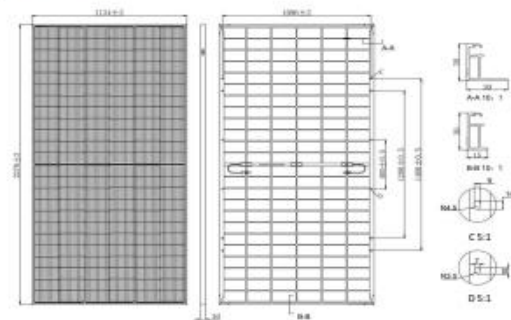
Electrical Characteristics (STC)						
Module type: TWMND-72HD***						
Maximum Power: Pmax [W]	555	560	565	570	575	580
Open Circuit Voltage: Voc [V]	50.64	50.84	51.04	51.24	51.44	51.64
Short Circuit Current: Isc [A]	14.09	14.13	14.17	14.21	14.25	14.29
Voltage at Maximum Power: Vmp [V]	42.28	42.48	42.68	42.88	43.08	43.28
Current at Maximum Power: Imp [A]	13.13	13.18	13.24	13.29	13.35	13.40
Module Efficiency: η [%]	21.5	21.7	21.9	22.1	22.3	22.5
STC: Irradiance 1000W/m ² , Cell Temperature 25°C, AM=1.5, Test Uncertainty: ±3%						

Electrical Characteristics (NMOT)						
Maximum Power: Pmax [W]	417.4	421.1	424.8	428.6	432.4	436.1
Open Circuit Voltage: Voc [V]	47.80	48.29	48.48	48.67	48.86	49.05
Short Circuit Current: Isc [A]	11.37	11.42	11.47	11.52	11.56	11.60
Voltage at Maximum Power: Vmp [V]	39.80	39.84	39.89	39.95	40.00	40.19
Current at Maximum Power: Imp [A]	10.49	10.56	10.63	10.70	10.78	10.85
NMOT: Irradiance 800W/m ² , Ambient Temperature 20°C, AM=1.5, Wind Speed 1m/s						

Electrical characteristics with different rear side power gain							
5%	Maximum Power: Pmax[W]	582.8	588.0	593.3	598.5	603.8	609.0
	Module Efficiency: η [%]	22.6	22.8	23.0	23.2	23.4	23.6
15%	Maximum Power: Pmax[W]	638.3	644.0	649.8	655.5	661.3	667.0
	Module Efficiency: η [%]	24.7	24.9	25.2	25.4	25.6	25.8
25%	Maximum Power: Pmax[W]	693.8	700.0	706.3	712.5	718.8	725.0
	Module Efficiency: η [%]	26.9	27.1	27.3	27.6	27.8	28.1

Mechanical Parameters	
Cell Type	TNC
Cell Orientation	144[6×24]
Dimensions	2278±2×1134±2×30mm
Weight	32.7kg
Front Glass	2.0 mm AR coated heat strengthened glass
Rear Glass	2.0 mm heat strengthened glass
Frame	Anodized aluminum alloy frame
Junction Box	IP68, 3 diodes
Cable	4.0 mm ²
Cable length	+400mm,-200mm,length can be customized
Wind/Snow load	2400Pa/5400Pa
Packaging	36 pcs per pallet,720 pcs per 40'HC
Fire class rating	Class C

Drawing (Unit:mm)



Statement: With technological process and product update, there maybe deviation between the technical parameters of Tongwei's module products and the technical parameters contained in the specification, and Tongwei Solar has the right to adjust the technical parameters at any time without notifying the customer, the final interpretation of the technical specification is vested in Tongwei Solar.

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