CEA I PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | SEG Solar

Author: George Touloupas
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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.

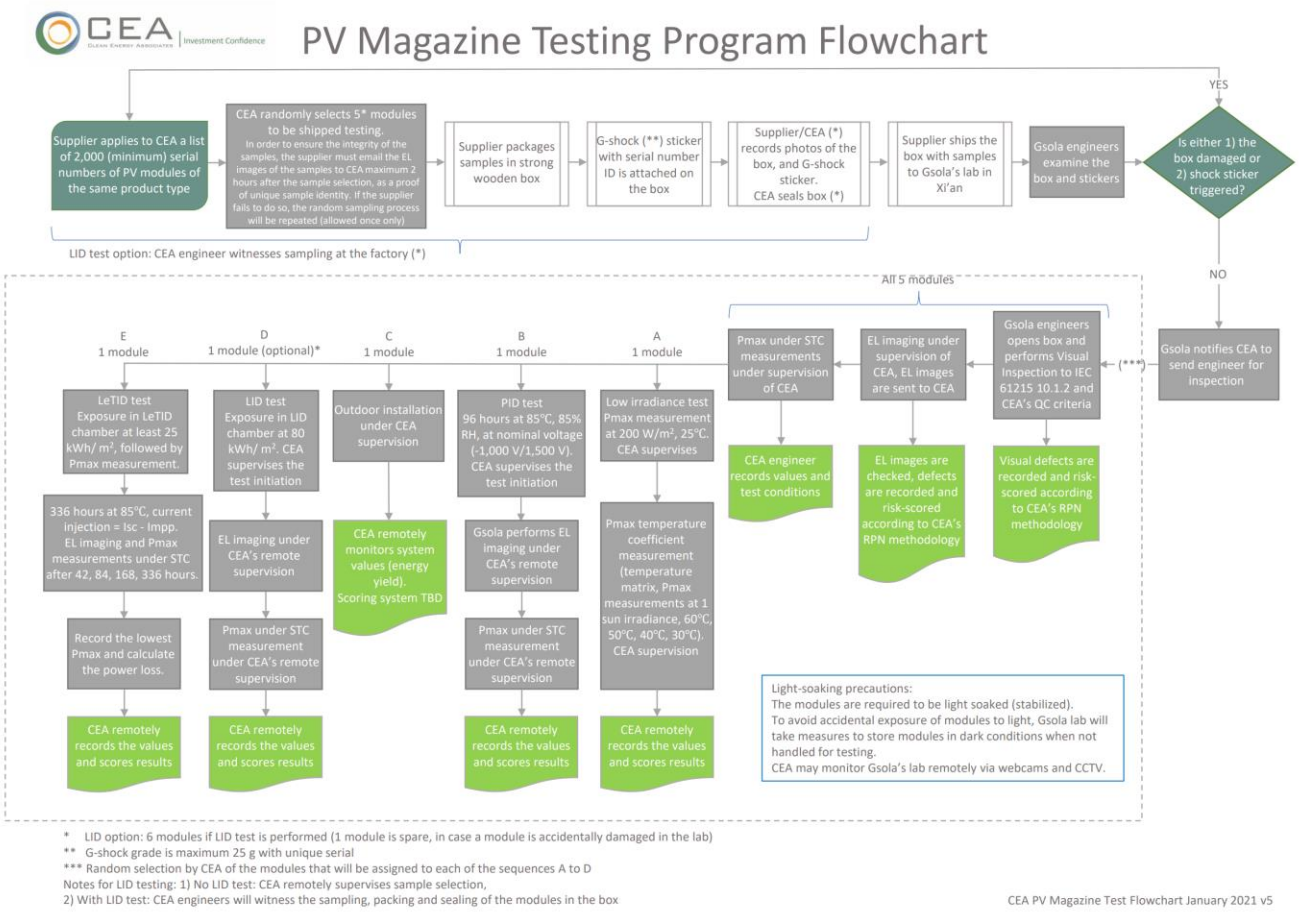


Figure 1 Test flowchart

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.

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 SEG-575-BTA-BG 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	SEGCNJT4AD2307000011
2	SEGCNJT4AD2307000012
3	SEGCNJT4AD2307000055
4	SEGCNJT4AD2307000003
5	SEGCNJT4AD2307000025

Table 4 Product information

Model	SEG-575-BTA-BG
Cell technology	n-type TOPCon
Cell number	144
Cell format	182x182 mm
Number of busbars	16
Junction box	IP68, 3 bypass diodes
Laminate construction	Glass
Bifaciality ratio	80±10%

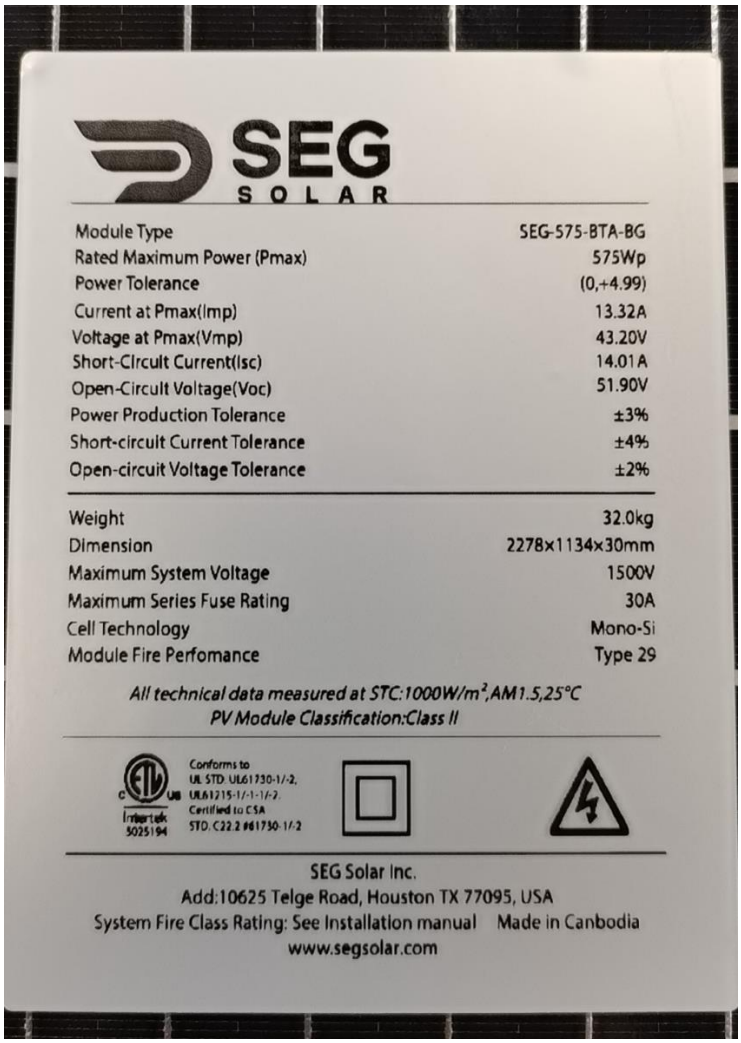


Figure 2 Product nameplate

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

SEG-575-BTA-BG	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

SEG-575-BTA-BG	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

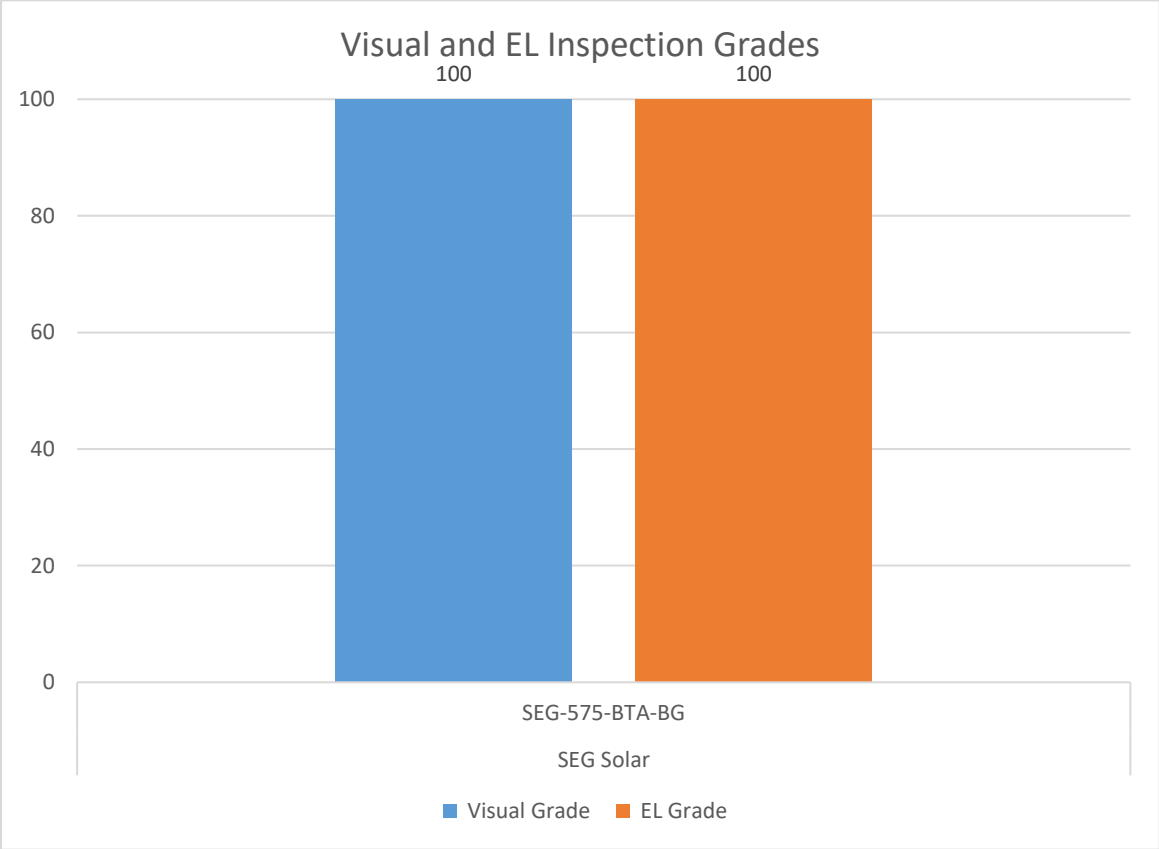


Figure 3 Visual and EL inspection results

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

SEG-575-BTA-BG	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side low irradiance efficiency loss (%)	4.91%					60

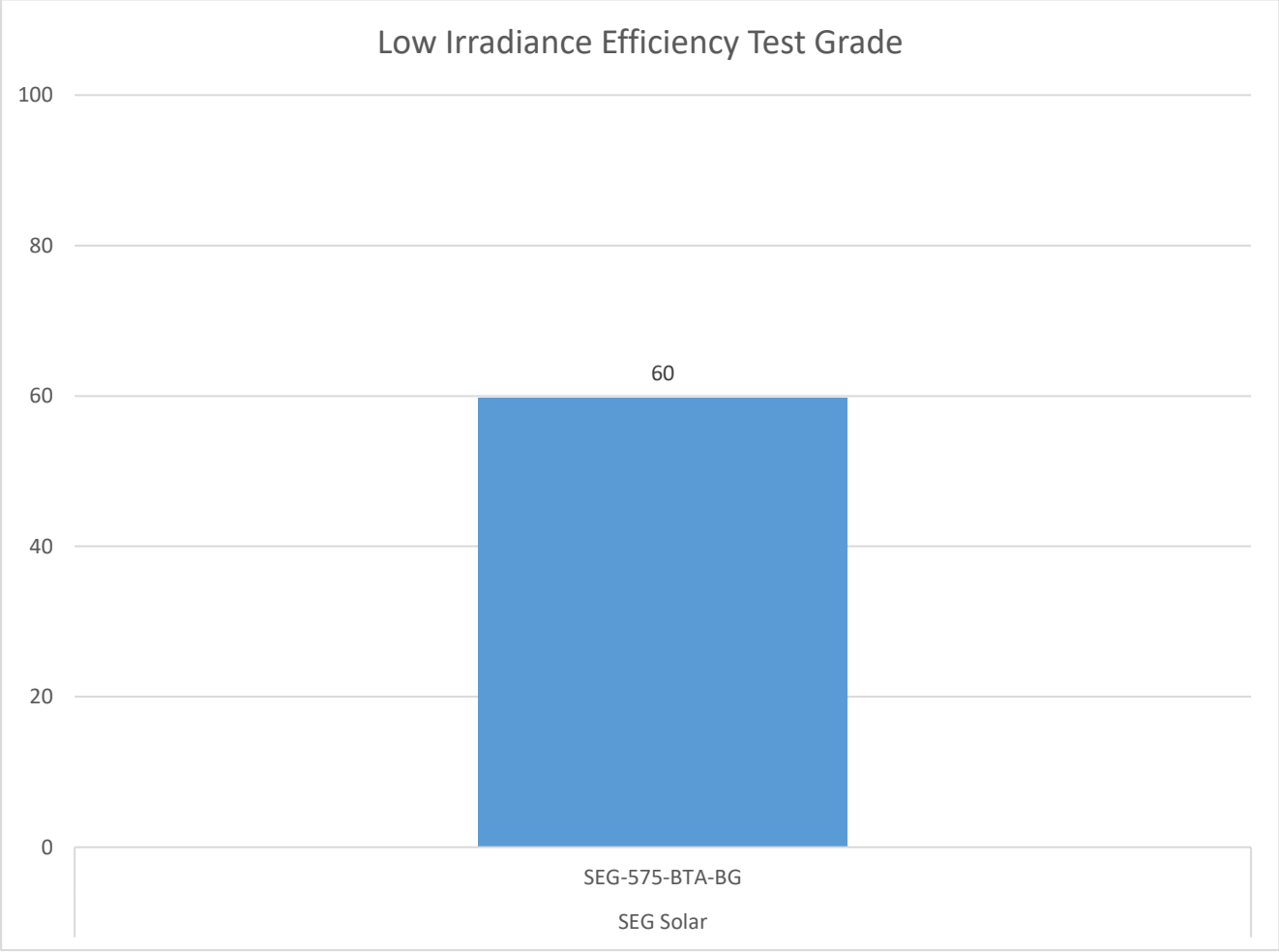


Figure 4 Low irradiance test result

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

SEG-575-BTA-BG	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)	-0.282%					104

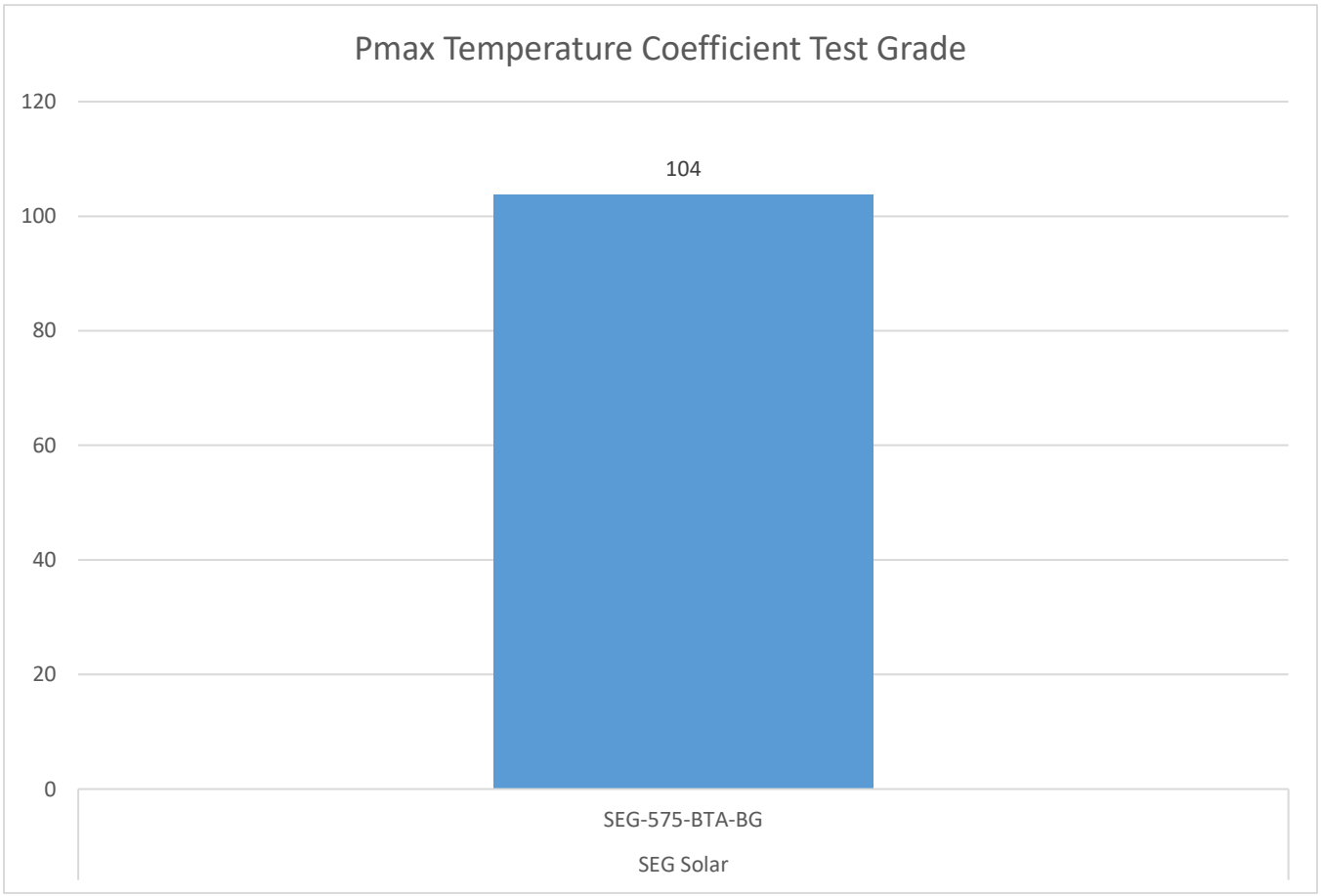


Figure 5 Pmax temperature coefficient test result

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

SEG-575-BTA-BG	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)			0.72%			90

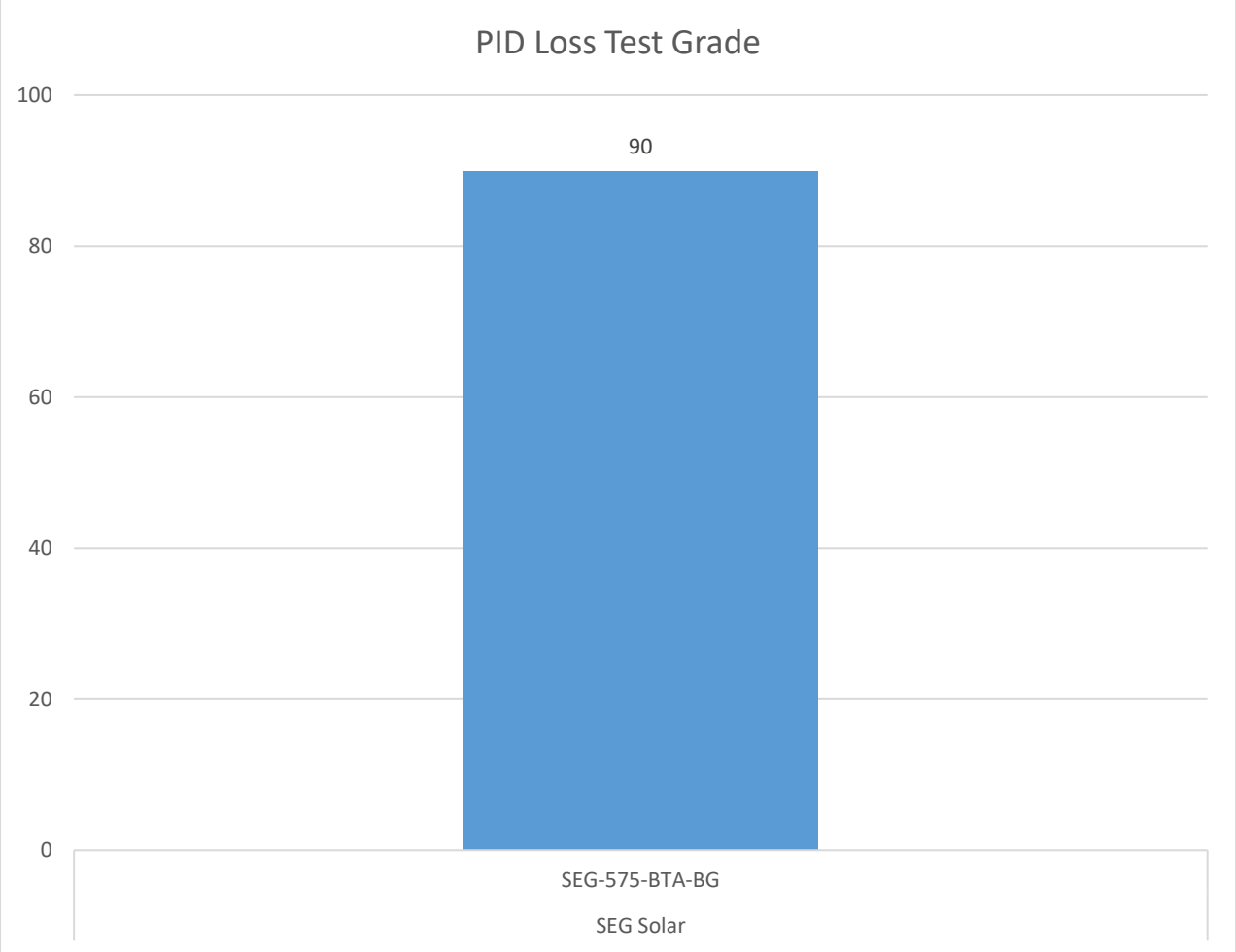


Figure 6 PID loss test result

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

SEG-575-BTA-BG	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LID loss (%)		-0.16%				92

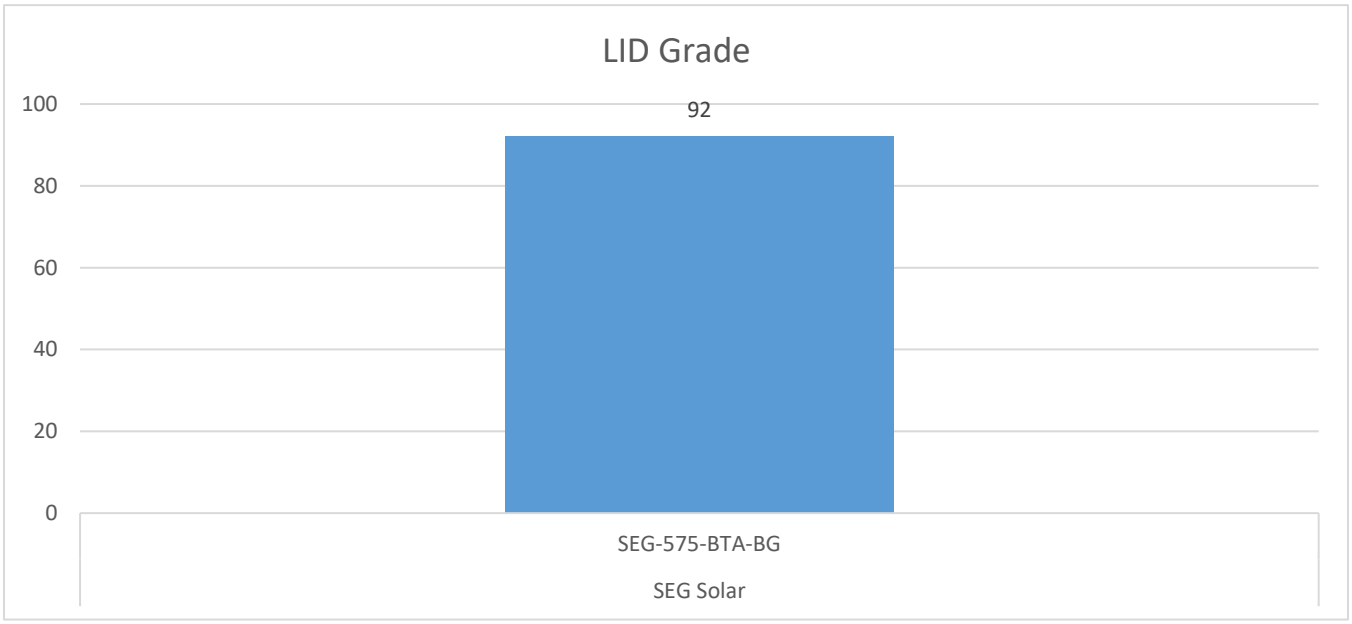


Figure 7 LID loss test result

3.7. LeTID loss test

Table 12 and Figure 8 depicts the LeTID loss test results:

Table 12 LeTID loss test result

SEG-575-BTA-BG	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LeTID loss (%)						

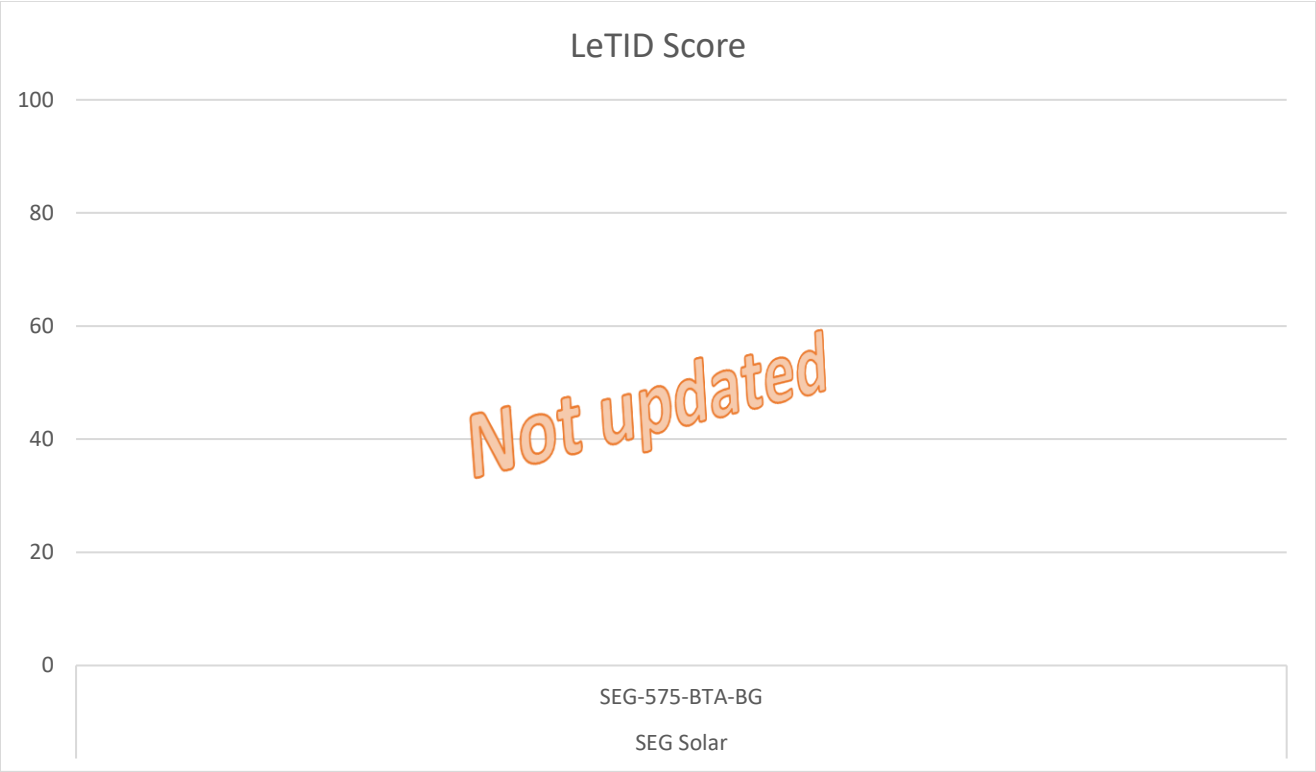


Figure 8 LeTID loss test result

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

SEG-575-BTA-BG	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
Bifaciality ratio (%)	73.23%	73.27%	73.27%	73.30%	73.22%	73.26%

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.

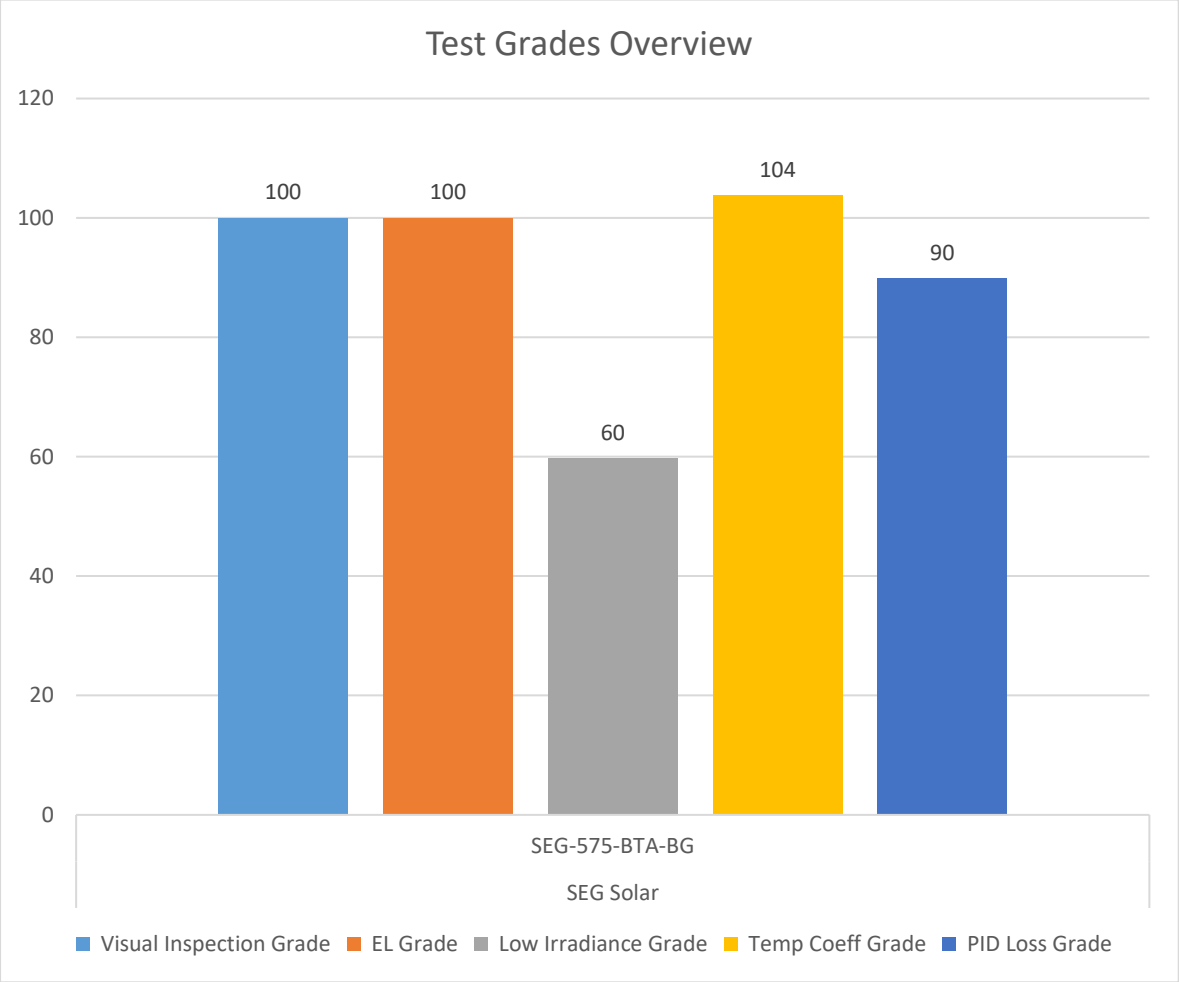


Figure 9 Test results overview

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

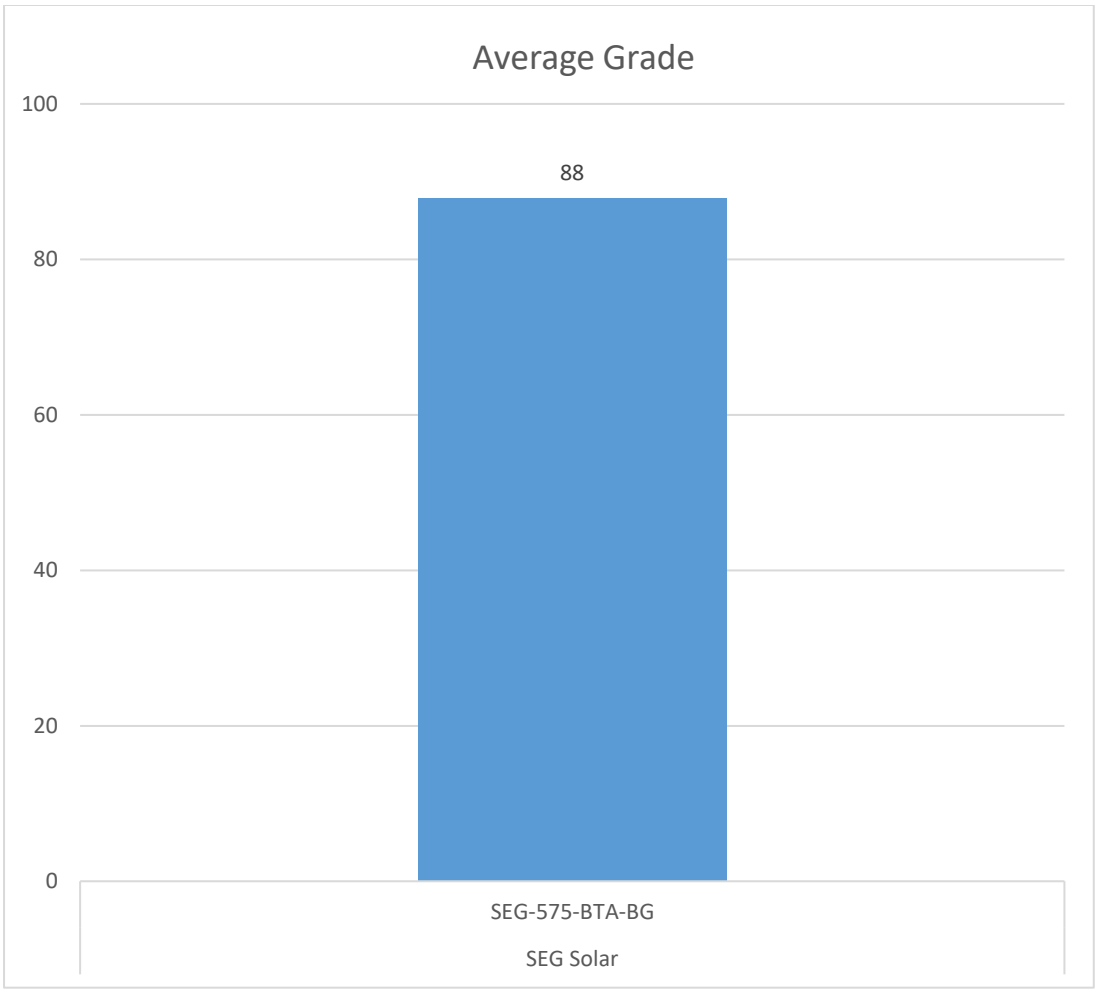


Figure 10 Average test grade

Appendix 1 – SEG-575-BTA-BG Datasheet

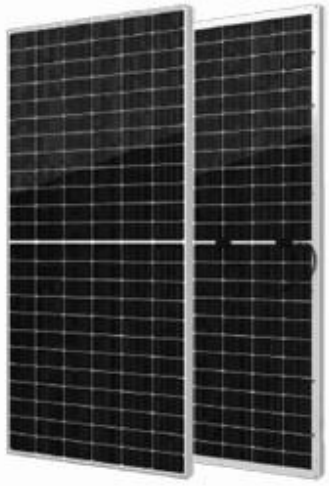
SEG SOLAR

www.segsolar.com

YUKON N Series

Half-Cell N-Type TOPCon
Bifacial Module

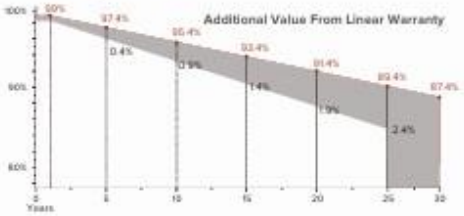
565-580Wp Module Power Output | **22.45%** Max Efficiency



Key Features

- High module conversion efficiency
- Better temperature coefficient
- Super multi busbar technology
- Low attenuation long warranty
- Superior load capacity
- Higher bifacially
- USA based liability insurance
- Houston, Texas based company

Warranty



15 <Years> Guarantee on product material and workmanship

30 <Years> Linear power output warranty

Product Certification

IEC61215:2016; IEC 61730:2016;	UL1703; UL61730
IEC62804	PID
IEC61701	Salt Mist
IEC62716	Ammonia Resistance
IEC60068	Dust and Sand
IEC61215	Hailstone
Fire Type (UL61730):Type29	
ISO14001:2015; ISO9001:2015; ISO45001:2018	

FSEC CALIFORNIA ENERGY COMMISSION

About SEG Solar

SEG Solar is a leading manufacturer of high-performance solar panels for residential, commercial, and utility applications. The company, headquartered in Houston, Texas, is committed to providing cost-effective and reliable solar solutions that

SEG SOLAR

YUKON N Series SEG-XXX-BTA-BG(144Cells)

Electrical Characteristics

Module Type	SEG-565-BTA-BG			SEG-570-BTA-BG			SEG-575-BTA-BG			SEG-580-BTA-BG		
	Front STC	Front NOCT	Back STC	Front STC	Front NOCT	Back STC	Front STC	Front NOCT	Back STC	Front STC	Front NOCT	Back STC
Maximum Power -Pmp(Wp)	565	425	452	570	429	456	575	433	460	580	437	464
Open Circuit Voltage -Voc(V)	51.50	48.93	51.48	51.70	49.12	51.68	51.90	49.31	51.88	52.10	49.50	52.08
Short Circuit Current -Isc(A)	13.89	11.11	11.11	13.95	11.16	11.16	14.01	11.21	11.21	14.07	11.26	11.26
Maximum Power Voltage -Vmp(V)	42.80	40.22	42.78	43.00	40.44	42.98	43.20	40.63	43.18	43.40	40.86	43.38
Maximum Power Current -Imp(A)	13.21	10.57	10.57	13.26	10.61	10.61	13.32	10.66	10.66	13.37	10.70	10.70
Module Efficiency(%)		21.87			22.07			22.26			22.45	
Power Tolerance	(0, +3%)											
Maximum System Voltage	1500V DC											
Maximum Series Fuse Rating	30 A											

STC: Irradiance 1000 W/m² module temperature 25°C AM=1.5 NOCT: Irradiance 800W/m² ambient temperature 20°C module temperature 45°C wind speed 1m/s

Mechanical Specifications

External Dimension	2278 x 1134 x 30 mm
Weight	32.0 kg
Solar Cells	N-TOPCon 182 x 91mm(144 pcs)
Front /Back Glass	2.0mm AR coating semi-tempered glass / low iron
Frame	Anodized aluminium alloy
Junction Box	IP68 / 3 diodes
Connector Type	PV-CO02-xy
Cable Type Cable Length	12 AWG PV Wire（UL） Portrait: 400 mm(+) / 200 mm(-) Landscape: 1200 mm(+) / 1200 mm(-) or customized length
Mechanical Load(Front)	5400 Pa / 113 psf*
Mechanical Load(Rear)	2400 Pa / 50 psf*

*Refer to SEG installation Manual for details

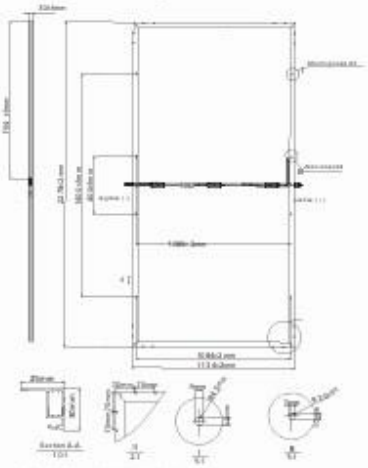
Packing Configuration

Container	20'GP	40'HQ
Pieces per Pallet	36	36
Pallets per Container	4	20
Pieces per Container	144	720

Temperature Characteristics

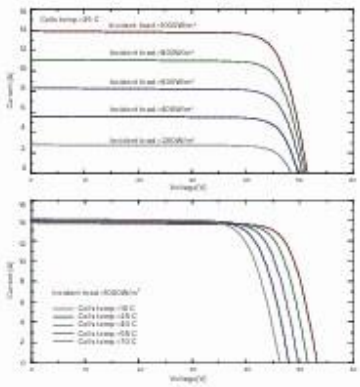
Pax Temperature Coefficient	-0.30 %/°C
Voc Temperature Coefficient	-0.25 %/°C
Isc Temperature Coefficient	+0.046 %/°C
Operating Temperature	-40~+85 °C
Nominal Operating Cell Temperature (NOCT)	45±2 °C

Technical Drawing



*Refer to SEG installation Manual for details

I-V Curve



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