

CEA | PV MAGAZINE PROGRAM TEST REPORT

SUPPLIER | LONGi

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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.

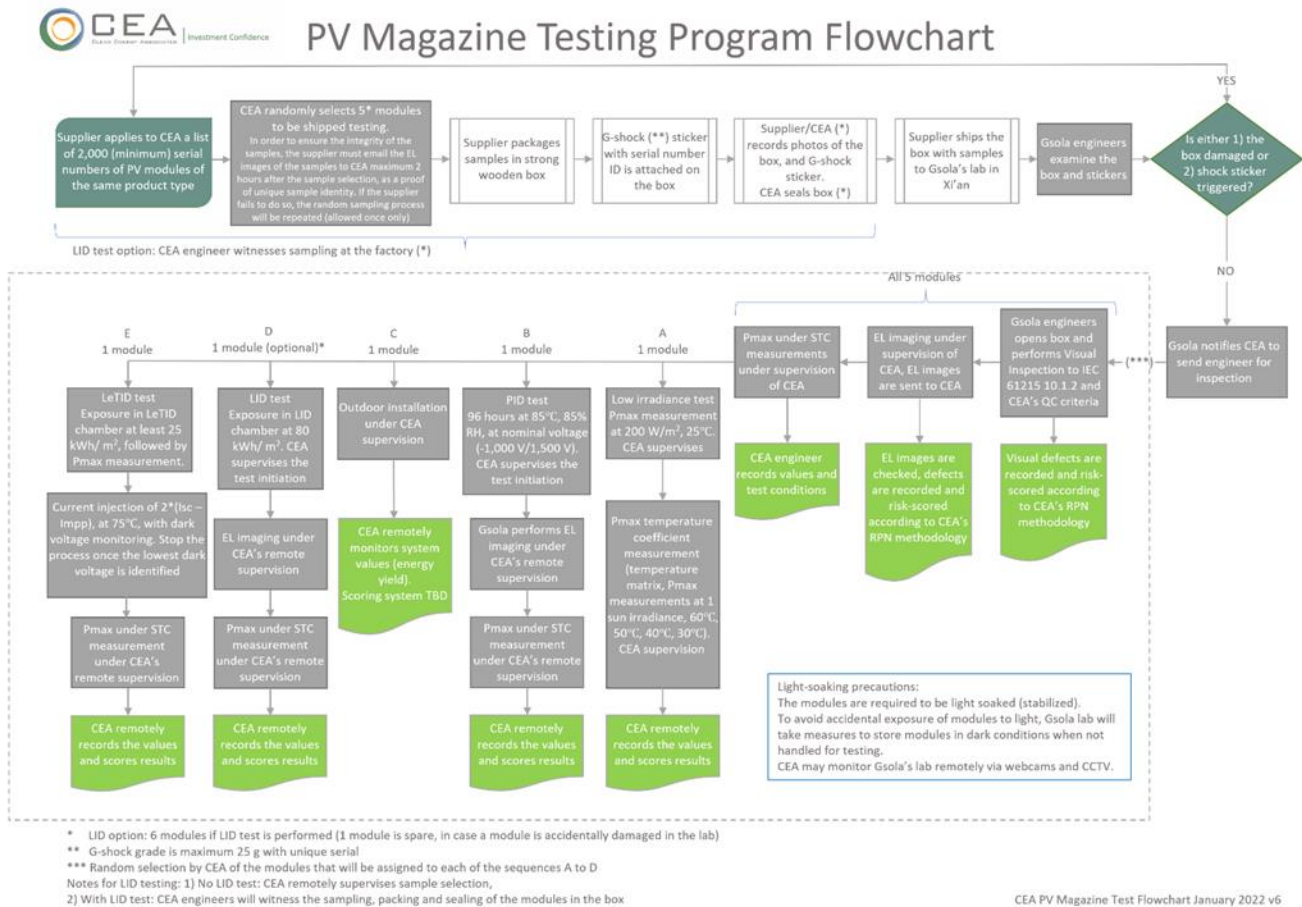


Figure 1 Test flowchart

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	LeTID	1	Test	%	NA	1-100
7	LID loss (optional)	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	LeTID	≤0.00%	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.

Please note that the random selection procedure described in the flowchart above was not followed. These samples were selected and shipped to the lab directly by LONGi.

Table 3 Test sample information

Sample #	Serial number
1	LRP904106201000401479
2	LRP904106201000401682
3	LRP904106201000401489
4	LRP904106201000401710
5	LRP904106201000401449

Table 4 Product information

Model	LR5-72HBD-535M
Cell technology	Mono PERC Bifacial
Cell number	144
Cell format	182 × 91 mm
Number of busbars	9
Junction box	IP68 rated
Laminate construction	Framed glass/glass
Bifaciality ratio	--



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

LR5-72HBD-535M	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

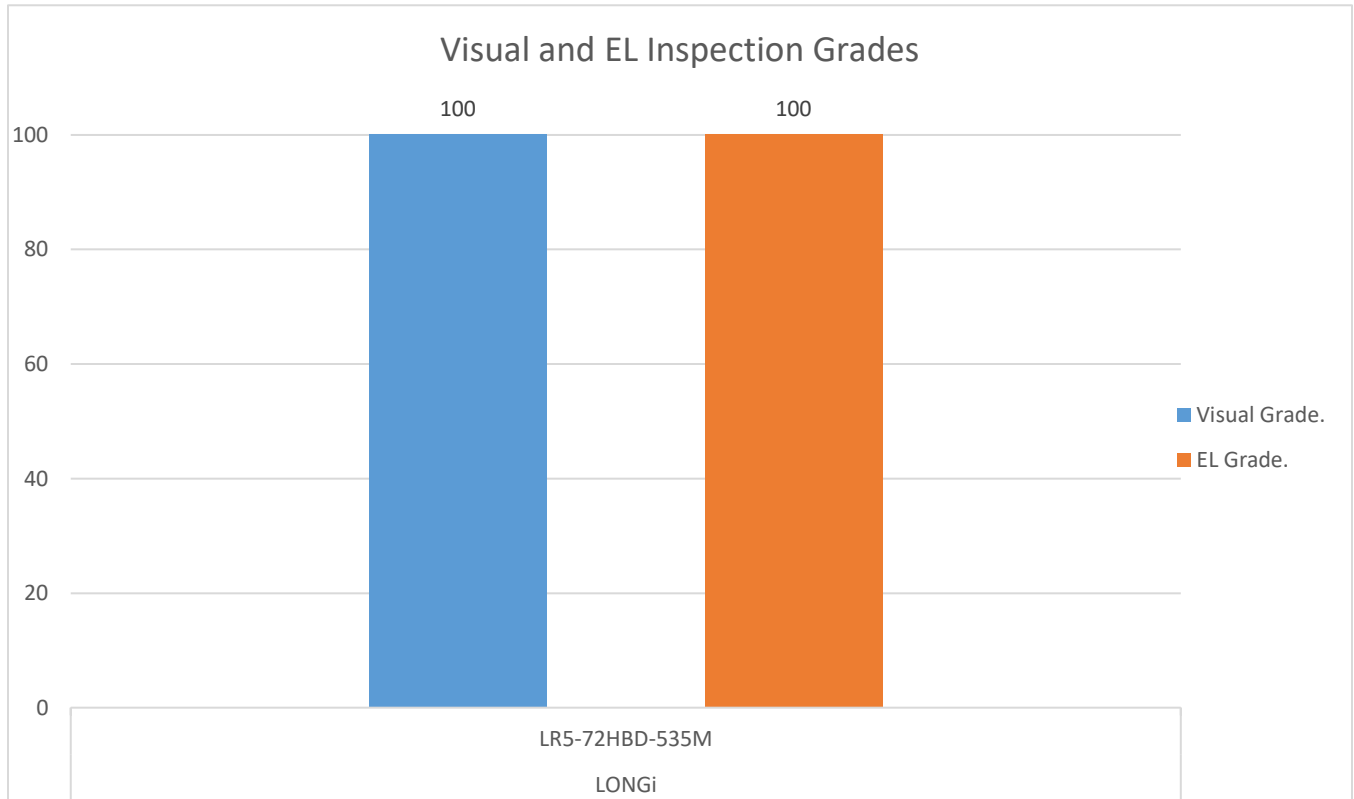


Figure 3.

Table 7 EL image inspection results

LR5-72HBD-535M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Score	Grade
EL image inspection	None	None	None	None	None	0	100

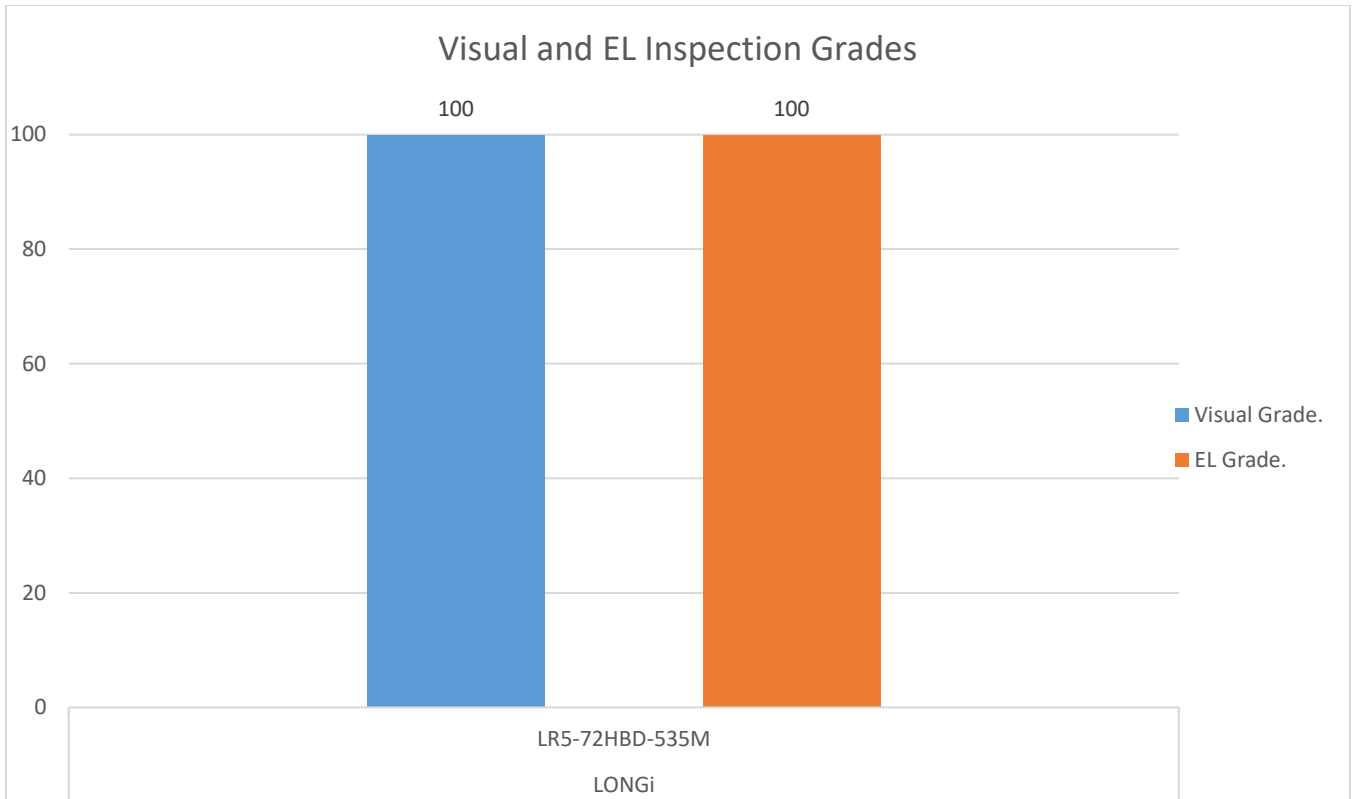


Figure 3 Visual and EL inspection results

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

LR5-72HBD-535M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade

Front side low irradiance efficiency loss (%)	4.57%					62
---	-------	--	--	--	--	----

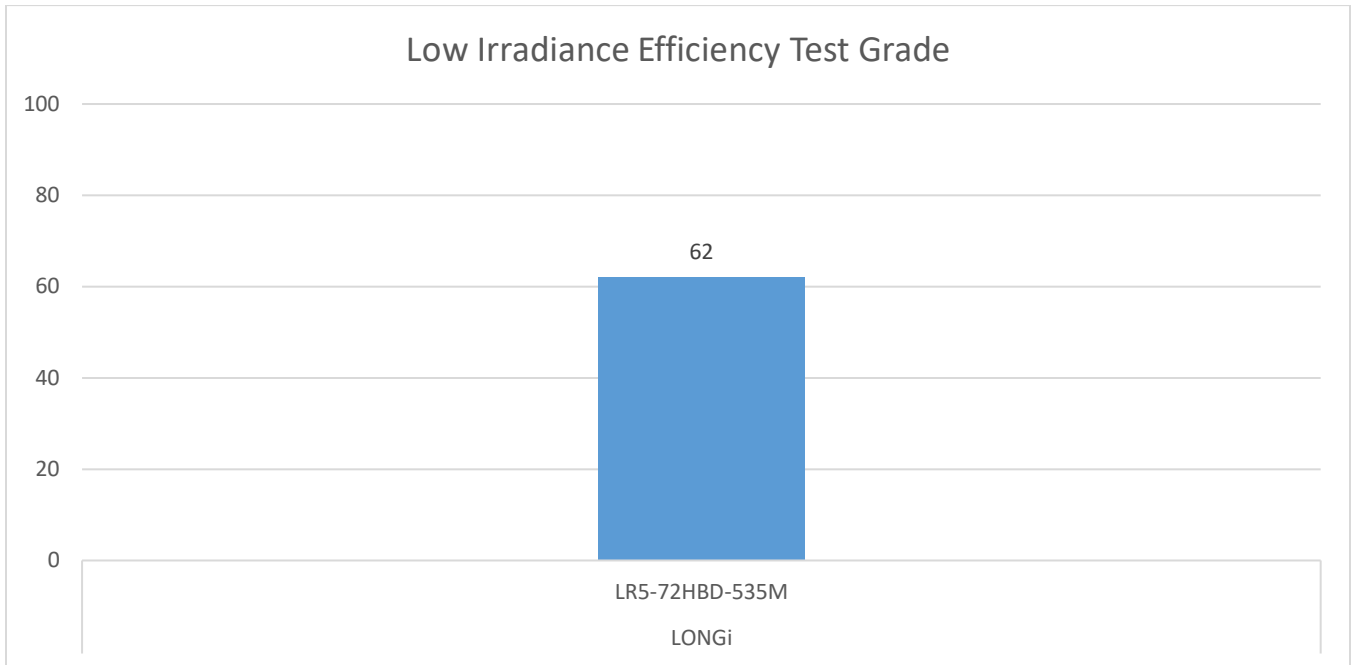


Figure 4 Low irradiance test result

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

LR5-72HBD-535M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Pmax Temperature coefficient (%/°C)			-0.339%			90

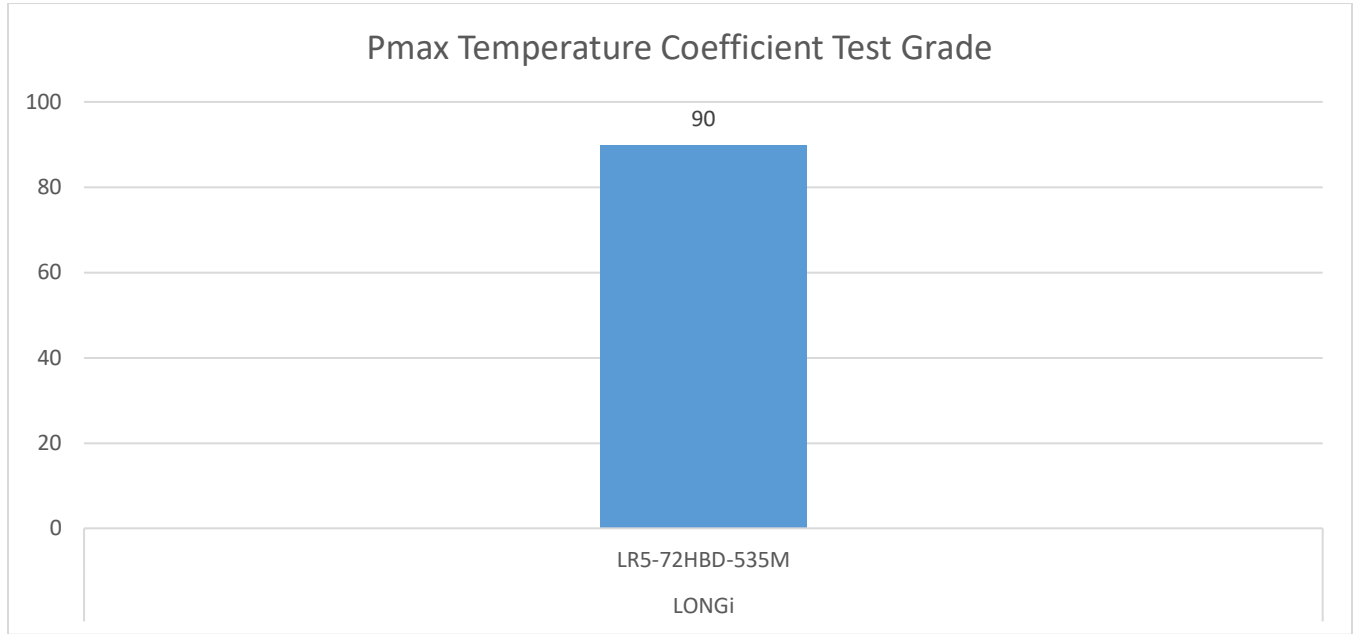


Figure 5 Pmax temperature coefficient test result

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

LR5-72HBD-535M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side PID loss (%)		0.227%				96

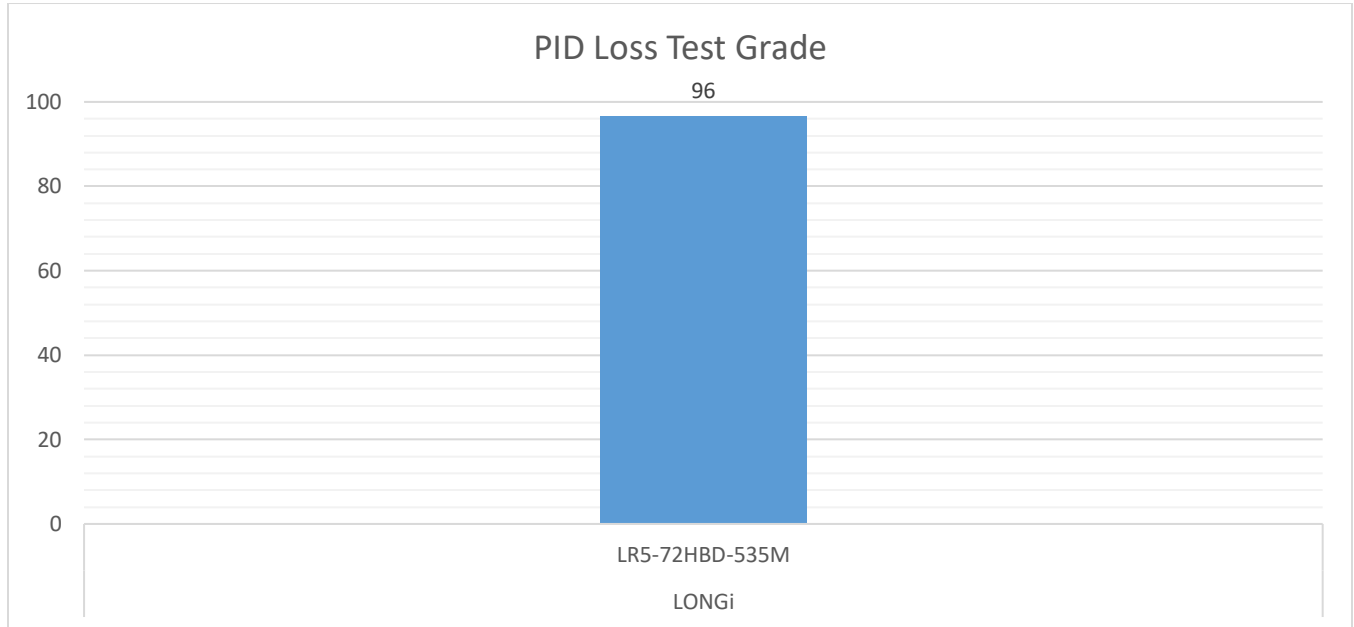


Figure 6 PID loss test result

3.6. LETID loss test

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

Table 11 LeTID loss test result

LR5-72HBD-535M	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Grade
Front side LETID loss (%)				-0.36%		100

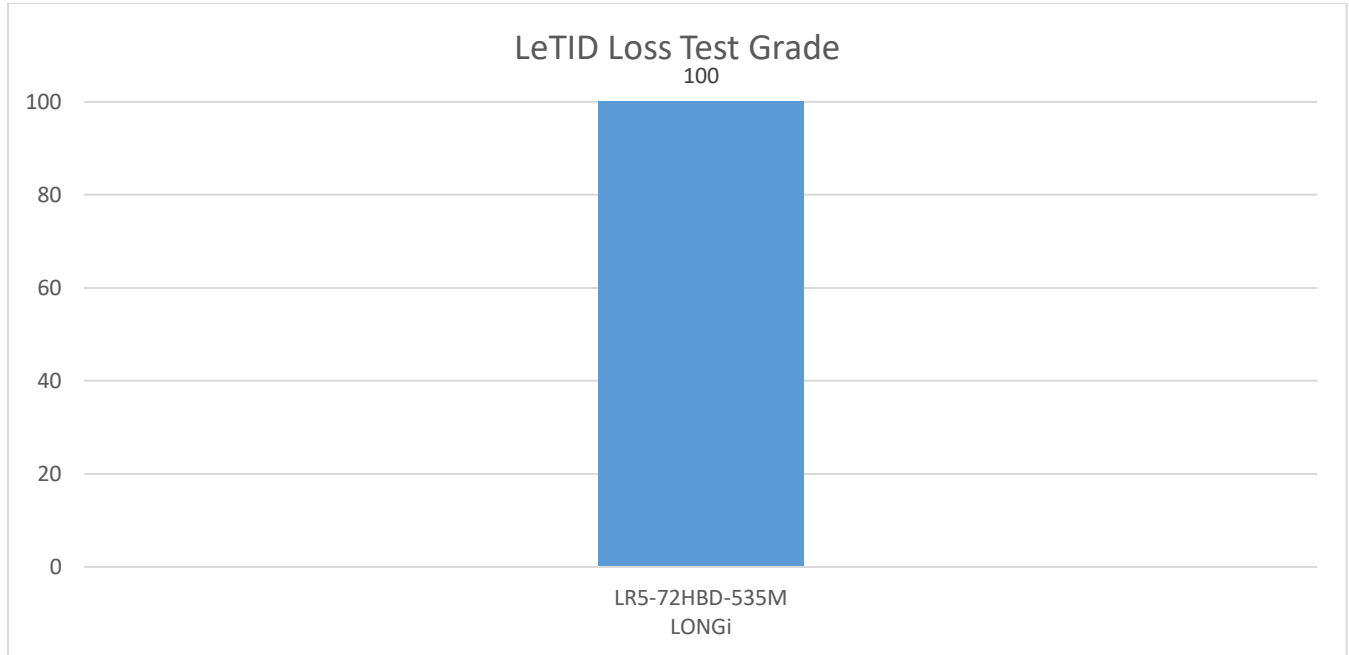


Figure 7 LeTID loss test result

3.7. Score overview

Fehler! Verweisquelle konnte nicht gefunden werden.8 shows the overview of the scores.

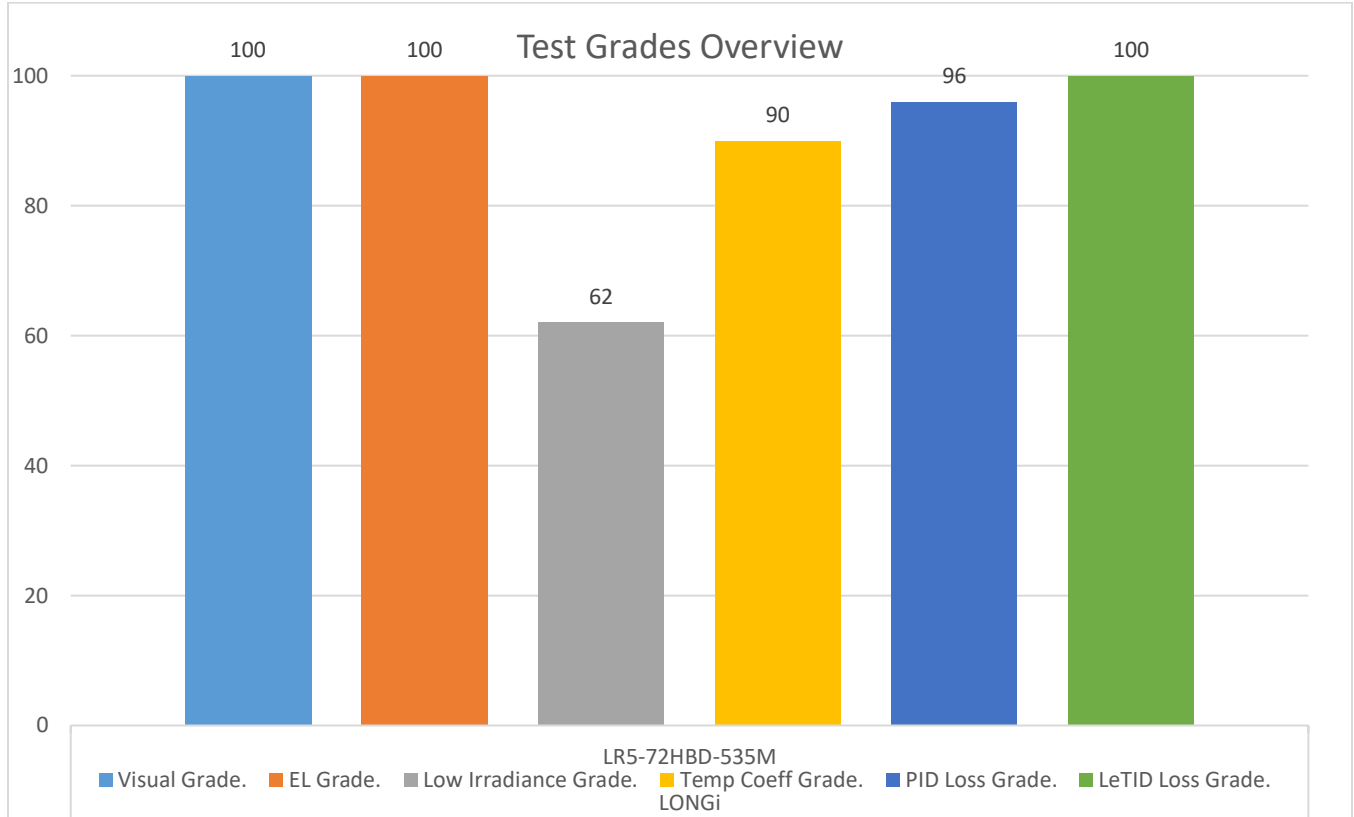


Figure 8 Test score overview


Appendix 1 - LR4-72HBD-445M Datasheet

Hi-MO 5

LR5-72HBD 530~550M

- Based on M10-182mm wafer, best choice for ultra-large power plants
- Advanced module technology delivers superior module efficiency
 - M10 Gallium-doped Wafer • Smart Soldering • 9-busbar Half-cut Cell
- Globally validated bifacial energy yield
- High module quality ensures long-term reliability

 12-year Warranty for Materials and Processing

 30-year Warranty for Extra Linear Power Output

Complete System and Product Certifications

IEC 61215, IEC 61730, UL 61730

ISO 9001:2015: ISO Quality Management System

ISO 14001: 2015: ISO Environment Management System

TS62941: Guideline for module design qualification and type approval

ISO 45001: 2018: Occupational Health and Safety

LONGI



Hi-MO 5

LR5-72HBD 530~550M

21.5%
MAX MODULE
EFFICIENCY

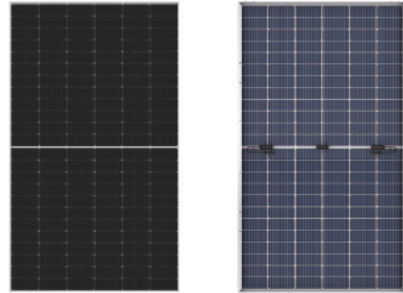
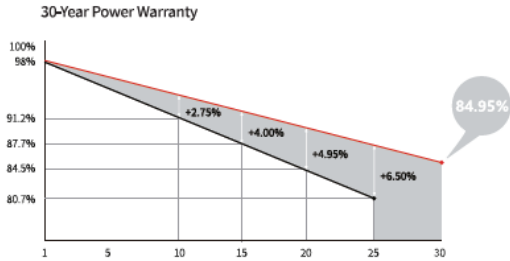
0~3%
POWER
TOLERANCE

<2%
FIRST YEAR
POWER DEGRADATION

0.45%
YEAR 2-30
POWER DEGRADATION

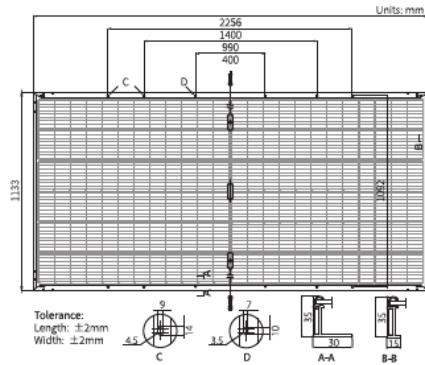
HALF-CELL
Lower operating temperature

Additional Value



Mechanical Parameters

Cell Orientation	144 (6×24)
Junction Box	IP68, three diodes
Output Cable	4mm ² , +400, -200mm/±1400mm length can be customized
Glass	Dual glass, 2.0+2.0mm heat strengthened glass
Frame	Anodized aluminum alloy frame
Weight	32.3kg
Dimension	2256×1133×35mm
Packaging	31pcs per pallet / 155pcs per 20' GP / 558pcs per 40' HC



Electrical Characteristics	STC: AM1.5 1000W/m ² 25°C				NOCT: AM1.5 800W/m ² 20°C 1m/s				*Test uncertainty for Pmax: ±3%	
	LR5-72HBD-530M		LR5-72HBD-535M		LR5-72HBD-540M		LR5-72HBD-545M		LR5-72HBD-550M	
Testing Condition	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax/W)	530	396.2	535	399.9	540	403.6	545	407.4	550	411.1
Open Circuit Voltage (Voc/V)	49.20	46.26	49.35	46.40	49.50	46.54	49.65	46.68	49.80	46.82
Short Circuit Current (Isc/A)	13.71	11.07	13.78	11.12	13.85	11.17	13.92	11.23	13.99	11.29
Voltage at Maximum Power (Vmp/V)	41.35	38.58	41.50	38.72	41.65	38.86	41.80	39.00	41.95	39.14
Current at Maximum Power (Imp/A)	12.82	10.27	12.90	10.33	12.97	10.39	13.04	10.45	13.12	10.51
Module Efficiency(%)	20.7		20.9		21.1		21.3		21.5	

Operating Parameters

Operational Temperature	-40°C ~ +85°C
Power Output Tolerance	0 ~ 3%
Voc and Isc Tolerance	±3%
Maximum System Voltage	DC1500V (IEC/UL)
Maximum Series Fuse Rating	30A
Nominal Operating Cell Temperature	45±2°C
Protection Class	Class II
Bifaciality	70±5%
Fire Rating	UL type 29 IEC Class C

Mechanical Loading

Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Hailstone Test	25mm Hailstone at the speed of 23m/s

Temperature Ratings (STC)

Temperature Coefficient of Isc	+0.050%/°C
Temperature Coefficient of Voc	-0.265%/°C
Temperature Coefficient of Pmax	-0.340%/°C



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Specifications included in this datasheet are subject to change without notice. LONGI reserves the right of final interpretation. (20211101V14)