TÜV Rheinland (Shanghai) Co., Ltd.
Solar & Commercial Products

Test Report

Photovoltaic Module Tests

according to Client's Requirements

TÜV Report No. CN24G2P3 001

Shanghai, September 2024

Test report No.: *Prüfbericht - Nr.:*	**CN24G2P3 001**		Page 2 / 15
Client (Customer No. + address): *Auftraggeber (Kunden-Nr. + Adresse):*	**Tongwei Co, Ltd.** No.588, Middle Section Tianfu Avenue, High-Tech Zone, Chengdu, China(Sichuan)Pilot Free Trade Zone,Chengdu, 610041 Sichuan P.R. China		
Test Item: *Gegenstand der Prüfung:*	Photovoltaic (PV) Module(s)	**Date of receipt:** *Eingangsdatum:*	03/09/2024
Identification: *Bezeichnung:*	TWMNF-66HD710		
Order No.: *Auftragsnummer:*	326052126	**Quotation No.:** *Angebotsnummer:*	P01625867
Testing location: *Prüfort:*	**TÜV Rheinland (Suzhou) Co., Ltd.** Building 14, Plainvim (Taicang) Modern Industrial Park, No. 525 South Lingang Road, Shaxi Town, Taicang, Suzhou, Jiangsu		
Test specification: *Prüfgrundlage:*	Refer to section 3 for test methodology		
Test Result: *Prüfergebnis:*	See section 5 for detailed results		

tested by / *geprüft:*			**reviewed by** / *kontrolliert:*		
25/09/2024	Project Engineer/ Daniel Wang		25/09/2024	Reviewer/ Wenyao Lu	
Date *Datum*	**Title/Name** *Titel/Name*	**Signature** *Unterschrift*	**Date** *Datum*	**Title/Name** *Titel/Name*	**Signature** *Unterschrift*

Other Aspects / *Sonstiges: N/A*.

TÜV Rheinland (Shanghai) Co., Ltd. * Inspection/Testing *

Abkürzungen:				*Abbreviations:*			
	P(ass)	=	*entspricht Prüfgrundlage*		*P(ass)*	=	*passed*
	F(ail)	=	*entspricht nicht Prüfgrundlage*		*F(ail)*	=	*failed*
	N/A	=	*nicht anwendbar*		*N/A*	=	*not applicable*
	N/T	=	*nicht getestet*		*N/T*	=	*not tested*

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.

Table of Content

1 General Information 5

2 Executive Summary 6

3 Test Methodology 7

3.1 Visual inspection 7

3.2 Maximum power determination 7

3.3 Electroluminescence 8

3.4 Insulation test 8

3.5 Wet leakage current test 9

3.6 Hail test 9

4 Sampling and Test Assignment 10

4.1 Sampling procedure 10

4.2 Module test assignment 10

5 Test Results 11

5.1 Visual inspection 11

5.2 Maximum power determination 11

5.3 Electroluminescence 11

5.4 Insulation test 11

5.5 Wet leakage current test 12

5.6 Hail test 12

5.6.1 Visual inspection after HI 12

5.6.2 Maximum power determination after HI 12

5.6.3 Electroluminescence after HI 13

5.6.4 Insulation test after HI 13

5.6.5 Wet leakage current test after HI 13

6 Annex 14

6.1 Annex 1: Photos of test module 14

6.2 Annex 2: EL-imaging 15

List of Tables

Table 1: Test result summary 6
Table 2: Measuring equipment for visual inspection 7
Table 3: Measuring equipment for maximum power determination 8
Table 4: Measurement related software for maximum power determination 8
Table 5: Module assignment 10

1 General Information

Date(s) of performance of tests： 13/09/2024 – 14/09/2024

Abbreviations used in this report:

Pmax	– Maximum power	Vmpp	– Maximum power point voltage
Impp	– Maximum power point current	Voc	– Open circuit voltage
Isc	– Short circuit current	FF	– Fill factor
VI	– Visual inspection	MPD	– Maximum power determination
EL	– Electroluminescence	INS	– Insulation test
WLC	– Wet leakage current test	HI	– Hail test

Possible test case verdicts:

- Test case does not apply to the test object ..... : N/A
- Test object does meet the requirement ..... : Pass (P)
- Test object does not meet the requirement..... : Fail (F)

Further Remarks

- The test verdicts presented in this report relate only to the test specimen.
- This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
- I-V curves are only included in this report if they show any deviations. If required, other I-V curves will be provided upon request.
- Any question in regard to this report, please contact TÜV Rheinland (Shanghai) Co., Ltd. within one week after report issued.
- Acceptance criteria mentioned in this report are provided by client.

2 Executive Summary

TÜV Rheinland has performed module tests for Tongwei Co, Ltd. at TÜV Rheinland (Suzhou) Co., Ltd.

Table 1: Test result summary

Test	Quantity	Results	Report no.
VI	1	See section 5.1 for details	CN24G2P3 001
MPD	1	See section 5.2 for details	
EL	1	See section 5.3 for details	
INS	1	See section 5.4 for details	
WLC	1	See section 5.5 for details	
Hail	1	See section 5.6 for details	

3 Test Methodology

3.1 Visual inspection

The Visual inspection is performed in accordance with IEC 61215-2: 2021, MQT 01 and comprises the verification of the following:

- Front of the module
  - Inclusions in the laminate
  - Inclusions in the glass
  - Broken cells
  - Scratches, bubbles or defects in the glass that may compromise the performance or safety of the module
  - Bubbles
  - Yellowing
  - Condition of the frame
  - Condition of welded parts
- Back of the module
  - Scratches or cuts in the back sheet
  - Any kind of bubbles or delamination
  - Bumps or depressions on the back sheet

Table 2: Measuring equipment for visual inspection

Device	Index no.	Measured variable	Application
Ruler	PV-273	Measure defects	Visual inspection

3.2 Maximum power determination

Maximum power determination test is performed in accordance with IEC 61215-2: 2021, MQT 02. Power measurements are performed with an AAA pulsed solar simulator in a dark chamber designed to reduce the impact of indirect light. Temperature correction is applied by using the temperature coefficient which was provided by the manufacturer. The measurement reproducibility is confined within ±0.8%, k=2. The described experimental setup shows a combined expanded measurement uncertainty, which is less than ±2.5%, k=2 under the commonly referred Standard Test Condition (as detailed in IEC 61215: 1000W/m², 25°C and AM1.5G)

Table 3: Measuring equipment for maximum power determination

Device	Index no.	Measured variable	Application
Pulsed solar load	PV-446	Current, voltage, irradiance	Pulsed solar simulator measurements
IR-sensor	PV-201 PV-202 PV-204 PV-211	Specimen temperature	Pulsed solar simulator measurements

Table 4: Measurement related software for maximum power determination

Program	Version no.	Date	Application
Pulsed Solar Simulator Software	HighLight-R2.4.5	02.06.2021	Operating software pulsed solar simulator

Statement of the estimated uncertainty of the test verdicts

- The verdicts of performance rating are only related to the test samples that were subjected to the tests.
- The STC measurement was performed with a pulsed solar simulator of Class AAA according to IEC60904-9: 2020. The extended measurement uncertainty is:
  - Uncertainty in P_{MAX} within ± 2.5 %, k=2
  - Uncertainty in I_{SC} within ± 2.4 %, k=2
  - Uncertainty in V_{OC} within ± 0.9 %, k=2

3.3 Electroluminescence

The electroluminescence test makes cracks and other cell related defects visible.

This test is to be performed referring to standard IEC TS 60904-13: 2018.

3.4 Insulation test

This test is to be performed referring to standard IEC 61215-2: 2021, MQT 03.

Acceptance criteria:

Measured insulation resistance times the area of the module shall not be less than 40 MΩ·m².

3.5 Wet leakage current test

This test is to be performed referring to standard IEC 61215-2: 2021, MQT 15.

Acceptance criteria:

Measured insulation resistance times the area of the module shall not be less than 40 MΩ·m².

3.6 Hail test

This test is to be performed referring to standard IEC 61215-2: 2021, MQT 17.

4 Sampling and Test Assignment

4.1 Sampling procedure

☐	Random sampling from production (e.g. during factory audit (FA) or inline inspection)
☐	Random sampling from the warehouse, container or transportation boxes
☒	Modules have been submitted by the manufacturer/ client without random sampling by TÜV Rheinland

4.2 Module test assignment

Table 5: Module assignment

Module manufacturer		Tongwei Co, Ltd.					
Module type		TWMNF-66HD710					
Module technology		Mono-crystalline N-TOPCon Bifacial half-cell c-Si Module, 132 pcs					
No.	**S/N**	**VI**	**MPD**	**EL**	**INS**	**WLC**	**Hail**
1	H5E247003000017	x	x	x	x	x	x
x: selected samples for test							
Supplementary information: N/A							

5 Test Results

5.1 Visual inspection

Test date [DD/MM/YYYY]	13/09/2024	
Sample #	Nature and position of findings	Verdict
1	No visual defect	P
Supplementary information: N/A.		

5.2 Maximum power determination

Test date [DD/MM/YYYY]			14/09/2024			
Module temperature [°C]			25 ± 1			
Irradiance [W/m²]			1000			
Sample #	Pmax [W]	Vmpp [V]	Impp [A]	Voc [V]	Isc [A]	FF [%]
1	713.6	41.89	17.036	48.84	18.088	80.8
Supplementary information: N/A.						

5.3 Electroluminescence

Test date [DD/MM/YYYY]	14/09/2024
Current applied	Isc ± 5%
Sample #	Remarks
1	No significant defect
Supplementary information: Refer to Annex 2: EL Imaging.	

5.4 Insulation test

Test date [DD/MM/YYYY]				14/09/2024		
Maximum system voltage [VDC]				1500		
High voltage applied [VDC]				8000		
Insulation resistance measured at [VDC]				1500		
Sample #	Measured	Area	Result*	Dielectric breakdown		Verdict
	GΩ	m²	GΩ·m²	Yes (description)	No	
1	50.00	3.11	155.50	—	No	P
* Pass criteria: No dielectric breakdown, insulation resistance shall be greater than 40 MΩ·m².						

5.5 Wet leakage current test

Test date [DD/MM/YYYY]	14/09/2024			
Insulation resistance measured at [VDC]	1500			
Solution resistivity [Ω·cm]	< 3500			
Solution temperature [°C]	22 ± 2			
Sample #	Measured	Area	Result	Verdict
	MΩ	m²	MΩ·m²	
1	5000.0	3.11	15550.0	P
Pass criteria: No dielectric breakdown, insulation resistance shall be greater than 40 MΩ·m².				

5.6 Hail test

Test date [DD/MM/YYYY]	14/09/2024	
Ice ball diameter [mm]	45	
Ice ball mass [g]	43.9 ± 5 %	
Ice ball velocity [m/s]	30.7 ± 5 %	
Number of impact locations	11	
Sample #	—	Verdict
1	—	P
Supplementary information: N/A.		

5.6.1 Visual inspection after HI

Test date [DD/MM/YYYY]	14/09/2024	
Sample #	Nature and position of findings	Verdict
1	No visual defect	P
Supplementary information: N/A.		

5.6.2 Maximum power determination after HI

Test date [DD/MM/YYYY]	14/09/2024							
Module temperature [°C]	25 ± 1							
Irradiance [W/m²]	1000							
Sample #	Pmax[W]	Vmpp [V]	Impp [A]	Voc [V]	Isc [A]	FF [%]	Degradation [%]	Verdict
1	711.9	41.70	17.071	48.87	18.080	80.6	-0.24%	P
Supplementary information: N/A.								

5.6.3 Electroluminescence after HI

Test date [DD/MM/YYYY]	14/09/2024
Current applied	Isc ± 5%
Sample #	Remarks
1	No significant defect
Supplementary information: Refer to Annex 2: EL Imaging.	

5.6.4 Insulation test after HI

Test date [DD/MM/YYYY]				14/09/2024		
Maximum system voltage [VDC]				1500		
High voltage applied [VDC]				8000		
Insulation resistance measured at [VDC]				1500		
Sample #	Measured	Area	Result*	Dielectric breakdown		Verdict
	GΩ	m²	GΩ·m²	Yes (description)	No	
1	50.00	3.11	155.50	—	No	P
* Pass criteria: No dielectric breakdown, insulation resistance shall be greater than 40 MΩ·m².						

5.6.5 Wet leakage current test after HI

Test date [DD/MM/YYYY]	14/09/2024			
Insulation resistance measured at [VDC]	1500			
Solution resistivity [Ω·cm]	< 3500			
Solution temperature [°C]	22 ± 2			
Sample #	Measured	Area	Result	Verdict
	MΩ	m²	MΩ·m²	
1	5000.0	3.11	15550.0	P
Pass criteria: No dielectric breakdown, insulation resistance shall be greater than 40 MΩ·m².				

6 Annex

6.1 Annex 1: Photos of test module



Figure 1: Front view of module TWMNF-66HD710



Figure 2: Rear view of module TWMNF-66HD710

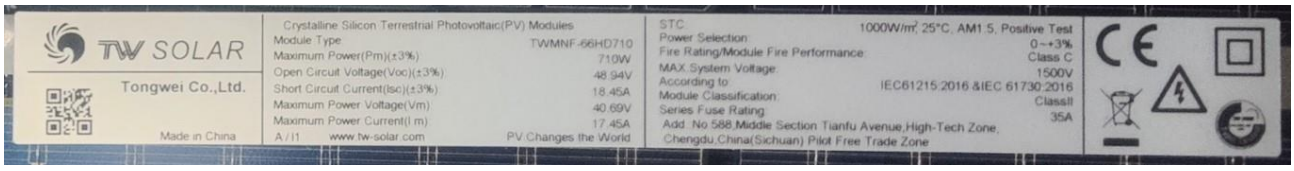


Figure 3: Rating label of module type TWMNF-66HD710



Figure 4: Junction boxes of module type TWMNF-66HD710

6.2 Annex 2: EL-imaging

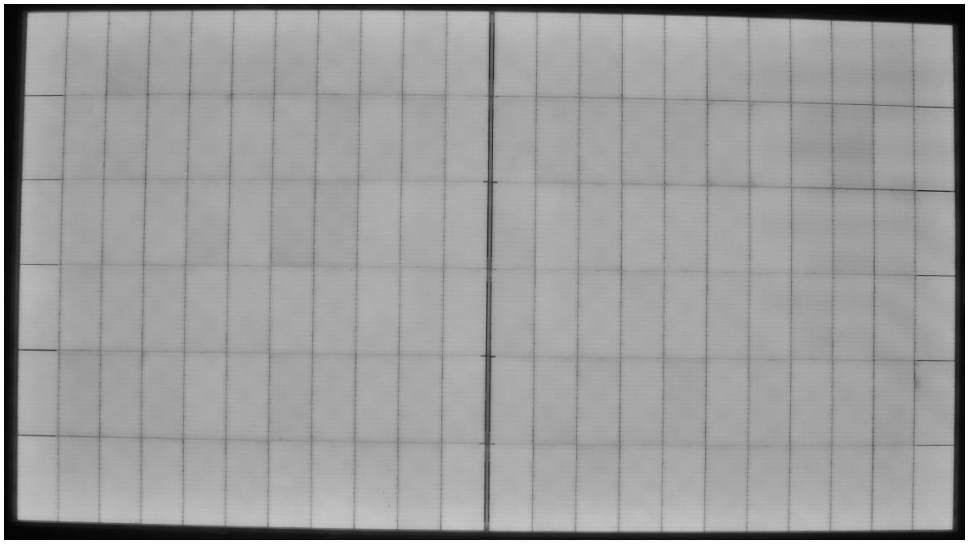


Figure 5: EL-image of sample no. 1 (initial)

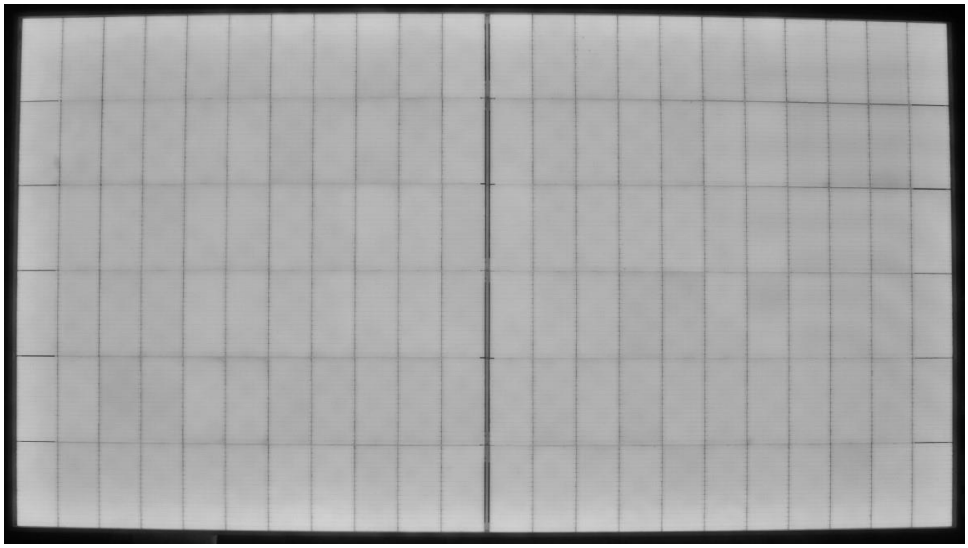


Figure 6: EL-image of sample no. 1 (after Hail test)

End of Test Report CN24G2P3 001