HIGHLY ACCELERATED LIFE AND EXTENDED RELIABILITY TESTING REPORT

Philadelphia Solar

SOLAR MODULE: PS-MNB144(HCBF)-580W

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EVALUATION OF
PS-MNB144(HCBF)-580W

RENDERED by

Philadelphia Solar

Date of receipt of the test item: December 19, 2023

Date of performance of the test item: December 19, 2023 to June 19, 2024

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Date of issue : June 19, 2024

Contents

Executive Summary

Philadelphia Solar contracted Intertek Testing Services Shanghai (Intertek) to perform highly accelerated life testing (HALT) and extended reliability testing, on the model PS-MNB144(HCBF)-580W and crystalline silicon module and evaluate the characterization under HALT. The testing program is shown on page 8.

General Product Information

Description of module construction:			
Model	Size of Module (mm)	Cell technology	No. of cells
PS-MNB144(HCBF)-580W	2277*1133*35	N Type, Bifacial Mono Crystalline Topcon solar cell with 16 busbars	144

Product Electrical Rating:					
Model No.	Voc (V)	Isc (Amps)	Pmp (W)	Vmp (V)	Imp (Amps)
PS-MNB144(HCBF)-580W	51.65	14.1	580	43.64	13.33

List of Test Samples

List of test samples			
Sample No.	Series No.	Type / model	Remark
0231219-05-2	PS111223BN144000418	PS-MNB144(HCBF)-580W	Thermal Cycling Test
0231219-05-3	PS111223BN144000438	PS-MNB144(HCBF)-580W	Thermal Cycling Test
0231219-05-4	PS111223BN144000436	PS-MNB144(HCBF)-580W	Damp Heat Test
0231219-05-5	PS111223BN144000437	PS-MNB144(HCBF)-580W	Damp Heat Test
0231219-05-6	PS111223BN144000413	PS-MNB144(HCBF)-580W	Backsheet durability test
0231219-05-7	PS111223BN144000460	PS-MNB144(HCBF)-580W	Backsheet durability test
0231219-05-8	PS111223BN144000420	PS-MNB144(HCBF)-580W	Mechanical Stress Sequence
0231219-05-9	PS111223BN144000421	PS-MNB144(HCBF)-580W	Mechanical Stress Sequence
0231219-05-10	PS111223BN144000422	PS-MNB144(HCBF)-580W	PID
0231219-05-11	PS111223BN144000459	PS-MNB144(HCBF)-580W	PID
0231219-05-12	PS111223BN144000419	PS-MNB144(HCBF)-580W	PID
0231219-05-13	PS111223BN144000434	PS-MNB144(HCBF)-580W	PID
0231219-05-14	PS111223BN144000440	PS-MNB144(HCBF)-580W	LeTID
0231219-05-15	PS111223BN144000426	PS-MNB144(HCBF)-580W	LeTID
0231219-05-16	PS111223BN144000414	PS-MNB144(HCBF)-580W	Hail Test
0231219-05-17	PS111223BN144000409	PS-MNB144(HCBF)-580W	Hail Test
0231219-05-18	PS111223BN144000456	PS-MNB144(HCBF)-580W	PAN File & IAM
0231219-05-20	PS111223BN144000410	PS-MNB144(HCBF)-580W	UVID test
0231219-05-21	PS111223BN144000415	PS-MNB144(HCBF)-580W	UVID test
0231219-05-22	PS111223BN144000416	PS-MNB144(HCBF)-580W	Field Exposure
0231219-05-23	PS111223BN144000427	PS-MNB144(HCBF)-580W	Field Exposure
0231219-05-24	PS111223BN144000428	PS-MNB144(HCBF)-580W	Field Exposure
0231219-05-25	PS111223BN144000439	PS-MNB144(HCBF)-580W	Field Exposure

Testing Standard Description

Tests performed (name of test and test clause)	
Tests	Standard
Visual inspection	IEC 61215-2: 2021 Ed. 1.0 Cl. 4.1 IEC TS 63209-1-2021, Cl. 5.3
Maximum power determination	IEC 61215-2: 2021 Ed. 1.0 Cl. 4.2
Insulation test	IEC 61215-2: 2021 Ed. 1.0 Cl. 4.3
Wet leakage current test	IEC 61215-2: 2021 Ed. 1.0 Cl. 4.15
Temperature cycling test	IEC TS 63209-1-2021, Cl. 6.3
Damp heat test	IEC TS 63209-1-2021, Cl. 6.5
Backsheet durability test	IEC TS 63209-1-2021, Cl. 6.5
UVID test	IEC 61215-2: 2021 Ed. 1.0 Cl. 4.10
Potential Induced Degradation test	IEC TS 62804-1:2015 Ed. 1.0
Mechanical Stress Sequence	IEC TS 63209-1-2021, Cl. 6.4
LeTID	IEC TS 63342: 2022
Bypass diode functionality test	IEC 61215-2: 2021 Ed. 2.0 Cl. 4.18.2
Stabilization	IEC 61215-2: 2021 Ed. 2.0 Cl.4.19
Hail Test	IEC 61215-2: 2021 Ed. 2.0 Cl.4.17
Field Exposure	IEC 61215-2: 2021 Ed. 2.0 Cl.4.8

Supplementary information:

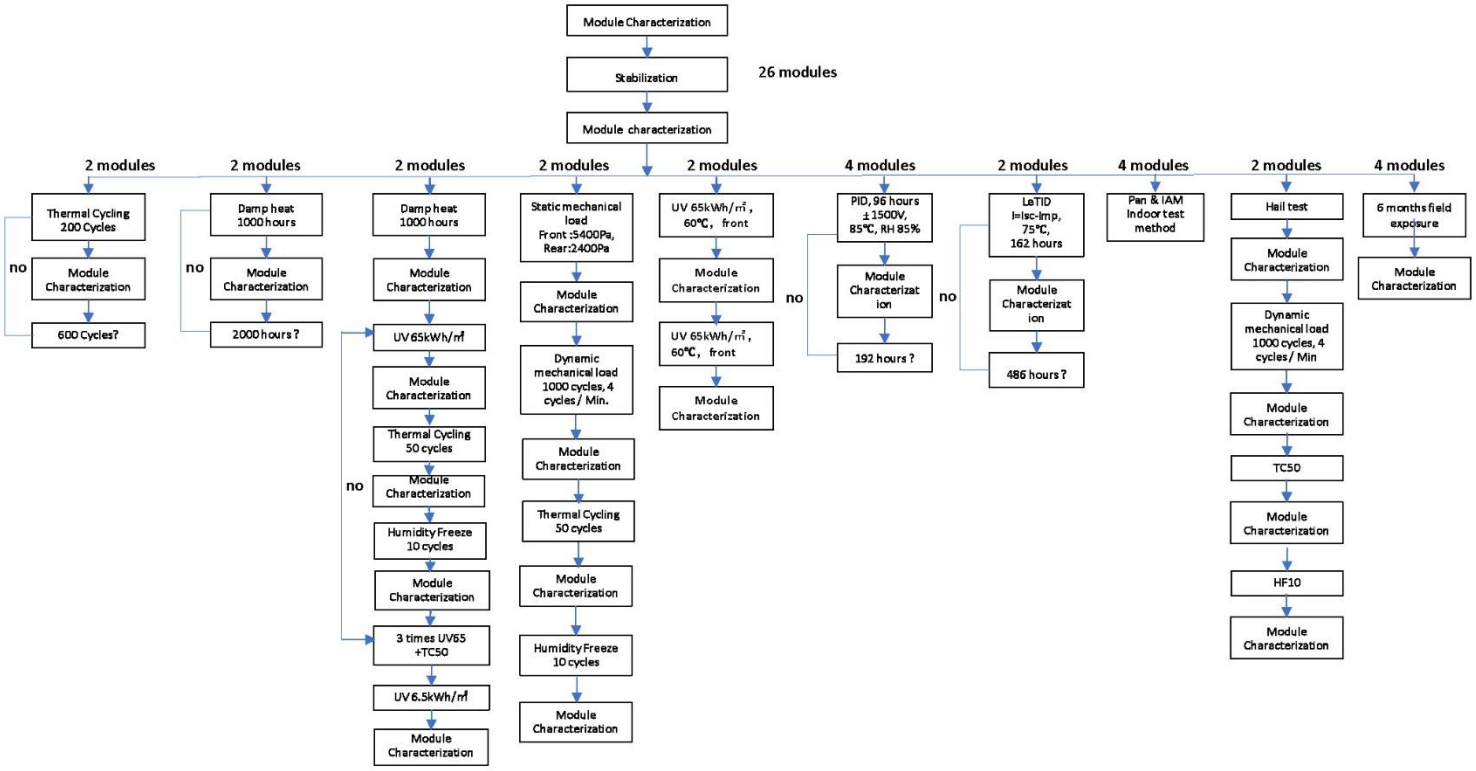
1. Stabilization: test was performed under simulate irradiance, total irradiation for TC and DH samples should ⩾40 kWh/m2, no need stabilization for Backsheet durability test and Field Exposure.
2. Low irradiance is 200W/m^2,
3. Performance at BNPI means module was measured on the front side at equivalent irradiance levels corresponding to 1000 W·m^{-2} on the front side plus 135W/m^2 rear side irradiance levels G_{Ri}. The equivalent irradiance levels are determined as functions of the bifaciality coefficient φ according to the equation below:

$$G_{BNPI} = 1000\ W \cdot m^{-2} + \varphi \cdot 135W \cdot m^{-2}$$

$$\varphi = Min(\varphi_{Isc}, \varphi_{Pmax})$$

4. Backsheet durability test and UVID test: UV irradiance: 150~170W/m^2, module temperature: 60 ± 5 °C.
5. Static mechanical load test: fixed with 4 clamps at outer mounting hole location, distance from centerline of the mounting clamp to the short side is 569mm. Test load: front (downward) 5400Pa, rear (upward) 2400Pa, 3 cycles.
6. Dynamic mechanical load test: mounted as same as static mechanical load test, 1000 cycles, 4 cycles / Min. Both positive and negative load: 1000 Pa.
7. Potential Induced Degradation test: +1500V and -1500V, 85℃±2℃ and Rh 85%±3%, 96 hours per cycle, 2 cycles.
8. Hail test: ice ball diameter: 55mm±5%, Mass 80.2g±5%, velocity 33.9±5%, 11 impact locations according to requirement of IEC 61215: 2021 Cl.4.17
9. Stabilizatioin: indoor Method, irradiance 800~1000w/m^2.
10. Field Exposure: 4 modules were mounted on an open rack, tilt angle is 35 degrees, and connected to MPPT, 6 months test from December 19, 2023 to June 19, 2024

Testing Program



1. Stabilization

1.1. Initial Visual inspection

Test Date [YYYY-MM-DD]..... :	2023-12-19	—
Sample #	Nature and position of initial findings – comments or attach photos	—
0231219-05-2	No major visible defect	PASS
0231219-05-3	No major visible defect	PASS
0231219-05-4	No major visible defect	PASS
0231219-05-5	No major visible defect	PASS
0231219-05-6	No major visible defect	PASS
0231219-05-7	No major visible defect	PASS
0231219-05-8	No major visible defect	PASS
0231219-05-9	No major visible defect	PASS
0231219-05-10	No major visible defect	PASS
0231219-05-11	No major visible defect	PASS
0231219-05-12	No major visible defect	PASS
0231219-05-13	No major visible defect	PASS
0231219-05-14	No major visible defect	PASS
0231219-05-15	No major visible defect	PASS
0231219-05-16	No major visible defect	PASS
0231219-05-17	No major visible defect	PASS
0231219-05-18	No major visible defect	PASS
0231219-05-20	No major visible defect	PASS
0231219-05-21	No major visible defect	PASS
0231219-05-22	No major visible defect	PASS
0231219-05-23	No major visible defect	PASS
0231219-05-24	No major visible defect	PASS
0231219-05-25	No major visible defect	PASS
Supplementary information: NA		

1.2. Performance at STC before initial stabilization (front side)

Test Date [YYYY-MM-DD] .....:	2023-12-19						—
Test method.....:	■ Simulator ☐ Natural sunlight						—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0231219-05-2	52.561	44.923	13.437	12.826	576.171	81.58	—
0231219-05-3	52.394	44.548	13.485	12.856	572.732	81.06	—
0231219-05-4	52.511	44.794	13.462	12.840	575.144	81.36	—

0231219-05-5	52.285	44.577	13.487	12.881	574.190	81.42	—
0231219-05-8	52.447	44.847	13.503	12.829	575.331	81.24	—
0231219-05-9	52.451	44.849	13.509	12.829	575.376	81.20	—
0231219-05-10	52.488	44.842	13.471	12.839	575.720	81.42	—
0231219-05-11	52.378	44.648	13.477	12.869	574.572	81.40	—
0231219-05-12	52.340	44.657	13.463	12.828	572.866	81.30	—
0231219-05-13	52.465	44.875	13.443	12.820	575.293	81.57	—
0231219-05-14	52.301	44.542	13.473	12.857	572.684	81.27	—
0231219-05-15	52.356	44.621	13.441	12.830	572.478	81.35	—
0231219-05-16	52.332	44.361	13.494	12.909	572.665	81.09	—
0231219-05-17	52.603	44.587	13.465	12.870	573.853	81.02	—
0231219-05-18	52.483	44.835	13.486	12.864	576.769	81.49	—
0231219-05-20	52.411	44.731	13.459	12.848	574.721	81.48	—
0231219-05-21	52.465	44.705	13.442	12.834	573.733	81.36	—
Supplementary information: NA							

1.3. Performance at STC before initial stabilization (back side)

Test Date [YYYY-MM-DD] .....:	2023-12-19						—
Test method .....:	■ Simulator ☐ Natural sunlight						—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0231219-05-2	51.987	44.832	10.398	8.342	373.980	69.18	—
0231219-05-3	52.089	45.361	10.413	8.336	378.146	69.72	—
0231219-05-4	51.997	44.775	10.683	8.358	374.234	67.37	—
0231219-05-5	52.034	44.812	10.641	8.353	374.310	67.60	—
0231219-05-8	51.846	44.799	12.114	8.324	372.899	59.38	—
0231219-05-9	51.918	44.877	11.684	8.321	373.417	61.56	—
0231219-05-10	51.965	44.827	10.445	8.353	374.427	68.98	—
0231219-05-11	52.019	44.778	10.703	8.342	373.549	67.10	—
0231219-05-12	51.982	44.806	10.665	8.366	374.827	67.61	—
0231219-05-13	52.046	44.788	10.694	8.360	374.429	67.27	—
0231219-05-14	51.984	44.815	10.429	8.350	374.219	69.03	—
0231219-05-15	51.941	46.033	11.054	8.384	385.937	67.22	—
0231219-05-16	52.048	46.106	10.941	8.316	383.395	67.33	—
0231219-05-17	52.083	46.052	10.763	8.237	379.346	67.67	—
0231219-05-18	51.981	45.803	10.944	9.288	425.402	74.78	—
0231219-05-20	52.162	44.747	10.571	8.318	372.221	67.50	—

0231219-05-21	52.167	44.743	10.574	8.307	371.696	67.39	—
Supplementary information: NA							

1.4. Performance at BNPI before initial stabilization

Test Date [YYYY-MM-DD] .....:	2023-12-19	—
Test method .....:	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0231219-05-2	52.634	44.817	14.609	13.947	625.050	81.29	—
0231219-05-3	52.652	44.702	14.637	13.942	623.221	80.87	—
0231219-05-4	52.694	44.895	14.636	13.940	625.839	81.15	—
0231219-05-5	52.450	44.555	14.684	14.015	624.430	81.08	—
0231219-05-8	52.733	44.881	14.599	13.936	625.437	81.24	—
0231219-05-9	52.737	44.858	14.602	13.945	625.560	81.24	—
0231219-05-10	52.689	44.926	14.637	13.941	626.322	81.22	—
0231219-05-11	52.565	44.772	14.619	13.931	623.724	81.17	—
0231219-05-12	52.626	44.788	14.633	13.951	624.852	81.14	—
0231219-05-13	52.637	44.930	14.645	13.960	627.232	81.37	—
0231219-05-14	52.550	44.637	14.619	13.944	622.440	81.02	—
0231219-05-15	52.560	44.663	14.582	13.927	622.035	81.16	—
0231219-05-16	52.477	44.538	14.665	13.998	623.445	81.01	—
0231219-05-17	52.699	44.747	14.626	13.949	624.176	80.98	—
0231219-05-18	52.880	45.071	14.614	13.956	629.015	81.39	—
0231219-05-20	52.575	44.758	14.646	13.985	625.940	81.29	—
0231219-05-21	52.647	44.815	14.620	13.936	624.549	81.14	—
Supplementary information: NA							

1.5. Initial Stabilization procedure

Light exposure method .....:	■ Simulator ☐ Natural sunlight
Abbreviation: Regarding light source “S” for Solar simulator and “N” for Natural sunlight	
Stabilization criterion x per IEC 61215-1-x .....:	0.01

Sample #	0231219-05-2	Test Date (YYYY-MM-DD) start/end ..... :	2023-12-19 / 2024-01-02

Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	576.171	—	—

1	20	800-1000	50±10	Micro inverter	575.281	—	—
2	20	800-1000	50±10	Micro inverter	575.272	0.16	Yes

Sample #	0231219-05-3	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	572.732	—	—
1	20	800-1000	50±10	Micro inverter	570.070	—	—
2	20	800-1000	50±10	Micro inverter	569.852	0.50	Yes

Sample #	0231219-05-4	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	575.144	—	—
1	20	800-1000	50±10	Micro inverter	574.535	—	—
2	20	800-1000	50±10	Micro inverter	574.481	0.12	Yes

Sample #	0231219-05-5	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	574.190	—	—
1	20	800-1000	50±10	Micro inverter	573.743	—	—
2	20	800-1000	50±10	Micro inverter	573.063	0.20	Yes
Sample #	0231219-05-8	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	575.331	—	—
1	5	800-1000	50±10	Micro inverter	575.190	—	—
2	5	800-1000	50±10	Micro inverter	575.026	0.05	yes
Sample #	0231219-05-9	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)

Initial	—	—	—	—	575.376	—	—
1	5	800-1000	50±10	Micro inverter	575.325	—	—
2	5	800-1000	50±10	Micro inverter	575.055	0.06	yes
Sample #	0231219-05-10	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	575.720	—	—
1	5	800-1000	50±10	Micro inverter	575.651	—	—
2	5	800-1000	50±10	Micro inverter	575.295	0.07	yes
Sample #	0231219-05-11	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	574.572	—	—
1	5	800-1000	50±10	Micro inverter	574.130	—	—
2	5	800-1000	50±10	Micro inverter	574.013	0.10	yes
Sample #	0231219-05-12	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	572.866	—	—
1	5	800-1000	50±10	Micro inverter	572.651	—	—
2	5	800-1000	50±10	Micro inverter	572.275	0.10	yes
Sample #	0231219-05-13	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	(Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	575.293	—	—
1	5	800-1000	50±10	Micro inverter	574.769	—	—
2	5	800-1000	50±10	Micro inverter	574.301	0.17	yes
Sample #	0231219-05-14	Test Date (YYYY-MM-DD) start/end ..... :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)

Initial	—	—	—	—	572.684	—	—
1	5	800-1000	50±10	Micro inverter	572.602	—	—
2	5	800-1000	50±10	Micro inverter	571.543	0.20	yes

Sample #	0231219-05-15	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	572.478	—	—
1	5	800-1000	50±10	Micro inverter	572.154	—	—
2	5	800-1000	50±10	Micro inverter	570.923	0.27	yes

Sample #	0231219-05-16	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	572.665	—	—
1	5	800-1000	50±10	Micro inverter	571.056	—	—
2	5	800-1000	50±10	Micro inverter	570.289	0.42	yes

Sample #	0231219-05-17	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	573.853	—	—
1	5	800-1000	50±10	Micro inverter	573.772	—	—
2	5	800-1000	50±10	Micro inverter	572.631	0.21	yes
Sample #	0231219-05-18	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	576.769	—	—
1	5	800-1000	50±10	Micro inverter	575.342	—	—
2	5	800-1000	50±10	Micro inverter	575.277	0.26	yes
Sample #	0231219-05-20	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		

Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	574.721	—	—
1	5	800-1000	50±10	Micro inverter	574.465	—	—
2	5	800-1000	50±10	Micro inverter	573.390	0.23	yes
Sample #	0231219-05-21	Test Date (YYYY-MM-DD) start/end :			2023-12-19 / 2024-01-02		
Test cycle	Integrated irradiation (kWh/m2)	Irradiance (W/m2)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	573.733	—	—
1	5	800-1000	50±10	Micro inverter	572.624	—	—
2	5	800-1000	50±10	Micro inverter	571.758	0.34	yes
Supplementary information: Integrated irradiation for TC sequence and DH sequence is no less than 40kWh/m^2							

1.6. Performance at STC after initial stabilization

Test Date [YYYY-MM-DD]..... :	2024-01-02	—
Test method..... :	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0231219-05-2	52.537	44.893	13.432	12.814	575.272	81.52	—
0231219-05-3	52.144	44.270	13.461	12.872	569.852	81.18	—
0231219-05-4	52.528	44.825	13.437	12.816	574.481	81.39	—
0231219-05-5	52.230	44.520	13.478	12.872	573.063	81.41	—
0231219-05-8	52.448	44.833	13.503	12.826	575.026	81.20	—
0231219-05-9	52.449	44.847	13.511	12.823	575.055	81.15	—
0231219-05-10	52.456	44.808	13.467	12.839	575.295	81.44	—
0231219-05-11	52.358	44.642	13.467	12.858	574.013	81.41	—
0231219-05-12	52.317	44.628	13.458	12.823	572.275	81.28	—
0231219-05-13	52.358	44.744	13.460	12.835	574.301	81.49	—
0231219-05-14	52.372	44.637	13.419	12.804	571.543	81.32	—
0231219-05-15	52.303	44.563	13.426	12.812	570.923	81.30	—
0231219-05-16	52.469	44.566	13.382	12.797	570.289	81.22	—
0231219-05-17	52.533	44.470	13.472	12.877	572.631	80.91	—
0231219-05-18	52.496	44.814	13.449	12.837	575.277	81.48	—
0231219-05-20	52.306	44.594	13.466	12.858	573.390	81.41	—

0231219-05-21	52.483	44.734	13.392	12.781	571.758	81.35	—
Supplementary information: NA							

1.7. Performance at STC after initial stabilization (back side)

Test Date [YYYY-MM-DD]..... :			2024-01-02				—
Test method ..... :			■ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0231219-05-2	52.006	44.775	10.674	8.347	373.751	67.33	—
0231219-05-3	52.068	45.354	10.373	8.342	378.331	70.05	—
0231219-05-4	52.030	44.805	10.654	8.352	374.217	67.51	—
0231219-05-5	52.043	44.810	10.627	8.350	374.144	67.65	—
0231219-05-8	51.846	44.798	12.110	8.327	373.016	59.41	—
0231219-05-9	51.921	44.864	11.700	8.321	373.322	61.45	—
0231219-05-10	52.052	44.778	10.691	8.344	373.636	67.14	—
0231219-05-11	52.029	44.777	10.700	8.340	373.436	67.08	—
0231219-05-12	51.993	44.785	10.716	8.355	374.166	67.15	—
0231219-05-13	52.005	44.781	10.714	8.348	373.828	67.09	—
0231219-05-14	52.031	44.787	10.510	8.351	374.023	68.39	—
0231219-05-15	51.973	46.018	11.151	8.384	385.796	66.57	—
0231219-05-16	52.062	46.104	10.944	8.313	383.254	67.27	—
0231219-05-17	52.051	46.064	10.685	8.193	377.383	67.86	—
0231219-05-18	51.959	45.818	10.942	9.284	425.375	74.82	—
0231219-05-20	52.185	44.745	10.574	8.316	372.104	67.43	—
0231219-05-21	52.138	44.739	10.573	8.298	371.253	67.35	—
Supplementary information: NA							

1.8. Performance at BNPI after initial stabilization

Test Date [YYYY-MM-DD]..... :			2024-01-02				—
Test method ..... :			■ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0231219-05-2	52.620	14.617	44.807	13.933	624.290	81.17	—
0231219-05-3	52.426	14.654	44.448	13.962	620.579	80.78	—
0231219-05-4	52.699	14.613	44.878	13.928	625.051	81.17	—
0231219-05-5	52.472	14.663	44.587	13.988	623.690	81.06	—
0231219-05-8	52.733	14.595	44.869	13.937	625.357	81.25	—
0231219-05-9	52.734	14.597	44.864	13.940	625.429	81.25	—

0231219-05-10	52.676	14.629	44.900	13.940	625.900	81.23	—
0231219-05-11	52.524	14.620	44.650	13.949	622.808	81.11	—
0231219-05-12	52.605	14.641	44.748	13.963	624.794	81.12	—
0231219-05-13	52.621	14.639	44.885	13.966	626.876	81.38	—
0231219-05-14	52.571	14.597	44.674	13.922	621.935	81.04	—
0231219-05-15	52.533	14.560	44.644	13.904	620.735	81.15	—
0231219-05-16	52.737	14.536	44.876	13.874	622.603	81.22	—
0231219-05-17	52.593	14.669	44.627	13.975	623.658	80.84	—
0231219-05-18	52.878	45.071	14.611	13.954	628.921	81.40	—
0231219-05-20	52.596	14.624	44.761	13.962	624.940	81.25	—
0231219-05-21	52.668	14.605	44.795	13.935	624.233	81.15	—
Supplementary information: NA							

1.9. Performance at Low irradiance (200w/m^2) after initial stabilization

Test Date [YYYY-MM-DD]..... :	2024-01-02	—
Test method ..... :	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0231219-05-2	49.527	2.742	42.777	2.619	112.038	82.51	—
0231219-05-3	49.535	2.742	42.750	2.621	112.032	82.47	—
0231219-05-4	49.490	2.669	42.743	2.547	108.858	82.41	—
0231219-05-5	49.491	2.669	42.730	2.549	108.933	82.46	—
0231219-05-8	49.554	2.671	42.762	2.553	109.155	82.47	—
0231219-05-9	49.551	2.667	42.760	2.547	108.920	82.43	—
0231219-05-10	49.409	2.647	42.458	2.534	107.569	82.26	—
0231219-05-11	49.549	2.667	42.770	2.547	108.956	82.44	—
0231219-05-12	49.381	2.647	42.425	2.536	107.570	82.30	—
0231219-05-13	49.551	2.667	42.760	2.547	108.920	82.43	—
0231219-05-14	49.543	2.667	42.766	2.548	108.961	82.46	—
0231219-05-15	49.500	2.666	42.736	2.546	108.820	82.47	—
0231219-05-16	49.554	2.671	42.762	2.553	109.155	82.47	—
0231219-05-17	49.554	2.666	42.761	2.548	108.945	82.46	—
0231219-05-18	49.629	42.83	2.677	2.556	109.486	82.4	—
0231219-05-20	49.549	2.668	42.750	2.548	108.946	82.40	
0231219-05-21	49.543	2.667	42.766	2.548	108.961	82.46	—
Supplementary information: NA							

2. Thermal Cycling Test

2.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
PS-MNB144(HCBF)-580W	0231219-05-2	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-3	No major visible defect	Pass

2.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m²]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass
Post-TC200 Testing Data		0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass
Post-TC400 Testing Data		0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass
Post-TC600 Testing Data		0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

2.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data					
Size of the module: 2.58 [m²]					
Test Voltage applied: 1500 [V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass
Post-TC200 Testing Data		0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass
Post-TC400 Testing Data		0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass
Post-TC600 Testing Data		0231219-05-2	10	15.5	Pass
		0231219-05-3	10	15.5	Pass

Supplementary information: Maximum resistance measurement range is 10GΩ.

2.4. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-2				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.537	44.893	13.432	12.814	575.272	81.52	—
Pre-HALT Testing Data-Rear Side	52.006	44.775	10.674	8.347	373.751	67.33	—
Pre-HALT Testing Data-BNPI	52.620	44.807	14.617	13.933	624.290	81.17	—
Post-TC200 Testing Data-Front Side	52.187	44.325	13.463	12.871	570.498	81.20	-0.83
Post-TC200 Testing Data-Rear Side	51.808	44.850	11.804	8.265	370.700	60.62	-0.82
Post-TC200 Testing Data-BNPI	52.204	44.117	14.629	13.984	616.934	80.79	-1.18
Post-TC400 Testing Data-Front Side	52.345	44.738	13.370	12.630	565.027	80.73	-1.78
Post-TC400 Testing Data-Rear Side	51.790	44.819	11.769	8.182	366.701	60.16	-1.89
Post-TC400 Testing Data-BNPI	52.633	44.799	14.291	13.626	610.420	81.16	-2.22
Post-TC600 Testing Data-Front Side	52.335	44.753	13.317	12.534	560.928	80.48	-2.49
Post-TC600 Testing Data-Rear Side	51.772	44.788	11.760	8.126	363.959	59.78	-2.62
Post-TC600 Testing Data-BNPI	52.620	44.794	14.145	13.482	603.891	81.13	-3.27

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-3				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]

Pre-HALT Testing Data-Front Side	52.144	44.270	13.461	12.872	569.852	81.18	—
Pre-HALT Testing Data-Rear Side	52.068	45.354	10.373	8.342	378.331	70.05	—
Pre-HALT Testing Data-BNPI	52.426	44.448	14.654	13.962	620.579	80.78	—
Post-TC200 Testing Data-Front Side	52.065	44.230	13.504	12.874	569.399	80.98	-0.08
Post-TC200 Testing Data-Rear Side	52.043	45.395	10.238	8.264	375.149	70.41	-0.84
Post-TC200 Testing Data-BNPI	52.369	44.372	14.659	13.983	620.464	80.82	-0.02
Post-TC400 Testing Data-Front Side	52.294	44.414	13.398	12.747	566.152	80.80	-0.65
Post-TC400 Testing Data-Rear Side	51.692	45.286	10.499	8.262	374.150	68.94	-1.11
Post-TC400 Testing Data-BNPI	52.525	44.405	14.564	13.851	615.043	80.40	-0.89
Post-TC600 Testing Data-Front Side	52.376	44.798	13.292	12.546	562.040	80.73	-1.37
Post-TC600 Testing Data-Rear Side	51.689	45.271	10.585	8.259	373.894	68.34	-1.17
Post-TC600 Testing Data-BNPI	52.662	44.828	14.288	13.638	611.372	81.25	-1.48

2.5. Performance at Low irradiance (200w/m^2) Post HALT test

Test Date [YYYY-MM-DD]..... :	2024-04-30	—
Test method ..... :	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0231219-05-2	49.471	42.698	2.667	2.548	108.778	82.45	-2.91
0231219-05-3	49.327	42.482	2.666	2.545	108.105	82.21	-3.51

2.6. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data		
Sample No.	Diode No.	Pass/Fail

	D1	D2	D3	
0231219-05-2	Yes	Yes	Yes	Pass
0231219-05-3	Yes	Yes	Yes	Pass

3. Damp Heat Test

3.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
PS-MNB144(HCBF)-580W	0231219-05-4	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-5	No major visible defect	Pass

3.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-4	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-5	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-4	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-5	10	15.5	Pass
Post-DH2000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-4	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-5	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

3.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 1500 [V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-4	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-5	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-4	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-5	10	15.5	Pass
Post-DH2000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-4	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-5	10	15.5	Pass

Supplementary information: Maximum resistance measurement range is 10GΩ.

3.4. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-4				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.528	44.825	13.437	12.816	574.481	81.39	—
Pre-HALT Testing Data-Rear Side	52.030	44.805	10.654	8.352	374.217	67.51	—
Pre-HALT Testing Data-BNPI	52.699	44.878	14.613	13.928	625.051	81.17	—
Post-DH1000 Testing Data-Front Side	52.441	43.024	13.452	12.814	551.301	78.15	-4.03
Post-DH1000 Testing Data-Rear Side	52.152	45.568	10.273	8.281	377.337	70.43	0.83
Post-DH1000 Testing Data-BNPI	52.502	43.065	14.671	13.924	599.624	77.85	-4.07
Post- DH2000 Testing Data-Front Side	52.553	42.152	13.111	12.496	526.718	76.45	-8.31
Post- DH2000 Testing Data-Rear Side	52.111	45.543	10.045	8.143	370.844	70.85	-0.90
Post- DH2000 Testing Data-BNPI	52.785	41.910	14.220	13.592	569.625	75.89	-8.87

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-5				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.230	44.520	13.478	12.872	573.063	81.41	—
Pre-HALT Testing Data-Rear Side	52.043	44.810	10.627	8.350	374.144	67.65	—
Pre-HALT Testing Data-BNPI	52.472	44.587	14.663	13.988	623.690	81.06	—

Post-DH1000 Testing Data-Front Side	52.348	43.365	13.457	12.791	554.684	78.74	-3.21
Post-DH1000 Testing Data-Rear Side	52.035	45.518	10.267	8.289	377.301	70.62	0.84
Post-DH1000 Testing Data-BNPI	52.637	43.348	14.615	13.911	603.014	78.39	-3.32
Post- DH2000 Testing Data-Front Side	52.102	42.965	13.190	12.562	539.720	78.53	-5.82
Post- DH2000 Testing Data-Rear Side	51.977	45.438	10.216	8.324	378.232	71.23	1.09
Post- DH2000 Testing Data-BNPI	52.420	43.278	14.297	13.580	587.702	78.42	-5.77

3.5. Performance at Low irradiance (200w/m^2) Post HALT test

Test Date [YYYY-MM-DD]..... :	2024-04-02	—
Test method ..... :	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0231219-05-4	49.709	42.411	2.617	2.499	105.980	81.45	-2.64
0231219-05-5	49.563	42.405	2.617	2.500	105.993	81.73	-2.70

3.6. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data				
Sample No.	Diode No.			Pass/Fail
	D1	D2	D3	
0231219-05-4	Yes	Yes	Yes	Pass
0231219-05-5	Yes	Yes	Yes	Pass

4. Backsheet Durability Test

4.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
Pre-HALT Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-DH1000 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-UV 65 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post- TC50 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-HF10 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-UV 130 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post- TC100 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-HF20 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-UV 195 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post- TC150 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-HF30 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass
Post-UV 6.5 Testing Data	0231219-05-6	No major visible defect	Pass
	0231219-05-7	No major visible defect	Pass

4.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 65 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post- TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 130 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post- TC100 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-HF20 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 195 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post- TC150 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-HF30 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 6.5 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

4.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data				
Size of the module: 2.58 [m^2]				
Test Voltage applied: 1500 [V]				
Data	Model	Sample No.	Insulation Resistance	Pass/Fail

			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 65 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post- TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 130 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post- TC100 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-HF20 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 195 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post- TC150 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-HF30 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Post-UV 6.5 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-6	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-7	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

5. Mechanical Stress Sequence

5.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
PS-MNB144(HCBF)-580W	0231219-05-8	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-9	No major visible defect	Pass

5.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-SML Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-SML Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

5.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data
Size of the module: 2.58 [m^2]
Test Voltage applied: 1500 [V]

Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-SML Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-SML Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Post-HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-8	10	15.5	Pass
Post-HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-9	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

5.4. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-8				Irradiance: 1000 / 200 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.448	44.833	13.503	12.826	575.026	81.20	—
Pre-HALT Testing Data-Rear Side	51.846	44.798	12.110	8.327	373.016	59.41	—
Pre-HALT Testing Data-BNPI	52.733	44.869	14.595	13.937	625.357	81.25	—
Post-SML Testing Data-Front Side	52.447	44.837	13.511	12.825	575.025	81.15	0.00
Post-SML Testing Data-Rear Side	51.847	44.801	12.117	8.326	372.994	59.37	-0.01
Post-SML Testing Data-BNPI	52.734	44.864	14.597	13.940	625.429	81.25	0.01
Post-DML1000 Testing Data-Front Side	52.446	44.831	13.499	12.825	574.964	81.21	-0.01
Post-DML1000 Testing Data-Rear Side	51.847	44.799	12.112	8.327	373.061	59.41	0.01
Post-DML1000 Testing Data-BNPI	52.741	44.900	14.588	13.919	624.967	81.23	-0.06
Post-TC50 Testing Data-Front Side	52.444	44.859	13.460	12.758	572.305	81.07	-0.47
Post-TC50 Testing Data-Rear Side	51.904	44.848	11.702	8.263	370.566	61.01	-0.66

Post-TC50 Testing Data-BNPI	52.745	44.880	14.549	13.892	623.444	81.24	-0.31
Post-HF10 Testing Data-Front Side	52.415	44.842	13.481	12.728	570.777	80.78	-0.74
Post-HF10 Testing Data-Rear Side	51.824	44.786	11.921	8.211	367.753	59.53	-1.41
Post-HF10 Testing Data-BNPI	52.718	44.784	14.504	13.855	620.462	81.15	-0.78

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-9				Irradiance: 1000 / 200 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.449	44.847	13.511	12.823	575.055	81.15	—
Pre-HALT Testing Data-Rear Side	51.921	44.864	11.700	8.321	373.322	61.45	—
Pre-HALT Testing Data-BNPI	52.734	44.864	14.597	13.940	625.429	81.25	—
Post-SML Testing Data-Front Side	52.447	44.829	13.506	12.819	574.647	81.13	-0.07
Post-SML Testing Data-Rear Side	51.919	44.866	11.708	8.321	373.339	61.42	0.00
Post-SML Testing Data-BNPI	52.733	44.906	14.597	13.927	625.407	81.25	0.00
Post-DML1000 Testing Data-Front Side	52.447	44.837	13.511	12.825	575.025	81.15	-0.01
Post-DML1000 Testing Data-Rear Side	51.845	44.797	12.109	8.325	372.917	59.40	-0.11
Post-DML1000 Testing Data-BNPI	52.737	44.858	14.602	13.945	625.560	81.24	0.02
Post-TC50 Testing Data-Front Side	52.462	44.910	13.500	12.777	573.794	81.02	-0.22
Post-TC50 Testing Data-Rear Side	51.899	44.847	11.703	8.261	370.497	61.00	-0.76
Post-TC50 Testing Data-BNPI	52.747	44.898	14.554	13.893	623.750	81.25	-0.27
Post-HF10 Testing Data-Front Side	52.413	44.836	13.480	12.724	570.477	80.75	-0.80
Post-HF10 Testing Data-Rear Side	51.851	44.788	11.790	8.210	367.701	60.15	-1.51
Post-HF10 Testing Data-BNPI	52.718	44.527	14.505	13.907	619.215	80.98	-0.99

5.5. Performance at Low irradiance (200w/m^2) Post HALT test

Test Date [YYYY-MM-DD]..... :	2024-03-21		—
Test method ..... :	■ Simulator	☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0231219-05-8	49.505	42.721	2.615	2.493	106.484	82.25	-2.45%
0231219-05-9	49.508	42.723	2.615	2.495	106.581	82.33	-2.15%

5.6. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data				
Sample No.	Diode No.			Pass/Fail
	D1	D2	D3	
0231219-05-8	Yes	Yes	Yes	Pass
0231219-05-9	Yes	Yes	Yes	Pass

6. Potential Induced Degradation (PID) Test

6.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
PS-MNB144(HCBF)-580W	0231219-05-10	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-11	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-12	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-13	No major visible defect	Pass

6.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass /Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-10	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-11	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-12	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-13	10	15.5	Pass
Post-PID96 (-) Testing Data	PS-MNB144(HCBF)-580W	0231219-05-10	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-11	10	15.5	Pass
Post-PID96 (+) Testing Data	PS-MNB144(HCBF)-580W	0231219-05-12	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-13	10	15.5	Pass
Post-PID192 (-) Testing Dat	PS-MNB144(HCBF)-580W	0231219-05-10	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-11	10	15.5	Pass
Post-PID192 (+) Testing Data	PS-MNB144(HCBF)-580W	0231219-05-12	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-13	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

6.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 1500 [V]					
Data	Model	Sample No.	Insulation Resistance		Pass/ Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing	PS-MNB144(HCBF)-580W	0231219-05-10	10	15.5	Pass

Data	PS-MNB144(HCBF)-580W	0231219-05-11	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-12	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-13	10	15.5	Pass
Post-PID96 (-) Testing Data	PS-MNB144(HCBF)-580W	0231219-05-10	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-11	10	15.5	Pass
Post-PID96 (+) Testing Data	PS-MNB144(HCBF)-580W	0231219-05-12	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-13	10	15.5	Pass
Post-PID192 (-) Testing Dat	PS-MNB144(HCBF)-580W	0231219-05-10	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-11	10	15.5	Pass
Post-PID192 (+) Testing Data	PS-MNB144(HCBF)-580W	0231219-05-12	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-13	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

6.4. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-10				Irradiance: 1000 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.456	44.808	13.467	12.839	575.295	81.44	—
Pre-HALT Testing Data-Rear Side	52.052	44.778	10.691	8.344	373.636	67.14	—
Pre-HALT Testing Data-BNPI	52.676	44.900	14.629	13.940	625.900	81.23	—
Post-PID96 (-) Testing Data-Front Side	52.337	44.421	13.327	12.749	566.298	81.19	-1.56
Post-PID96 (-) Testing Data-Rear Side	51.892	46.042	11.026	8.306	382.418	66.84	2.35
Post-PID96 (-) Testing Data-BNPI	52.459	44.587	14.481	13.813	615.896	81.08	-1.60
Post-PID192 (-) Testing Data-Front Side	52.293	44.257	13.189	12.571	556.345	80.67	-3.29
Post-PID192 (-) Testing Data-Rear Side	51.869	46.230	10.689	8.198	378.986	68.35	1.43
Post-PID192 (-) Testing Data-BNPI	52.429	44.451	14.334	13.616	605.250	80.54	-3.30

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-11				Irradiance: 1000 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.358	44.642	13.467	12.858	574.013	81.41	—

Pre-HALT Testing Data-Rear Side	52.029	44.777	10.700	8.340	373.436	67.08	—
Pre-HALT Testing Data-BNPI	52.524	44.650	14.620	13.949	622.808	81.11	—
Post-PID96 (-) Testing Data-Front Side	52.230	44.225	13.333	12.740	563.433	80.91	-1.84
Post-PID96 (-) Testing Data-Rear Side	51.955	46.064	11.006	8.382	386.089	67.52	3.39
Post-PID96 (-) Testing Data-BNPI	52.374	44.372	14.504	13.841	614.157	80.85	-1.39
Post-PID192 (-) Testing Data-Front Side	52.350	44.201	13.120	12.539	554.220	80.69	-3.45
Post-PID192 (-) Testing Data-Rear Side	52.000	46.114	10.799	8.324	383.855	68.36	2.79
Post-PID192 (-) Testing Data-BNPI	52.520	44.374	14.260	13.599	603.418	80.57	-3.11

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-12				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.317	44.628	13.458	12.823	572.275	81.28	—
Pre-HALT Testing Data-Rear Side	51.993	44.785	10.716	8.355	374.166	67.15	—
Pre-HALT Testing Data-BNPI	52.605	44.748	14.641	13.963	624.794	81.12	—
Post-PID96 (-) Testing Data-Front Side	52.122	44.125	13.349	12.753	562.733	80.88	-1.67
Post-PID96 (-) Testing Data-Rear Side	51.842	44.814	11.809	8.267	370.487	60.52	-0.98
Post-PID96 (-) Testing Data-BNPI	52.284	44.366	14.508	13.810	612.683	80.77	-1.94
Post-PID192 (-) Testing Data-Front Side	52.248	44.100	13.206	12.563	554.004	80.29	-3.19
Post-PID192 (-) Testing Data-Rear Side	51.847	44.791	11.780	8.211	367.777	60.22	-1.71
Post-PID192 (-) Testing Data-BNPI	52.394	44.284	14.364	13.623	603.271	80.16	-3.44

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-13				Irradiance: 1000 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.358	44.744	13.460	12.835	574.301	81.49	—
Pre-HALT Testing Data-Rear Side	52.005	44.781	10.714	8.348	373.828	67.09	—
Pre-HALT Testing Data-BNPI	52.621	44.885	14.639	13.966	626.876	81.38	—
Post-PID96 (-) Testing Data-Front Side	52.212	44.345	13.337	12.741	564.985	81.14	-1.62
Post-PID96 (-) Testing Data-Rear Side	51.851	44.813	11.809	8.271	370.670	60.53	-0.84
Post-PID96 (-) Testing Data-BNPI	52.362	44.526	14.492	13.822	615.453	81.10	-1.82
Post-PID192 (-) Testing Data-Front Side	52.112	44.081	13.154	12.574	554.270	80.86	-3.49
Post-PID192 (-) Testing Data-Rear Side	51.847	44.788	11.777	8.209	367.654	60.21	-1.65
Post-PID192 (-) Testing Data-BNPI	52.271	44.324	14.292	13.614	603.414	80.77	-3.74

6.5. Performance at Low irradiance (200w/m²) Post HALT test

Test Date [YYYY-MM-DD]..... :	2024-03-15	—
Test method ..... :	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0231219-05-10	49.416	42.475	2.625	2.502	106.274	81.93	-1.20%
0231219-05-11	49.528	42.613	2.613	2.498	106.462	82.28	-2.29%
0231219-05-12	49.379	42.385	2.628	2.505	106.156	81.81	-1.31%
0231219-05-13	49.256	42.337	2.620	2.499	105.797	81.97	-2.87%

6.6. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data		
Sample No.	Diode No.	Pass/Fail

	D1	D2	D3	
0231219-05-10	Yes	Yes	Yes	Pass
0231219-05-11	Yes	Yes	Yes	Pass
0231219-05-12	Yes	Yes	Yes	Pass
0231219-05-13	Yes	Yes	Yes	Pass

7. Light and elevated temperature induced degradation (LeTID) test

7.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
PS-MNB144(HCBF)-580W	0231219-05-14	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-15	No major visible defect	Pass

7.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Post-LeTID162 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Post-LeTID324 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Post-LeTID486 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

7.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 1500 [V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Post-LeTID162	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass

Testing Data	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Post-LeTID324 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Post-LeTID486 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-14	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-15	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

7.4. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-14				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.372	44.637	13.419	12.804	571.543	81.32	—
Pre-HALT Testing Data-Rear Side	52.031	44.787	10.510	8.351	374.023	68.39	—
Pre-HALT Testing Data-BNPI	52.571	44.674	14.597	13.922	621.935	81.04	—
Post-LeTID162 Testing Data-Front Side	52.213	44.310	13.484	12.903	571.744	81.21	0.04%
Post-LeTID162 Testing Data-Rear Side	51.927	46.019	11.137	8.383	385.759	66.70	3.14%
Post-LeTID162 Testing Data-BNPI	52.363	44.497	14.661	14.002	623.051	81.16	0.18%
Post-LeTID324 Testing Data-Front Side	52.379	44.538	13.451	12.867	573.083	81.34	0.27%
Post-LeTID324 Testing Data-Rear Side	51.947	46.167	10.696	8.358	385.869	69.45	3.17%
Post-LeTID324 Testing Data-BNPI	52.394	44.543	14.643	13.980	622.718	81.17	0.13%
Post-LeTID486 Testing Data-Front Side	52.462	44.662	13.463	12.867	574.648	81.36	0.54%
Post-LeTID486 Testing Data-Rear Side	52.098	45.370	10.630	8.356	379.125	68.46	1.36%
Post-LeTID486 Testing Data-BNPI	52.635	44.687	14.629	13.981	624.757	81.14	0.45%

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-15				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.303	44.563	13.426	12.812	570.923	81.30	—
Pre-HALT Testing Data-Rear Side	51.973	46.018	11.151	8.384	385.796	66.57	—
Pre-HALT Testing Data-BNPI	52.533	44.644	14.560	13.904	620.735	81.15	—
Post-LeTID162 Testing Data-Front Side	52.185	44.231	13.455	12.906	570.838	81.30	-0.01
Post-LeTID162 Testing Data-Rear Side	51.854	46.020	11.145	8.381	385.703	66.74	-0.02
Post-LeTID162 Testing Data-BNPI	52.347	44.414	14.630	13.999	621.751	81.19	0.16
Post-LeTID324 Testing Data-Front Side	52.386	44.384	13.431	12.886	571.924	81.28	0.18
Post-LeTID324 Testing Data-Rear Side	51.909	46.161	10.728	8.349	385.397	69.21	-0.10
Post-LeTID324 Testing Data-BNPI	52.516	44.636	14.612	13.974	623.735	81.28	0.48
Post-LeTID486 Testing Data-Front Side	52.308	44.509	13.447	12.862	572.485	81.39	0.27
Post-LeTID486 Testing Data-Rear Side	51.930	44.950	11.887	8.580	385.689	62.48	-0.03
Post-LeTID486 Testing Data-BNPI	52.511	44.627	14.591	13.956	622.805	81.28	0.33

7.5. Performance at Low irradiance (200w/m^2) Post HALT test

Test Date [YYYY-MM-DD]..... :	2024-04-15						—
Test method ..... :	■ Simulator ☐ Natural sunlight						—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0231219-05-14	49.679	42.933	2.674	2.560	109.925	82.75	0.88%
0231219-05-15	49.563	42.893	2.677	2.557	109.688	82.66	0.80%

7.6. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data				
Sample No.	Diode No.			Pass/Fail
	D1	D2	D3	
0231219-05-14	Yes	Yes	Yes	Pass
0231219-05-15	Yes	Yes	Yes	Pass

8. Hail Stress Sequence Test

8.1. Hail Test

Sample #	0231219-05-16						—
Ice ball size [mm] ..... :	1	2	3	4	5	6	—
	54.8	55.1	54.7	55.8	55.7	55.5	
	7	8	9	10	11	/	
	55.0	55.2	55.5	55.6	55.2	/	
Ice ball weight [g] ..... :	1	2	3	4	5	6	—
	80.48	81.05	80.33	80.10	79.65	81.12	
	7	8	9	10	11	/	
	80.26	80.07	79.55	80.66	80.28	/	
Ice ball velocity [m/s]..... :	1	2	3	4	5	6	—
	34.2	33.8	33.6	33.8	33.6	34.3	
	7	8	9	10	11	/	
	33.9	33.7	33.6	33.6	33.4	/	
Number of impact locations ..... :	11						—

Sample #	0231219-05-17						—
Ice ball size [mm] ..... :	1	2	3	4	5	6	—
	55.6	55.3	54.8	55.7	55.2	55.6	
	7	8	9	10	11	/	
	54.9	54.8	55.4	55.2	55.2	/	
Ice ball weight [g] ..... :	1	2	3	4	5	6	—
	79.60	79.54	81.08	81.00	79.64	79.97	
	7	8	9	10	11	/	
	80.20	80.76	80.88	79.67	80.53	/	
Ice ball velocity [m/s]..... :	1	2	3	4	5	6	—
	33.4	33.5	33.6	33.9	34.3	34.5	
	7	8	9	10	11	/	
	33.7	34.0	34.4	34.3	34.2	/	
Number of impact locations ..... :	11						—

8.2. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail

PS-MNB144(HCBF)-580W	0231219-05-16	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-17	No major visible defect	Pass

8.3. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Post-Hail Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Post-DML Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Post-TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Post- HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

8.4. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 1500 [V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Post-Hail Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Post-DML Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Post-TC50 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass

Post- HF10 Testing Data	PS-MNB144(HCBF)-580W	0231219-05-16	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-17	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

8.5. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-16				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.469	44.566	13.382	12.797	570.289	81.22	—
Pre-HALT Testing Data-Rear Side	52.062	46.104	10.944	8.313	383.254	67.27	—
Pre-HALT Testing Data-BNPI	52.737	44.876	14.536	13.874	622.603	81.22	—
Post-Hail Testing Data-Front Side	52.457	44.887	13.459	12.713	570.629	80.82	0.06
Post-Hail Testing Data-Rear Side	51.888	44.871	12.197	8.549	383.598	60.61	0.09
Post-Hail Testing Data-BNPI	52.632	44.740	14.552	13.887	621.294	81.12	-0.21
Post-DML Testing Data-Front Side	52.453	44.862	13.449	12.703	569.866	80.78	-0.07
Post-DML Testing Data-Rear Side	51.881	44.862	12.191	8.526	382.492	60.48	-0.20
Post-DML Testing Data-BNPI	52.732	44.901	14.478	13.818	620.446	81.27	-0.35
Post-TC50 Testing Data-Front Side	52.444	44.883	13.419	12.657	568.099	80.72	-0.38
Post-TC50 Testing Data-Rear Side	51.879	44.861	12.164	8.485	380.660	60.32	-0.68
Post-TC50 Testing Data-BNPI	52.730	44.867	14.481	13.824	620.264	81.23	-0.38
Post-HF10 Testing Data-Front Side	52.398	44.838	13.394	12.587	564.399	80.42	-1.03
Post-HF10 Testing Data-Rear Side	51.879	44.869	11.834	8.408	377.255	61.45	-1.57

Post-HF10 Testing Data-BNPI	52.702	44.855	14.392	13.734	616.016	81.22	-1.06

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-17				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.533	44.470	13.472	12.877	572.631	80.91	—
Pre-HALT Testing Data-Rear Side	52.051	46.064	10.685	8.193	377.383	67.86	—
Pre-HALT Testing Data-BNPI	52.593	44.627	14.669	13.975	623.658	80.84	—
Post-Hail Testing Data-Front Side	52.362	44.500	13.448	12.819	570.433	81.01	-0.38
Post-Hail Testing Data-Rear Side	51.858	45.337	10.539	8.337	377.960	69.16	0.15
Post-Hail Testing Data-BNPI	52.623	44.609	14.624	13.939	621.828	80.81	-0.29
Post-DML Testing Data-Front Side	52.320	44.390	13.443	12.827	569.400	80.96	-0.56
Post-DML Testing Data-Rear Side	51.825	45.341	10.560	8.334	377.871	69.04	0.13
Post-DML Testing Data-BNPI	52.559	44.543	14.628	13.942	621.037	80.78	-0.42
Post-TC50 Testing Data-Front Side	52.117	44.113	13.440	12.853	566.969	80.94	-0.99
Post-TC50 Testing Data-Rear Side	51.790	45.365	10.455	8.333	378.021	69.82	0.17
Post-TC50 Testing Data-BNPI	52.409	44.263	14.595	13.950	617.485	80.73	-0.99
Post-HF10 Testing Data-Front Side	52.400	44.845	13.398	12.595	564.817	80.45	-1.36
Post-HF10 Testing Data-Rear Side	51.861	44.854	11.981	8.375	375.665	60.46	-0.46
Post-HF10 Testing Data-BNPI	52.700	44.850	14.341	13.681	613.617	81.19	-1.61

8.6. Performance at Low irradiance (200w/m²) Post HALT test

Test Date [YYYY-MM-DD]..... :	2024-06-05	—
Test method ..... :	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0231219-05-16	49.549	42.770	2.667	2.547	108.956	82.44	-0.18%
0231219-05-17	49.510	42.726	2.613	2.494	106.570	82.38	-2.18%

8.7. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data				
Sample No.	Diode No.			Pass/Fail
	D1	D2	D3	
0231219-05-16	Yes	Yes	Yes	Pass
0231219-05-17	Yes	Yes	Yes	Pass

9. PAN and IAM

9.1. Rserie and Rshunt Determination

PV module low-light efficiency is mainly affected by Rserie value, and low light behavior is dependent on the specific solar cell type. In the PV module definitions dialog, PVsyst offers the low-light tool to analyze the measured data from the representative PV module, to find a model behavior matching the measurements at best, which mainly concerning the low-light efficiency curve.
After getting the best fitting low-light behavior, Intertek will search in the parent module the Rserie corresponding to the best corresponding low-light curve.

Samples selected as Representative Model:

Model Number	Remark
0231219-05-18	low-light behavior measurement, Bifaciality Factor measurement, IAM, Temperature coefficient

were measured at test conditions: 25°C, and multiple irradiances: 100W/m^2, 200W/m^2, 400W/m^2, 600W/m^2, 800W/m^2, 1000W/m^2, 1100W/m^2, according to the testing standard IEC61853-1: 2011 to get a reliable low-light efficiency measurement.

Table 1 Measured Post-LID Maximum Powers at Test Conditions

Sample 0231219-05-18:

Gref (W/m2)	Tref (℃)	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmp (W)
1100	25	52.650	44.917	14.786	14.090	632.881
1000	25	52.496	44.814	13.449	12.837	575.277
800	25	52.133	44.747	10.772	10.272	459.641
600	25	51.615	44.502	8.078	7.710	343.110
400	25	50.904	43.951	5.372	5.138	225.820
200	25	49.950	43.086	2.669	2.551	109.912
100	25	48.569	41.765	1.325	1.252	52.290

The test results in maximum power (Pmp) at standard test conditions (STC = 25 °C and 1000W/m2), were a little different with the datasheet nominal power of rating but were within the tolerance of testing lab and manufacturer.

After importing testing data of representative model to dialog “Additional data”, with ‘Low-light tool’ given in PVsyst, incrementally increase the Rshunt value from the default value to get Optimized Rserie.

To eliminate the effect of the accuracy factor of filter during measurement process at different irradiance, Isc values was linearized by Gref for each test irradiance level with Low-light tool.

Since STC values of the parent model are different from the representative model’s reference operating point at STC, so the Rserie may be different, and Rshunt was adjusted to increasing the RSMax of parent model to reach the low-light behavior of representative measured model.

Rshunt at Ginc = 0 remain as default.5

Table 2 Info of Optimize result of measured Sample

Measured Sample	0231219-05-18	
Rshunt of Measure Model (Ohm)	1800	
Rserie (Ohm) of Measured sample	0.136	

Error Measured - Model	0.00%	
RMS Measured - Model	0.16%	
Isc/G linear RMS	0.00%	

After export the low light behavior to 'parent model' to get the Rserie and Rshunt.

Table 3 Rserie and Rshunt of Parent model

Parent model	PS-MNB144(HCBF)-580W	
Rshunt (Ohm)	1800	
Rserie (Ohm)	0.152	

9.2. Pmpp Temperature Coefficient

Intertek measured Pmpp Temperature coefficient on one sample of PS-MNB144(HCBF)-580W module as specified in IEC61215-2: 2021, since and PS-MNB144(HCBF)-580W have same solar cell.
Test conditions:
Temperatures: 25°C, 30°C, 35°C, 40°C, 45°C, 50°C, 55°C
Irradiances: 1000W/m^2
Pmpp temperature coefficient = -0.3021%/°C

9.3. IAM determination

IAM data was measured as per IEC 61853-2: 2016.
Model of PS-MNB144(HCBF)-580W and have same type of frontsheet, encapsulate and backsheet, test was performed on representative model 0231219-05-20, and test data was fitted according to analytical function:

$$\tau(\theta) = \frac{1 - \exp\frac{-\cos(\theta)}{A}}{1 - \exp\frac{-1}{A}}$$

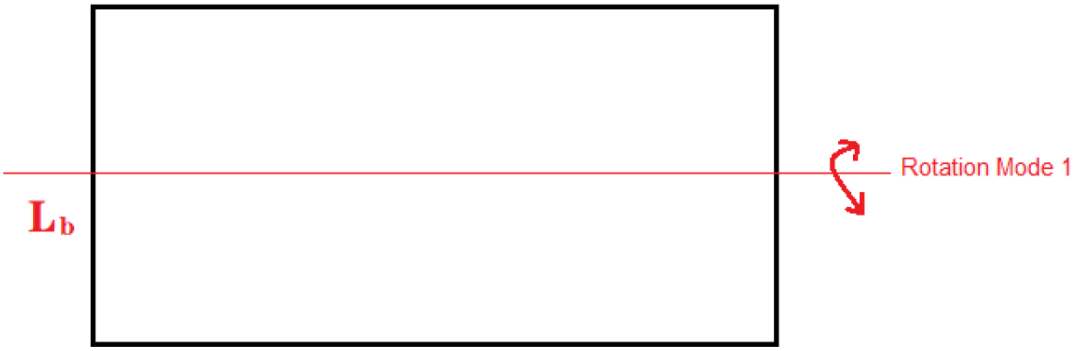
Measurement of incidence angle effects						
Test Method.....:			Indoor Method			
Sample # .....:			0231219-05-18			
Angle of incidence (°)	**Three Readings**	**Isc (A)**	**Sample temperature (℃)**	**Test irradiance (W/m2)**	**Average Isc**	**IAM,τ (θ)**
0	1	6.775	25	1000	6.775	1.000
	2	6.776	25	1000		
	3	6.774	25	1000		
10	1	6.680	25	1000	6.679	1.001
	2	6.679	25	1000		
	3	6.678	25	1000		
20	1	6.362	25	1000	6.362	0.999
	2	6.363	25	1000		
	3	6.361	25	1000		
30	1	5.856	25	1000	5.855	0.998
	2	5.855	25	1000		
	3	5.854	25	1000		
40	1	5.205	25	1000	5.205	1.003
	2	5.204	25	1000		
	3	5.206	25	1000		
45	1	4.787	25	1000	4.786	0.999
	2	4.786	25	1000		
	3	4.785	25	1000		
50	1	4.354	25	1000	4.355	1.000
	2	4.355	25	1000		
	3	4.356	25	1000		
55	1	3.865	25	1000	3.867	0.995
	2	3.868	25	1000		
	3	3.868	25	1000		
60	1	3.342	25	1000	3.341	0.986
	2	3.343	25	1000		
	3	3.338	25	1000		
65	1	2.724	25	1000	2.724	0.951
	2	2.725	25	1000		
	3	2.723	25	1000		
70	1	2.092	25	1000	2.090	0.902
	2	2.089	25	1000		
	3	2.089	25	1000		
75	1	1.441	25	1000	1.444	0.823
	2	1.441	25	1000		
	3	1.450	25	1000		
80	1	0.890	25	1000	0.888	0.754
	2	0.888	25	1000		

	3	0.886	25	1000		
85	1	0.417	25	1000	0.419	0.710
	2	0.417	25	1000		
	3	0.423	25	1000		
-10	1	6.687	25	1000	6.688	1.002
	2	6.687	25	1000		
	3	6.690	25	1000		
-20	1	6.365	25	1000	6.364	1.000
	2	6.364	25	1000		
	3	6.363	25	1000		
-30	1	5.888	25	1000	5.888	1.003
	2	5.889	25	1000		
	3	5.887	25	1000		
-40	1	5.183	25	1000	5.184	0.999
	2	5.184	25	1000		
	3	5.185	25	1000		
-45	1	4.833	25	1000	4.833	1.009
	2	4.834	25	1000		
	3	4.832	25	1000		
-50	1	4.360	25	1000	4.359	1.001
	2	4.357	25	1000		
	3	4.360	25	1000		
-55	1	3.871	25	1000	3.873	0.997
	2	3.874	25	1000		
	3	3.874	25	1000		
-60	1	3.367	25	1000	3.368	0.994
	2	3.368	25	1000		
	3	3.369	25	1000		
-65	1	2.741	25	1000	2.743	0.958
	2	2.745	25	1000		
	3	2.743	25	1000		
-70	1	2.103	25	1000	2.105	0.908
	2	2.104	25	1000		
	3	2.108	25	1000		
-75	1	1.434	25	1000	1.437	0.819
	2	1.438	25	1000		
	3	1.439	25	1000		
-80	1	0.876	25	1000	0.878	0.746
	2	0.878	25	1000		
	3	0.880	25	1000		
-85	1	0.429	25	1000	0.426	0.722
	2	0.424	25	1000		
	3	0.425	25	1000		

Test area Location:

	1	2	……	11	12	13	14	……	23	24	
F											F
E											E
D											D
C			……					……			C
B											B
A											A
	1	2	……	11	12	13	14	……	23	24	

Rotation Mode



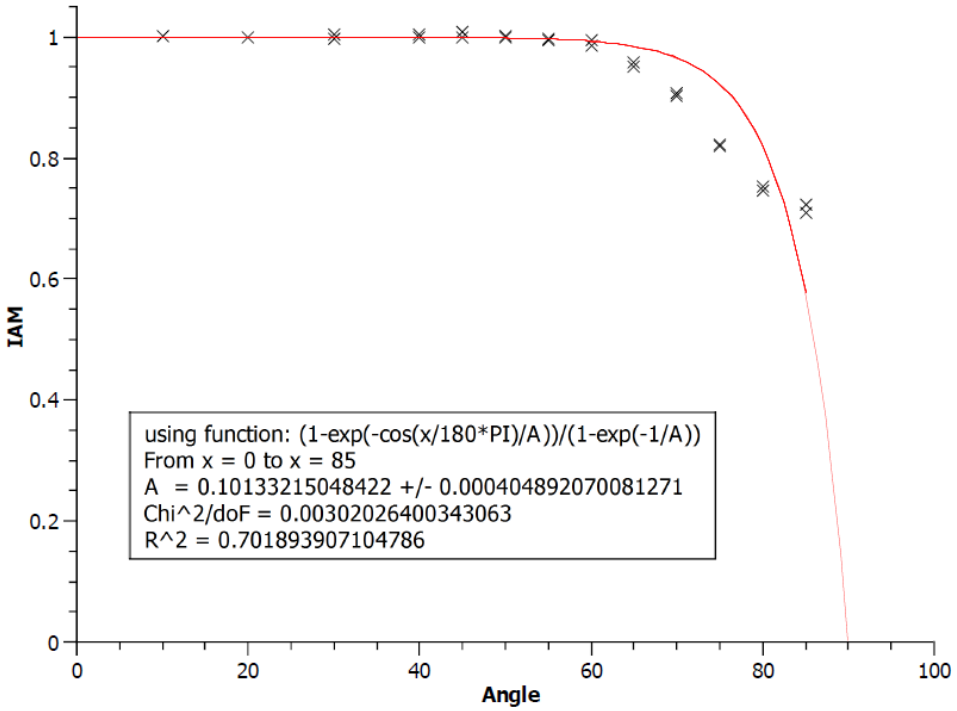


Table 4 IAM Data

Angle [°]	0	40	50	60	65	70	75	80	85
IAM	1.000	1.000	0.998	0.993	0.985	0.966	0.923	0.821	0.578

9.4. Bifaciality factor determination

$$\text{Bifaciality factor} = \frac{\text{Rear side output power at STC}}{\text{Front Side output power at STC}}$$

Table 5 Bifaciality factor calculation

Sample #	VOC	Vmp	ISC	Imp	Pmp	Bifaciality factor
0231219-05-18-Front	51.959	45.818	10.942	9.284	425.374	73.9%
0231219-05-18-Rear	52.496	44.814	13.449	12.837	575.277	

Shanghai Intertek Testing Services Co Ltd., (China)

PVsyst V7.4.2

PV module - PS-MNB144(HCBF)-575W

Manufacturer	Philadelphia Solar	**Commercial data**	
Model	PS-MNB144(HCBF)-575W	Data source :	Intertek Testing Services
Pnom STC power (manufacturer)	570 Wp	Technology	Si-mono
Module size (W x L)	1.133 x 2.277 m²	Rough module area (Amodule)	2.58 m²
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.38 m²

Specifications for the model (manufacturer or measurement data)

Reference temperature (TRef)	25 ° C	Reference irradiance (GRef)	1000 W/m²
Open circuit voltage (Voc)	51.5 V	Short-circuit current (Isc)	14.06 A
Max. power point voltage (Vmpp)	43.4 V	Max. power point current (Impp)	13.29 A
=> maximum power (Pmpp)	576.7 W	Isc temperature coefficient (muIsc)	6.3 mA/° C

One-diode model parameters

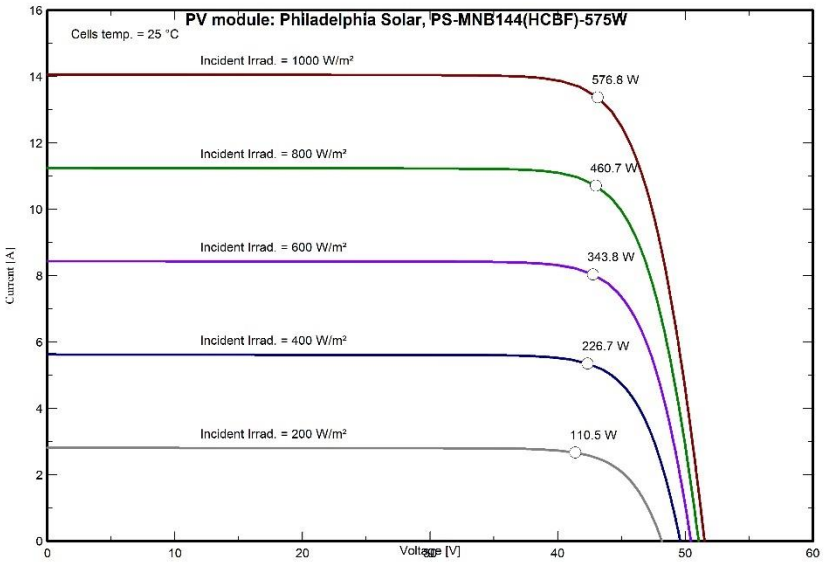
Shunt resistance (Rshunt)	1800 Ω	Diode saturation current (IoRef)	0.233 nA
Serie resistance (Rserie)	0.15 Ω	Voc temp. coefficient (MuVoc)	-127 mV/° C
Specified Pmax temper. coeff. (muPMaxR)	-0.30 %/° C	Diode quality factor (Gamma)	1.12
		Diode factor temper. coeff. (muGamma)	0.000 1/° C

Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch

Reverse characteristics (dark) (BRev)	3.20 mA/V²	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V

Model results for standard conditions (STC: T=25 ° C, G=1000 W/m² , AM=1.5)

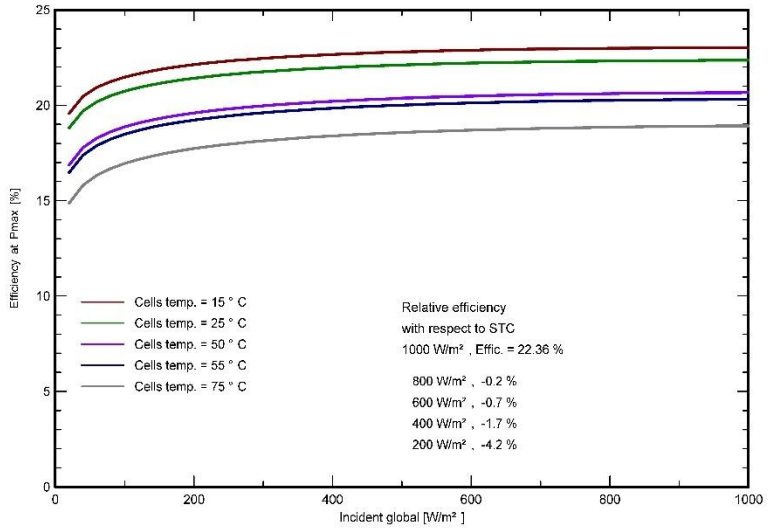
Max. power point voltage (Vmpp)	43.1 V	Max. power point current (Impp)	13.43 A
Maximum power (Pmpp)	576.8 Wp	Power temper. coefficient (muPmpp)	-0.30 %/° C
Efficiency(/ Module area) (Eff_mod)	22.4 %	Fill factor (FF)	0.796
Efficiency(/ Cells area) (Eff_cells)	24.2 %		



Shanghai Intertek Testing Services Co Ltd., (China)

PVsyst V7.4.2

PV module: Philadelphia Solar, PS-MNB144(HCBF)-575W



10. UVID Test

10.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
PS-MNB144(HCBF)-580W	0231219-05-20	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-21	No major visible defect	Pass

10.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m²]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-20	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-21	10	15.5	Pass
Post-First Round-UVID Testing Data	PS-MNB144(HCBF)-580W	0231219-05-20	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-21	10	15.5	Pass
Post-Second Round-UVID Testing Data	PS-MNB144(HCBF)-580W	0231219-05-20	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-21	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

10.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data					
Size of the module: 2.58 [m²]					
Test Voltage applied: 1500 [V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-20	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-21	10	15.5	Pass
Post-First Round-UVID Testing Data	PS-MNB144(HCBF)-580W	0231219-05-20	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-21	10	15.5	Pass
Post-Second	PS-MNB144(HCBF)-580W	0231219-05-20	10	15.5	Pass

Round-UVID Testing Data	PS-MNB144(HCBF)-580W	0231219-05-21	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

10.4. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W			Module temperature: 25 [°C]				
Sample No.: 0231219-05-20			Irradiance: 1000 [W/m^2]				
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.306	44.594	13.466	12.858	573.390	81.41	—
Pre-HALT Testing Data-Rear Side	52.185	44.745	10.574	8.316	372.104	67.43	—
Pre-HALT Testing Data-BNPI	52.596	44.761	14.624	13.962	624.940	81.25	—
Post- First Round UVID Testing Data-Front Side	51.497	43.571	13.432	12.810	558.161	80.69	-2.66
Post- First Round UVID Testing Data-Rear Side	51.137	45.416	10.222	8.243	374.361	71.62	0.61
Post- First Round UVID Testing Data-BNPI	51.773	43.691	14.545	13.869	605.946	80.46	-3.04
Post- Second Round UVID Testing Data-Front Side	50.445	42.324	13.352	12.805	541.942	80.46	-5.48
Post- Second Round UVID Testing Data-Rear Side	49.913	44.151	10.340	8.292	366.082	70.93	-1.62
Post- Second Round UVID Testing Data-BNPI	50.605	42.378	14.477	13.877	588.096	80.27	-5.90

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-21				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.483	44.734	13.392	12.781	571.758	81.35	—
Pre-HALT Testing Data-Rear Side	52.138	44.739	10.573	8.298	371.253	67.35	—
Pre-HALT Testing Data-BNPI	52.668	44.795	14.605	13.935	624.233	81.15	—
Post- First Round UVID Testing Data-Front Side	51.579	43.522	13.367	12.761	555.366	80.55	-2.87
Post- First Round UVID Testing Data-Rear Side	51.253	44.732	10.352	8.286	370.649	69.86	-0.16
Post- First Round UVID Testing Data-BNPI	51.700	43.442	14.521	13.863	602.240	80.22	-3.52
Post- Second Round UVID Testing Data-Front Side	50.160	42.080	13.299	12.748	536.435	80.41	-6.18
Post- Second Round UVID Testing Data-Rear Side	49.771	44.029	10.194	8.232	362.443	71.44	-2.37
Post- Second Round UVID Testing Data-BNPI	50.499	42.268	14.449	13.832	584.657	80.13	-6.34

10.5. Performance at Low irradiance (200w/m^2) Post HALT test

Test Date [YYYY-MM-DD]..... :	2024-03-29	—
Test method ..... :	■ Simulator ☐ Natural sunlight	—

Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0231219-05-20	49.553	42.757	2.667	2.549	108.973	82.45	0.02%
0231219-05-21	49.554	42.761	2.666	2.548	108.945	82.46	-0.01%

10.6. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data				
Sample No.	Diode No.			Pass/Fail
	D1	D2	D3	
0231219-05-20	Yes	Yes	Yes	Pass
0231219-05-21	Yes	Yes	Yes	Pass

11. Field Exposure

11.1. Visual Inspection Results

Visual inspection was performed according to IEC 61215-2:2021 prior to and after HALT. No major visual defects were found throughout testing.

Visual Inspection Pass/Fail Results			
Model	Sample No.	Nature and position of initial findings	Pass/Fail
PS-MNB144(HCBF)-580W	0231219-05-22	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-23	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-24	No major visible defect	Pass
PS-MNB144(HCBF)-580W	0231219-05-25	No major visible defect	Pass

11.2. Insulation Test Data

Insulation test was performed according to IEC 61215-2:2021 prior to and after HALT. Insulation resistance shall be no less than 40 MΩ·m^2.

Insulation Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 8000, 1500[V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT Testing Data	PS-MNB144(HCBF)-580W	0231219-05-22	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-23	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-24	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-25	10	15.5	Pass
Post-6 months Field Exposure Testing Data	PS-MNB144(HCBF)-580W	0231219-05-22	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-23	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-24	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-25	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

11.3. Wet Leakage Current Test Data

IEC 61215-2:2021 Clause. 10.15 defines a passing insulation resistance for the type of module tested to be no less than 40 MΩ·m^2.

Wet Leakage Current Test Data					
Size of the module: 2.58 [m^2]					
Test Voltage applied: 1500 [V]					
Data	Model	Sample No.	Insulation Resistance		Pass/Fail
			Measured [GΩ]	Required [MΩ]	
Pre-HALT	PS-MNB144(HCBF)-580W	0231219-05-22	10	15.5	Pass

Testing Data	PS-MNB144(HCBF)-580W	0231219-05-23	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-24	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-25	10	15.5	Pass
Post-6 months Field Exposure Testing Data	PS-MNB144(HCBF)-580W	0231219-05-22	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-23	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-24	10	15.5	Pass
	PS-MNB144(HCBF)-580W	0231219-05-25	10	15.5	Pass
Supplementary information: Maximum resistance measurement range is 10GΩ.					

11.4. Maximum Power Determination Data at STC

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-22				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.397	44.803	13.459	12.823	574.532	81.47	—
Pre-HALT Testing Data-Rear Side	51.849	44.834	11.970	8.321	373.068	60.11	—
Pre-HALT Testing Data-BNPI	52.720	44.863	14.604	13.934	625.108	81.19	—
Post-6 months Field Exposure Testing Data-Front Side							
Post-6 months Field Exposure Testing Data-Rear Side							
Post-6 months Field Exposure Testing Data-BNPI							

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-23				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.398	44.792	13.487	12.825	574.464	81.29	—
Pre-HALT Testing Data-Rear Side	51.852	44.829	11.980	8.320	372.959	60.04	—
Pre-HALT Testing Data-BNPI	52.716	44.798	14.609	13.946	624.755	81.12	—

Post-6 months Field Exposure Testing Data-Front Side							
Post-6 months Field Exposure Testing Data-Rear Side							
Post-6 months Field Exposure Testing Data-BNPI							

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-24				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.401	44.779	13.486	12.826	574.311	81.27	—
Pre-HALT Testing Data-Rear Side	51.851	44.833	11.967	8.318	372.925	60.10	—
Pre-HALT Testing Data-BNPI	52.717	44.841	14.609	13.930	624.657	81.11	—
Post-6 months Field Exposure Testing Data-Front Side							
Post-6 months Field Exposure Testing Data-Rear Side							
Post-6 months Field Exposure Testing Data-BNPI							

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-25				Irradiance: 1000 [W/m^2]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side	52.410	44.748	13.484	12.834	574.281	81.26	—
Pre-HALT Testing Data-Rear Side	51.850	44.832	11.972	8.318	372.899	60.07	—
Pre-HALT Testing Data-BNPI	52.723	44.842	14.603	13.929	624.588	81.13	—
Post-6 months Field Exposure Testing Data-Front Side							
Post-6 months Field Exposure Testing Data-Rear Side							
Post-6 months Field Exposure Testing Data-BNPI							

11.5. Performance at Low irradiance (200w/m²) Before and Post HALT test

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-22				Irradiance: 200 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side							—
Post-6 months Field Exposure Testing Data-Front Side							

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-23				Irradiance: 200 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side							—
Post-6 months Field Exposure Testing Data-Front Side							

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-24				Irradiance: 200 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side							—
Post-6 months Field Exposure Testing Data-Front Side							

Maximum Power Determination Data at STC							
Model: PS-MNB144(HCBF)-580W				Module temperature: 25 [°C]			
Sample No.: 0231219-05-25				Irradiance: 200 [W/m²]			
Data	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
Pre-HALT Testing Data-Front Side							—
Post-6 months Field Exposure Testing Data-Front Side							

11.6. Bypass diode functionality test

IEC 61215-2: 2021 ED. 2.0 CL. 4.18.2 defines this bypass diode functionality test is to verify that the bypass diode(s) of the test samples remain(s) functional following the HALT.

Bypass diode functionality test Data				
Sample No.	Diode No.			Pass/Fail
	D1	D2	D3	
0231219-05-22	Yes	Yes	Yes	Pass
0231219-05-23	Yes	Yes	Yes	Pass
0231219-05-24	Yes	Yes	Yes	Pass
0231219-05-25	Yes	Yes	Yes	Pass

12. APPENDIX A – Photos

Module_PS-MNB144(HCBF)-580W

13. APPENDIX B – Product Description Sheet

A1.1	MODULE TYPE/S
	PS-MNB144(HCBF)-xxxW

A1.2	SOLAR CELL	
	Cell type reference 1 .....:	PSMT18216BB Solarspace Technology Co.,Ltd. N type mono crystalline bifacial solar cell 182mm*91mm, 16 busbars 140μm
	Cell dimensions L x W (mm)..... :	182*91
	Cell thickness (μm) ..... :	140μm

A1.3	IDENTIFICATION OF MATERIALS	
	Front cover.....:	tempered glass with AR coating CSG Glass Co., Ltd. 3.20 mm thickness
	Rear cover .....:	Cynagard 455A(R)P Cybrid Technologies Inc Fluorine resin /PET /Fluorine resin /Fluorine resin mesh
	Encapsulate (upper side).....:	SE-556 Changzhou Sveck Pv New Material Co.,Ltd Polyolefin (POE) thickness 0.55mm
	Encapsulate (lower side) .....:	SV-15297P Changzhou Sveck Pv New Material Co.,Ltd Ethyl-Vinyl-acetate (EVA), thickness 0.55mm
	Frame .....:	6005-T6, anodized aluminum alloy Jiangsu Goodsun New Energy Co., Ltd.
	Adhesive for frame .....:	HT906Z Shanghai Huitian New Material Co. LTD.
	Flux.....:	Kester 952-S MacDermid Performance Solutions
	Fixing Tape .....:	FF3665-T50 3M Company
	Adhesive for junction box .....:	HT906Z Shanghai Huitian New Material Co. LTD.
	Potting material.....:	5299W-S Shanghai Huitian New Material Co. LTD.
	String Connector.....:	Sn 60%/Pb 40 % Taicang Juren International Trade Co., LTD 5mm wide by 0.4m thick, 6mm wide by 0.4m thick

	Cell Connector ..... :	Sn 60%/Pb 40 % Taicang Juren International Trade Co., LTD Φ0.27mm
A1.4	**IDENTIFICATION OF COMPONENTS**	
	Junction box ..... :	JM37xy ZHEJIANG JIAMING TIANHEYUAN PHOTOVOLTAIC TECHNOLOGY CO LTD
	Cable ..... :	62930 IEC 131 ZHEJIANG JIAMING TIANHEYUAN PHOTOVOLTAIC TECHNOLOGY CO LTD
	Connector ..... :	PV-KBT4/6II-UR PV-KST4/6II-UR Stäubli Electrical Connectors AG
	Bypass diode ..... :	MK5050 ZHEJIANG JIAMING TIANHEYUAN PHOTOVOLTAIC TECHNOLOGY CO LTD

14. APPENDIX C – Statement of the estimated uncertainty of the test results

The result of performance rating is only related testing samples that were subject to the test. They cannot be generalized the module from the series production. The calibration to STC was performed with Class AAA solar simulator. The total measurement uncertainty is:
Pm ≤ +/-2.4%
Isc ≤ +/- 2.2%
Voc ≤ +/- 1.04%
The accuracy of reproduction of the measurement with solar simulator is less than 1%.