

HIGHLY ACCELERATED LIFE AND EXTENDED RELIABILITY TESTING REPORT

Philadelphia Solar

SOLAR MODULE:
PS-MNG144(HCBF)-570W
PS-MNG108(HCBF)-425W

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EVALUATION OF

PS-MNG144(HCBF)-570W

PS-MNG108(HCBF)-425W

RENDERED by

Philadelphia Solar

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

Date of performance of the test item: September 19, 2023 to March 28, 2024

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Date of issue : April 10, 2024

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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-MNG144(HCBF)-570W and crystalline silicon module and evaluate the characterization under HALT. The testing program is shown in page 8.

General Product Information

Description of module construction:					
Model	Size of Module (mm)	Cell technology		No. of cells	
PS-MNG144(HCBF)-570W	2278*1134*30	N Type, Bifacial Mono Crystalline Topcon solar cell with 16 busbars		144	
PS-MNG108(HCBF)-425W	1722*1134*30	N Type, Bifacial Mono Crystalline Topcon solar cell with 16 busbars		108	

Product Electrical Rating:					
Model No.	Voc (V)	Isc (Amps)	Pmp (W)	Vmp (V)	Imp (Amps)
PS-MNG144(HCBF)-570W	51.37	14.02	570	43.15	13.25
PS-MNG108(HCBF)-425W	38.36	14.16	425	31.69	13.41

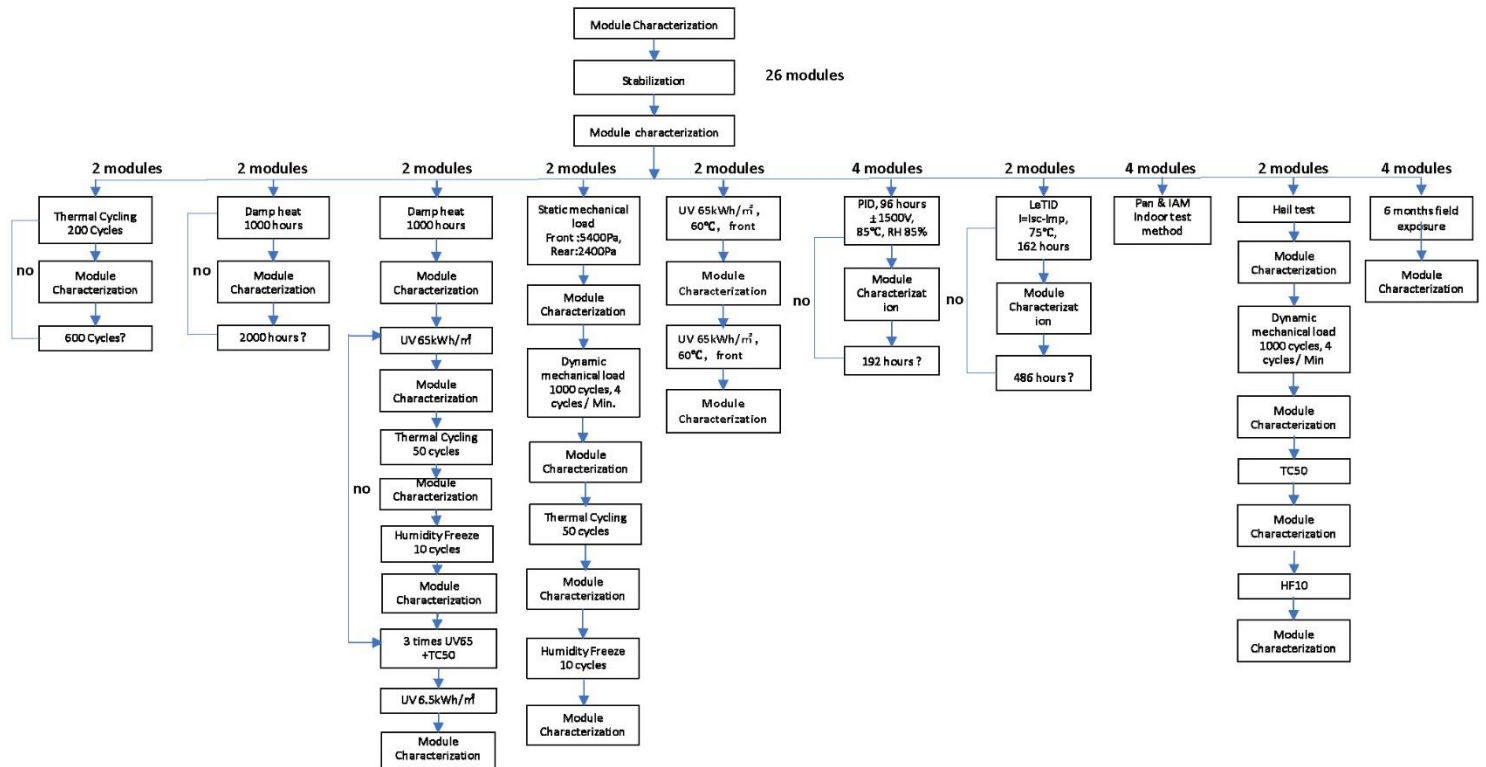
List of Test Samples

List of test samples			
Sample No.	Series No.	Type / model	Remark
0230919-20-2	PS080823BN1440000192	PS-MNG144(HCBF)-570W	Thermal Cycling Test
0230919-20-3	PS080823BN1440000187	PS-MNG144(HCBF)-570W	Thermal Cycling Test
0230919-20-4	PS080823BN1440000098	PS-MNG144(HCBF)-570W	Damp Heat Test
0230919-20-5	PS080823BN1440000169	PS-MNG144(HCBF)-570W	Damp Heat Test
0230919-20-6	PS080823BN1440000027	PS-MNG144(HCBF)-570W	Backsheet durability test
0230919-20-7	PS080823BN1440000161	PS-MNG144(HCBF)-570W	Backsheet durability test
0230919-20-8	PS080823BN1440000148	PS-MNG144(HCBF)-570W	Mechanical Stress Sequence
0230919-20-9	PS080823BN1440000008	PS-MNG144(HCBF)-570W	Mechanical Stress Sequence
0230919-20-10	PS080823BN14400000216	PS-MNG144(HCBF)-570W	PID
0230919-20-11	PS080823BN14400000215	PS-MNG144(HCBF)-570W	PID
0230919-20-12	PS080823BN14400000209	PS-MNG144(HCBF)-570W	PID
0230919-20-13	PS080823BN14400000210	PS-MNG144(HCBF)-570W	PID
0230919-20-14	PS080823BN14400000222	PS-MNG144(HCBF)-570W	LeTID
0230919-20-15	PS080823BN14400000212	PS-MNG144(HCBF)-570W	LeTID
0230919-20-16	PS080823BN14400000219	PS-MNG144(HCBF)-570W	Hail Test
0230919-20-17	PS080823BN1440000105	PS-MNG144(HCBF)-570W	Hail Test
0230919-20-18	PS080823BN1440000097	PS-MNG144(HCBF)-570W	PAN File & IAM
0230919-20-19	PS270823BN1080000034	PS-MNG108(HCBF)-425W	Pan File
0230919-20-20	PS080823BN14400000206	PS-MNG144(HCBF)-570W	UVID test
0230919-20-21	PS080823BN1440000195	PS-MNG144(HCBF)-570W	UVID test
0230919-20-22	PS080823BN1440000055	PS-MNG144(HCBF)-570W	Field Exposure
0230919-20-23	PS080823BN1440000024	PS-MNG144(HCBF)-570W	Field Exposure
0230919-20-24	PS080823BN1440000184	PS-MNG144(HCBF)-570W	Field Exposure
0230919-20-25	PS080823BN1440000066	PS-MNG144(HCBF)-570W	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/m², 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/m² rear side irradiance levels G_{Ri}. The equivalent irradiance levels are determined as functions of the bifaciality coefficient φ according to the equation below: $G_{BNPI} = 1000 W \cdot m^{-2} + \varphi \cdot 135 W \cdot m^{-2}$ $\varphi = \text{Min}(\varphi_{ISC}, \varphi_{Pmax})$	
4. Backsheet durability test and UVID test: UV irradiance: 150~170W/m², 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°C ± 2°C and Rh 85%±3%, 96 hours per cycle, 2 cycles. 8. Hail test: ice ball diameter: 45mm ± 5%, Mass 43.9g ± 5%, velocity 30.7 ± 5%, 11 impact locations according to requirement of IEC 61215: 2021 Cl.4.17 9. Stabilization: indoor Method, irradiance 800~1000w/m². 10. Field Exposure: 4 modules were mounted on an open rack, tilt angle is 35 degrees, and connected to MPPT, 6 months test from September 28, 2023 to March 28, 2024.	

Testing Program



1. Stabilization

1.1. Initial Visual inspection

Test Date [YYYY-MM-DD].....: 2023-09-19		—
Sample #	Nature and position of initial findings – comments or attach photos	—
0230919-20-2	No major visible defect	PASS
0230919-20-3	No major visible defect	PASS
0230919-20-4	No major visible defect	PASS
0230919-20-5	No major visible defect	PASS
0230919-20-6	No major visible defect	PASS
0230919-20-7	No major visible defect	PASS
0230919-20-8	No major visible defect	PASS
0230919-20-9	No major visible defect	PASS
0230919-20-10	No major visible defect	PASS
0230919-20-11	No major visible defect	PASS
0230919-20-12	No major visible defect	PASS
0230919-20-13	No major visible defect	PASS
0230919-20-14	No major visible defect	PASS
0230919-20-15	No major visible defect	PASS
0230919-20-16	No major visible defect	PASS
0230919-20-17	No major visible defect	PASS
0230919-20-18	No major visible defect	PASS
0230919-20-19	No major visible defect	PASS
0230919-20-20	No major visible defect	PASS
0230919-20-21	No major visible defect	PASS
0230919-20-22	No major visible defect	PASS
0230919-20-23	No major visible defect	PASS
0230919-20-24	No major visible defect	PASS
0230919-20-25	No major visible defect	PASS
Supplementary information: NA		

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

Test Date [YYYY-MM-DD]:			2023-09-20				—
Test method:			■ Simulator □ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0230919-20-2	52.006	44.197	13.447	12.827	566.910	81.06	—
0230919-20-3	51.814	44.120	13.486	12.857	567.249	81.18	—

0230919-20-4	52.033	44.242	13.464	12.847	568.377	81.13	—
0230919-20-5	52.127	44.303	13.488	12.856	569.576	81.01	—
0230919-20-8	52.099	44.534	13.434	12.842	571.916	81.71	—
0230919-20-9	52.074	44.453	13.456	12.829	570.310	81.39	—
0230919-20-10	51.993	44.257	13.521	12.868	569.491	81.01	—
0230919-20-11	52.134	44.383	13.540	12.867	571.076	80.90	—
0230919-20-12	52.194	44.409	13.505	12.844	570.392	80.92	—
0230919-20-13	51.961	44.165	13.551	12.876	568.668	80.76	—
0230919-20-14	52.088	44.273	13.491	12.835	568.254	80.86	—
0230919-20-15	52.158	44.327	13.520	12.828	568.616	80.64	—
0230919-20-16	52.032	44.235	13.496	12.899	570.603	81.26	—
0230919-20-17	52.032	44.232	13.483	12.896	570.416	81.31	—
0230919-20-18	52.267	44.284	13.473	12.830	568.158	80.68	—
0230919-20-19	38.774	32.952	13.511	12.922	425.806	81.28	—
0230919-20-20	52.411	44.731	13.459	12.848	574.721	81.48	—
0230919-20-21	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]			2023-09-20				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0230919-20-2	51.533	45.047	10.382	9.230	415.789	77.71	—
0230919-20-3	51.586	45.415	11.039	9.173	416.580	73.15	—
0230919-20-4	51.574	44.960	10.627	9.210	414.078	75.55	—
0230919-20-5	51.596	45.531	10.876	9.090	413.858	73.75	—
0230919-20-8	51.615	44.952	10.846	9.280	417.172	74.52	—
0230919-20-9	51.595	44.972	10.631	9.312	418.772	76.34	—
0230919-20-10	51.600	44.840	10.841	9.205	412.752	73.78	—
0230919-20-11	51.990	44.848	11.052	9.366	420.046	73.10	—
0230919-20-12	51.728	44.926	10.563	9.198	413.225	75.63	—
0230919-20-13	51.589	44.871	10.823	9.276	416.236	74.55	—
0230919-20-14	51.610	44.743	10.894	9.227	412.844	73.43	—
0230919-20-15	51.690	44.823	11.111	9.283	416.086	72.45	—
0230919-20-16	51.502	44.761	11.310	9.268	414.845	71.22	—
0230919-20-17	51.595	45.031	10.873	9.297	418.653	74.63	—

0230919-20-18	51.725	45.152	10.713	9.255	417.882	75.41	—
0230919-20-19	38.031	33.572	10.878	9.524	319.727	77.28	—
0230919-20-20	51.132	44.747	10.471	9.318	416.953	77.88	—
0230919-20-21	51.067	44.743	10.574	9.307	416.423	77.12	—
Supplementary information: NA							

1.4. Performance at BNPI before initial stabilization

Test Date [YYYY-MM-DD]			2023-09-20				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0230919-20-2	52.182	44.307	14.943	14.204	629.339	80.71	—
0230919-20-3	52.165	44.426	14.779	14.083	625.637	81.15	—
0230919-20-4	52.313	44.542	15.193	14.083	627.294	78.93	—
0230919-20-5	52.392	44.712	14.792	14.061	628.692	81.12	—
0230919-20-8	52.196	44.490	14.777	14.026	624.006	80.90	—
0230919-20-9	52.194	44.663	14.780	13.995	625.060	81.03	—
0230919-20-10	52.393	44.665	14.405	13.353	596.400	79.02	—
0230919-20-11	52.343	44.581	14.434	13.641	608.129	80.49	—
0230919-20-12	52.245	44.449	14.684	13.924	618.927	80.68	—
0230919-20-13	52.587	44.844	14.658	13.786	618.209	80.20	—
0230919-20-14	52.198	44.227	14.774	14.080	622.692	80.75	—
0230919-20-15	52.217	44.434	14.775	14.040	623.866	80.87	—
0230919-20-16	52.434	44.584	14.738	13.911	620.188	80.26	—
0230919-20-17	52.517	44.664	14.767	13.885	620.160	79.97	—
0230919-20-18	52.291	44.867	14.809	13.895	623.427	80.51	—
0230919-20-19	38.937	32.968	14.874	14.211	468.518	80.90	—
0230919-20-20	52.575	44.758	14.646	13.985	625.940	81.29	—
0230919-20-21	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 #	0230919-20-2	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	566.910	—	—
1	20	800-1000	50±10	Micro inverter	566.814	—	—
2	20	800-1000	50±10	Micro inverter	566.990	0.03	yes

Sample #	0230919-20-3	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	567.249	—	—
1	20	800-1000	50±10	Micro inverter	567.702	—	—
2	20	800-1000	50±10	Micro inverter	566.146	0.27	yes

Sample #	0230919-20-4	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	568.377	—	—
1	20	800-1000	50±10	Micro inverter	568.666	—	—
2	20	800-1000	50±10	Micro inverter	568.647	0.05	yes

Sample #	0230919-20-5	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	569.576	—	—
1	20	800-1000	50±10	Micro inverter	568.290	—	—
2	20	800-1000	50±10	Micro inverter	567.001	0.45	yes

Sample #	0230919-20-8	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	571.916	—	—

1	5	800-1000	50±10	Micro inverter	571.847	—	—
2	5	800-1000	50±10	Micro inverter	571.744	0.03	yes
Sample #	0230919-20-9	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
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	—	—	—	—	570.310	—	—
1	5	800-1000	50±10	Micro inverter	570.182	—	—
2	5	800-1000	50±10	Micro inverter	570.145	0.03	yes
Sample #	0230919-20-10	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
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	—	—	—	—	569.491	—	—
1	5	800-1000	50±10	Micro inverter	568.963	—	—
2	5	800-1000	50±10	Micro inverter	568.543	0.17	yes
Sample #	0230919-20-11	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
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	—	—	—	—	571.076	—	—
1	5	800-1000	50±10	Micro inverter	571.462	—	—
2	5	800-1000	50±10	Micro inverter	571.885	0.14	yes
Sample #	0230919-20-12	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
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	—	—	—	—	570.392	—	—
1	5	800-1000	50±10	Micro inverter	570.146	—	—
2	5	800-1000	50±10	Micro inverter	570.567	0.07	yes
Sample #	0230919-20-13	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
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	—	—	—	—	568.668	—	—

1	5	800-1000	50±10	Micro inverter	568.338	—	—
2	5	800-1000	50±10	Micro inverter	567.078	0.28	yes
Sample #	0230919-20-14	Test Date (YYYY-MM-DD) start/end			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	568.254	—	—
1	5	800-1000	50±10	Micro inverter	568.191	—	—
2	5	800-1000	50±10	Micro inverter	568.217	0.01	yes

Sample #	0230919-20-15	Test Date (YYYY-MM-DD) start/end			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	568.616	—	—
1	5	800-1000	50±10	Micro inverter	568.390	—	—
2	5	800-1000	50±10	Micro inverter	568.176	0.08	yes

Sample #	0230919-20-16	Test Date (YYYY-MM-DD) start/end			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	570.603	—	—
1	5	800-1000	50±10	Micro inverter	569.873	—	—
2	5	800-1000	50±10	Micro inverter	569.191	0.25	yes

Sample #	0230919-20-17	Test Date (YYYY-MM-DD) start/end			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	570.416	—	—
1	5	800-1000	50±10	Micro inverter	570.390	—	—
2	5	800-1000	50±10	Micro inverter	570.668	0.05	yes
Sample #	0230919-20-18	Test Date (YYYY-MM-DD) start/end			2023-09-20 / 2023-10-08		

Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	568.158	—	—
1	5	800-1000	50±10	Micro inverter	568.942	—	—
2	5	800-1000	50±10	Micro inverter	569.192	0.18	yes
Sample #	0230919-20-19	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	Module temperature (°C)	Resistive load	Pmax (W) at the end of cycle	Pmax – Pmin) / Paverage (%)	Stable (Yes/No)
Initial	—	—	—	—	425.806	—	—
1	5	800-1000	50±10	Micro inverter	424.268	—	—
2	5	800-1000	50±10	Micro inverter	424.616	0.36	yes
Sample #	0230919-20-20	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	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 #	0230919-20-21	Test Date (YYYY-MM-DD) start/end :			2023-09-20 / 2023-10-08		
Test cycle	Integrated irradiation (kWh/m ²)	Irradiance (W/m ²)	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]..... :				2023-10-08			—
Test method..... :				☒ Simulator ☐ Natural sunlight			—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0230919-20-2	52.011	44.246	13.443	12.814	566.990	81.09	—
0230919-20-3	51.732	44.019	13.490	12.861	566.146	81.12	—

0230919-20-4	52.047	44.280	13.456	12.842	568.647	81.19	—
0230919-20-5	51.990	44.144	13.427	12.844	567.001	81.22	—
0230919-20-8	52.101	44.549	13.429	12.834	571.744	81.72	—
0230919-20-9	52.062	44.444	13.459	12.828	570.145	81.37	—
0230919-20-10	51.896	44.162	13.532	12.874	568.543	80.96	—
0230919-20-11	52.211	44.477	13.531	12.858	571.885	80.95	—
0230919-20-12	52.133	44.387	13.505	12.854	570.567	81.04	—
0230919-20-13	51.855	44.007	13.563	12.886	567.078	80.63	—
0230919-20-14	52.097	44.319	13.481	12.821	568.217	80.90	—
0230919-20-15	52.162	44.241	13.516	12.843	568.176	80.59	—
0230919-20-16	51.993	44.406	13.412	12.818	569.191	81.62	—
0230919-20-17	52.053	44.372	13.367	12.861	570.668	82.02	—
0230919-20-18	52.270	44.264	13.506	12.859	569.192	80.63	—
0230919-20-19	38.778	32.951	13.488	12.886	424.616	81.18	—
0230919-20-20	52.306	44.594	13.466	12.858	573.390	81.41	—
0230919-20-21	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]..... :			2023-10-08				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0230919-20-2	51.544	45.132	10.335	9.223	416.234	78.13	—
0230919-20-3	51.609	45.427	10.666	9.162	416.193	75.61	—
0230919-20-4	51.581	44.853	10.579	9.209	413.057	75.70	—
0230919-20-5	51.664	45.407	11.490	9.153	415.601	70.01	—
0230919-20-8	51.610	44.954	10.669	9.278	417.100	75.75	—
0230919-20-9	51.589	45.000	10.516	9.301	418.521	77.15	—
0230919-20-10	51.699	44.873	10.860	9.204	413.004	73.56	—
0230919-20-11	52.013	44.973	10.727	9.359	420.902	75.44	—
0230919-20-12	51.796	44.839	10.815	9.202	412.591	73.65	—
0230919-20-13	51.567	44.868	10.641	9.273	416.076	75.82	—
0230919-20-14	51.617	44.802	10.818	9.128	408.938	73.24	—
0230919-20-15	51.684	44.823	11.073	9.262	415.154	72.54	—
0230919-20-16	51.505	44.994	10.773	9.275	417.312	75.21	—
0230919-20-17	51.469	45.011	10.820	9.299	418.557	75.16	—

0230919-20-18	51.603	45.054	10.512	9.238	416.209	76.73	—
0230919-20-19	38.440	33.441	10.895	9.546	319.226	76.22	—
0230919-20-20	52.185	44.745	10.574	9.316	416.844	75.54	—
0230919-20-21	52.138	44.739	10.573	9.298	415.983	75.46	—
Supplementary information: NA							

1.8. Performance at BNPI after initial stabilization

Test Date [YYYY-MM-DD]..... :			2023-10-08				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0230919-20-2	52.235	44.381	14.900	14.165	628.660	80.77	—
0230919-20-3	52.132	44.385	14.789	14.091	625.428	81.12	—
0230919-20-4	52.349	44.575	15.192	14.083	627.740	78.93	—
0230919-20-5	52.063	44.350	15.153	14.073	624.126	79.11	—
0230919-20-8	52.221	44.493	14.777	14.021	623.852	80.84	—
0230919-20-9	52.189	44.460	14.778	14.027	623.646	80.86	—
0230919-20-10	51.888	43.469	14.524	13.679	594.606	78.90	—
0230919-20-11	51.914	44.442	14.631	13.618	605.211	79.68	—
0230919-20-12	52.230	44.379	14.630	13.880	615.986	80.61	—
0230919-20-13	52.363	44.550	14.606	13.869	617.855	80.78	—
0230919-20-14	52.193	44.240	14.778	14.076	622.734	80.74	—
0230919-20-15	52.287	44.455	14.696	13.996	622.197	80.97	—
0230919-20-16	52.435	44.580	14.721	13.899	619.624	80.27	—
0230919-20-17	52.418	44.578	14.705	13.926	620.793	80.54	—
0230919-20-18	52.107	44.616	14.753	13.979	623.687	81.13	—
0230919-20-19	38.812	32.926	14.851	14.133	465.343	80.73	—
0230919-20-20	52.596	44.761	14.624	13.962	624.940	81.25	—
0230919-20-21	52.668	44.795	14.605	13.935	624.233	81.15	—
Supplementary information: NA							

1.9. Performance at Low irradiance (200w/m²) after initial stabilization

Test Date [YYYY-MM-DD]..... :			2023-10-08				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Result
0230919-20-2	49.088	43.082	2.699	2.588	111.516	84.16	—
0230919-20-3	49.576	42.963	2.703	2.581	110.895	82.76	—
0230919-20-4	49.855	42.783	2.683	2.585	112.080	83.79	—
0230919-20-5	49.973	43.475	2.688	2.566	111.332	82.88	—
0230919-20-8	49.569	43.587	2.693	2.603	112.462	84.24	—
0230919-20-9	49.620	42.875	2.703	2.604	112.376	83.80	—
0230919-20-10	49.130	43.195	2.712	2.583	111.491	83.68	—
0230919-20-11	49.600	43.534	2.712	2.613	112.487	83.64	—
0230919-20-12	49.485	43.446	2.705	2.618	111.774	83.51	—
0230919-20-13	49.262	43.043	2.711	2.629	111.488	83.47	—
0230919-20-14	49.247	42.542	2.702	2.617	112.052	84.20	—
0230919-20-15	49.653	42.839	2.714	2.617	111.760	82.93	—
0230919-20-16	50.114	43.173	2.683	2.574	111.127	82.65	—
0230919-20-17	36.550	31.569	2.677	2.571	81.177	82.98	—
0230919-20-18	49.536	42.845	2.705	2.576	110.388	82.37	—
0230919-20-21	49.659	43.336	2.681	2.565	111.147	83.48	—
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-MNG144(HCBF)-570W	0230919-20-2	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-3	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·m².

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-MNG144(HCBF)-570W	0230919-20-2	10	15.5	Pass
		0230919-20-3	10	15.5	Pass
Post-TC200 Testing Data		0230919-20-2	10	15.5	Pass
		0230919-20-3	10	15.5	Pass
Post-TC400 Testing Data		0230919-20-2	10	15.5	Pass
		0230919-20-3	10	15.5	Pass
Post-TC600 Testing Data		0230919-20-2	10	15.5	Pass
		0230919-20-3	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·m².

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-MNG144(HCBF)-570W	0230919-20-2	10	15.5	Pass
		0230919-20-3	10	15.5	Pass
Post-TC200 Testing Data		0230919-20-2	10	15.5	Pass
		0230919-20-3	10	15.5	Pass
Post-TC400 Testing Data		0230919-20-2	10	15.5	Pass
		0230919-20-3	10	15.5	Pass
Post-TC600 Testing Data		0230919-20-2	10	15.5	Pass
		0230919-20-3	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-2				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	52.011	44.246	13.443	12.814	566.990	81.09	—
Pre-HALT Testing Data-Rear Side	51.544	45.132	10.335	9.223	416.234	78.13	—
Pre-HALT Testing Data-BNPI	52.235	44.381	14.900	14.165	628.660	80.77	—
Post-TC200 Testing Data-Front Side	51.765	43.819	13.502	12.869	563.907	80.68	-0.54
Post-TC200 Testing Data-Rear Side	51.332	44.954	10.895	9.197	413.430	73.93	-0.67
Post-TC200 Testing Data-BNPI	52.126	44.256	14.802	14.070	622.680	80.70	-0.95
Post-TC400 Testing Data-Front Side	51.736	43.774	13.488	12.861	562.963	80.68	-0.71
Post-TC400 Testing Data-Rear Side	51.311	44.942	10.896	9.187	412.899	73.85	-0.80
Post-TC400 Testing Data-BNPI	52.078	44.256	14.809	14.059	622.190	80.67	-1.03
Post-TC600 Testing Data-Front Side	51.703	43.707	13.485	12.857	561.946	80.60	-0.89
Post-TC600 Testing Data-Rear Side	51.148	44.745	10.735	9.194	411.399	74.92	-1.16
Post-TC600 Testing Data-BNPI	52.039	44.168	14.815	14.068	621.359	80.60	-1.16

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-3				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	51.732	44.019	13.490	12.861	566.146	81.12	—
Pre-HALT Testing Data-Rear Side	51.609	45.427	10.666	9.162	416.193	75.61	—
Pre-HALT Testing Data-BNPI	52.132	44.385	14.789	14.091	625.428	81.12	—
Post-TC200 Testing Data-Front Side	51.871	44.119	13.379	12.798	564.616	81.36	-0.27
Post-TC200 Testing Data-Rear Side	51.588	45.478	11.074	9.125	414.996	72.65	-0.29
Post-TC200 Testing Data-BNPI	52.079	44.311	14.681	13.988	619.817	81.07	-0.90
Post-TC400 Testing Data-Front Side	52.367	44.449	13.341	12.687	563.939	80.72	-0.39
Post-TC400 Testing Data-Rear Side	51.763	45.358	10.544	9.169	415.905	76.20	-0.07
Post-TC400 Testing Data-BNPI	52.504	44.654	14.754	13.914	621.313	80.21	-0.66
Post-TC600 Testing Data-Front Side	52.367	44.442	13.321	12.674	563.247	80.74	-0.51
Post-TC600 Testing Data-Rear Side	51.762	45.359	10.526	9.171	416.011	76.35	-0.04
Post-TC600 Testing Data-BNPI	52.502	44.660	14.755	13.909	621.190	80.19	-0.68

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

Test Date [YYYY-MM-DD]..... :		2023-10-08					—
Test method		☒ Simulator ☐ Natural sunlight					—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0230919-20-2	49.285	42.791	2.690	2.582	110.481	83.33	-0.93%
0230919-20-3	49.335	42.730	2.677	2.565	109.602	83.01	-1.17%

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	
0230919-20-2	Yes	Yes	Yes	Pass
0230919-20-3	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-MNG144(HCBF)-570W	0230919-20-4	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-5	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·m².

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-MNG144(HCBF)-570W	0230919-20-4	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-5	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-4	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-5	10	15.5	Pass
Post-DH2000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-4	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-5	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·m².

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-MNG144(HCBF)-570W	0230919-20-4	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-5	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-4	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-5	10	15.5	Pass
Post-DH2000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-4	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-5	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-4				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	52.047	44.280	13.456	12.842	568.647	81.19	—
Pre-HALT Testing Data-Rear Side	51.581	44.853	10.579	9.209	413.057	75.70	—
Pre-HALT Testing Data-BNPI	52.349	44.575	15.192	14.083	627.740	78.93	—
Post-DH1000 Testing Data-Front Side	52.052	44.316	13.385	12.811	567.722	81.49	-0.16
Post-DH1000 Testing Data-Rear Side	51.584	44.914	11.118	9.323	418.717	73.01	1.37
Post-DH1000 Testing Data-BNPI	52.200	44.413	15.198	14.082	625.445	78.84	-0.37
Post- DH2000 Testing Data-Front Side	51.845	44.082	13.491	12.861	566.942	81.06	-0.30
Post- DH2000 Testing Data-Rear Side	51.398	44.944	11.041	9.203	413.600	72.89	0.13
Post- DH2000 Testing Data-BNPI	52.172	44.381	15.184	14.063	624.132	78.79	-0.57

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-5				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	51.990	44.144	13.427	12.844	567.001	81.22	—
Pre-HALT Testing Data-Rear Side	51.664	45.407	11.490	9.153	415.601	70.01	—
Pre-HALT Testing Data-BNPI	52.063	44.350	15.153	14.073	624.126	79.11	—

Post-DH1000 Testing Data-Front Side	51.975	44.293	13.401	12.796	566.790	81.37	-0.04
Post-DH1000 Testing Data-Rear Side	51.584	45.362	11.353	9.144	414.781	70.83	-0.20
Post-DH1000 Testing Data-BNPI	52.133	44.385	14.753	14.039	623.105	81.02	-0.16
Post- DH2000 Testing Data-Front Side	51.776	44.001	13.477	12.852	565.511	81.04	-0.26
Post- DH2000 Testing Data-Rear Side	51.379	44.940	11.086	9.195	413.226	72.55	-0.57
Post- DH2000 Testing Data-BNPI	52.141	44.352	15.174	14.069	623.998	78.87	-0.02

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

Test Date [YYYY-MM-DD]..... :			2023-10-08				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0230919-20-4	49.305	42.822	2.688	2.578	110.388	83.31	-1.51
0230919-20-5	49.755	42.652	2.672	2.606	110.168	82.86	-1.05

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	
0230919-20-4	Yes	Yes	Yes	Pass
0230919-20-5	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	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-DH1000 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-UV 65 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post- TC50 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-HF10 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-UV 130 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post- TC100 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-HF20 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-UV 195 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post- TC150 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-HF30 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	No major visible defect	Pass
Post-UV 6.5 Testing Data	0230919-20-6	No major visible defect	Pass
	0230919-20-7	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·m².

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-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 65 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post- TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 130 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post- TC100 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-HF20 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 195 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post- TC150 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-HF30 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 6.5 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	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·m².

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-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-DH1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 65 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post- TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 130 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post- TC100 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-HF20 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 195 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post- TC150 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-HF30 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	10	15.5	Pass
Post-UV 6.5 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-6	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-7	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-MNG144(HCBF)-570W	0230919-20-8	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-9	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·m².

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-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Pre-HALT Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-SML Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-SML Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	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·m².

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-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Pre-HALT Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-SML Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-SML Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-DML 1000 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	10	15.5	Pass
Post-HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-8	10	15.5	Pass
Post-HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-9	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-8				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	52.101	44.549	13.429	12.834	571.744	81.72	—
Pre-HALT Testing Data-Rear Side	51.610	44.954	10.669	9.278	417.100	75.75	—
Pre-HALT Testing Data-BNPI	52.221	44.493	14.777	14.021	623.852	80.84	—
Post-SML Testing Data-Front Side	52.062	44.470	13.450	12.837	570.858	81.52	-0.15
Post-SML Testing Data-Rear Side	51.601	45.401	11.321	9.200	417.697	71.50	0.14
Post-SML Testing Data-BNPI	52.194	44.502	14.769	14.012	623.558	80.89	-0.05
Post-DML1000 Testing Data-Front Side	52.114	44.551	13.417	12.820	571.120	81.68	-0.11
Post-DML1000 Testing Data-Rear Side	51.621	44.849	11.302	9.309	417.500	71.56	0.10
Post-DML1000 Testing Data-BNPI	52.196	44.498	14.779	14.029	624.238	80.92	0.06
Post-TC50 Testing Data-Front Side	52.057	44.460	13.376	12.727	565.859	81.27	-1.03
Post-TC50 Testing Data-Rear Side	51.603	45.399	11.316	9.199	417.636	71.52	0.13

Post-TC50 Testing Data-BNPI	52.256	44.592	14.759	13.944	621.799	80.62	-0.33
Post-HF10 Testing Data-Front Side	51.965	44.287	13.286	12.635	559.550	81.05	-2.13
Post-HF10 Testing Data-Rear Side	51.595	45.065	10.566	9.161	412.837	75.73	-1.02
Post-HF10 Testing Data-BNPI	52.086	44.426	14.754	13.825	614.198	79.92	-1.55

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-9				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	52.062	44.444	13.459	12.828	570.145	81.37	—
Pre-HALT Testing Data-Rear Side	51.589	45.000	10.516	9.301	418.521	77.15	—
Pre-HALT Testing Data-BNPI	52.189	44.460	14.778	14.027	623.646	80.86	—
Post-SML Testing Data-Front Side	51.967	44.388	13.468	12.831	569.532	81.37	-0.11
Post-SML Testing Data-Rear Side	51.484	45.331	10.351	9.231	418.464	78.53	-0.01
Post-SML Testing Data-BNPI	52.205	44.098	14.787	14.137	623.401	80.76	-0.04
Post-DML1000 Testing Data-Front Side	52.106	44.416	13.469	12.814	569.139	81.10	-0.18
Post-DML1000 Testing Data-Rear Side	51.605	45.403	11.315	9.198	417.601	71.52	-0.22
Post-DML1000 Testing Data-BNPI	52.192	44.298	14.777	14.107	624.923	81.03	0.20
Post-TC50 Testing Data-Front Side	52.060	44.338	13.379	12.740	564.884	81.10	-0.92
Post-TC50 Testing Data-Rear Side	51.606	45.409	11.308	9.205	418.005	71.63	-0.12
Post-TC50 Testing Data-BNPI	52.254	44.535	14.830	13.938	620.737	80.10	-0.47
Post-HF10 Testing Data-Front Side	51.991	44.304	13.275	12.631	559.611	81.08	-1.85
Post-HF10 Testing Data-Rear Side	11.248	9.137	51.641	45.444	415.222	71.49	-0.79
Post-HF10 Testing Data-BNPI	52.098	44.399	14.686	13.826	613.877	80.24	-1.57

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

Test Date [YYYY-MM-DD]..... :				2023-10-08			—
Test method				☒ Simulator ☐ Natural sunlight			—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0230919-20-8	49.398	42.795	2.661	2.581	110.468	84.04	-1.77
0230919-20-9	49.300	42.819	2.689	2.579	110.443	83.30	-1.72

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	
0230919-20-8	Yes	Yes	Yes	Pass
0230919-20-9	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-MNG144(HCBF)-570W	0230919-20-10	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-11	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-12	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-13	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·m².

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-MNG144(HCBF)-570W	0230919-20-10	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-11	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-12	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-13	10	15.5	Pass
Post-PID96 (-) Testing Data	PS-MNG144(HCBF)-570W	0230919-20-10	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-11	10	15.5	Pass
Post-PID96 (+) Testing Data	PS-MNG144(HCBF)-570W	0230919-20-12	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-13	10	15.5	Pass
Post-PID192 (-) Testing Dat	PS-MNG144(HCBF)-570W	0230919-20-10	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-11	10	15.5	Pass
Post-PID192 (+) Testing Data	PS-MNG144(HCBF)-570W	0230919-20-12	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-13	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·m².

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-MNG144(HCBF)-570W	0230919-20-10	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-11	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-12	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-13	10	15.5	Pass
Post-PID96 (-) Testing Data	PS-MNG144(HCBF)-570W	0230919-20-10	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-11	10	15.5	Pass
Post-PID96 (+) Testing Data	PS-MNG144(HCBF)-570W	0230919-20-12	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-13	10	15.5	Pass
Post-PID192 (-) Testing Dat	PS-MNG144(HCBF)-570W	0230919-20-10	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-11	10	15.5	Pass
Post-PID192 (+) Testing Data	PS-MNG144(HCBF)-570W	0230919-20-12	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-13	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-10				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	51.896	44.162	13.532	12.874	568.543	80.96	—
Pre-HALT Testing Data-Rear Side	51.699	44.873	10.860	9.204	413.004	73.56	—
Pre-HALT Testing Data-BNPI	51.888	43.469	14.524	13.679	594.606	78.90	—
Post-PID96 (-) Testing Data-Front Side	51.744	44.082	13.472	12.748	561.957	80.61	-1.16
Post-PID96 (-) Testing Data-Rear Side	51.251	44.495	10.554	9.088	404.371	74.76	-2.09
Post-PID96 (-) Testing Data-BNPI	51.915	43.526	14.511	13.678	595.349	79.03	0.12
Post-PID192 (-) Testing Data-Front Side	51.721	43.504	13.219	12.588	547.628	80.10	-3.68
Post-PID192 (-) Testing Data-Rear Side	51.298	44.824	10.675	9.018	404.223	73.82	-2.13

Post-PID192 (-) Testing Data-BNPI	52.418	44.679	14.442	13.344	596.197	78.76	0.27
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Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-11				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	52.211	44.477	13.531	12.858	571.885	80.95	—
Pre-HALT Testing Data-Rear Side	52.013	44.973	10.727	9.359	420.902	75.44	—
Pre-HALT Testing Data-BNPI	51.914	44.442	14.631	13.618	605.211	79.68	—
Post-PID96 (-) Testing Data-Front Side	52.146	44.373	13.403	12.733	565.010	80.84	-1.20
Post-PID96 (-) Testing Data-Rear Side	51.912	45.464	11.085	9.241	420.126	73.01	-0.18
Post-PID96 (-) Testing Data-BNPI	52.393	44.632	14.418	13.449	600.256	79.46	-0.82
Post-PID192 (-) Testing Data-Front Side	51.751	43.616	13.329	12.517	545.944	79.15	-4.54
Post-PID192 (-) Testing Data-Rear Side	51.317	44.601	10.893	9.145	407.870	72.96	-3.10
Post-PID192 (-) Testing Data-BNPI	52.310	44.536	14.365	13.448	598.941	79.71	-1.04

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-12				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	52.133	44.387	13.505	12.854	570.567	81.04	—
Pre-HALT Testing Data-Rear Side	51.796	44.839	10.815	9.202	412.591	73.65	—
Pre-HALT Testing Data-BNPI	52.230	44.379	14.630	13.880	615.986	80.61	—
Post-PID96 (-) Testing Data-Front Side	52.212	44.548	13.375	12.707	566.089	81.06	-0.78
Post-PID96 (-) Testing Data-Rear Side	51.763	44.961	11.373	9.194	413.379	70.22	0.19

Post-PID96 (-) Testing Data-BNPI	52.158	44.340	14.639	13.928	617.556	80.88	0.25
Post-PID192 (-) Testing Data-Front Side	52.127	44.438	13.312	12.636	561.530	80.92	-1.58
Post-PID192 (-) Testing Data-Rear Side	51.751	44.933	11.098	9.095	408.641	71.15	-0.96
Post-PID192 (-) Testing Data-BNPI	52.249	44.385	14.626	13.889	616.453	80.66	0.08

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-13				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	51.855	44.007	13.563	12.886	567.078	80.63	—
Pre-HALT Testing Data-Rear Side	51.567	44.868	10.641	9.273	416.076	75.82	—
Pre-HALT Testing Data-BNPI	52.363	44.550	14.606	13.869	617.855	80.78	—
Post-PID96 (-) Testing Data-Front Side	52.162	44.493	13.403	12.721	566.018	80.96	-0.19
Post-PID96 (-) Testing Data-Rear Side	51.715	45.108	11.026	9.202	415.072	72.80	-0.24
Post-PID96 (-) Testing Data-BNPI	52.220	44.510	14.630	13.915	619.379	81.07	0.25
Post-PID192 (-) Testing Data-Front Side	52.163	44.491	13.305	12.632	562.021	80.98	-0.89
Post-PID192 (-) Testing Data-Rear Side	51.810	44.995	10.817	9.114	410.108	73.18	-1.43
Post-PID192 (-) Testing Data-BNPI	52.380	44.578	14.603	13.876	618.567	80.87	0.12

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

Test Date [YYYY-MM-DD]..... :			2023-10-08				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0230919-20-10	48.382	42.612	2.640	2.552	108.746	85.14	-2.46
0230919-20-11	49.376	42.717	2.675	2.562	109.455	82.88	-2.70

0230919-20-12	49.099	42.418	2.658	2.589	109.820	84.15	-1.75
0230919-20-13	49.151	42.373	2.660	2.554	108.203	82.76	-2.95

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	
0230919-20-10	Yes	Yes	Yes	Pass
0230919-20-11	Yes	Yes	Yes	Pass
0230919-20-12	Yes	Yes	Yes	Pass
0230919-20-13	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-MNG144(HCBF)-570W	0230919-20-14	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-15	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·m².

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-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-15	10	15.5	Pass
Post-LeTID162 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-15	10	15.5	Pass
Post-LeTID324 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-15	10	15.5	Pass
Post-LeTID486 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-15	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·m².

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-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-15	10	15.5	Pass
Post-LeTID162	PS-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass

Testing Data	PS-MNG144(HCBF)-570W	0230919-20-15	10	15.5	Pass
Post-LeTID324 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-15	10	15.5	Pass
Post-LeTID486 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-14	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-15	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-14				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	52.097	44.319	13.481	12.821	568.217	80.90	—
Pre-HALT Testing Data-Rear Side	51.617	44.802	10.818	9.128	408.938	73.24	—
Pre-HALT Testing Data-BNPI	52.193	44.240	14.778	14.076	622.734	80.74	—
Post-LeTID162 Testing Data-Front Side	52.234	44.491	13.491	12.841	571.319	81.07	0.55
Post-LeTID162 Testing Data-Rear Side	51.755	44.756	10.650	9.066	405.754	73.61	-0.78
Post-LeTID162 Testing Data-BNPI	52.194	44.230	14.781	14.103	623.765	80.85	0.17
Post-LeTID324 Testing Data-Front Side	51.993	44.269	13.516	12.867	569.595	81.05	0.24
Post-LeTID324 Testing Data-Rear Side	51.610	44.734	11.013	9.068	405.663	71.37	-0.80
Post-LeTID324 Testing Data-BNPI	52.196	44.219	14.775	14.100	623.503	80.85	0.12
Post-LeTID486 Testing Data-Front Side	52.302	44.686	13.508	12.849	574.170	81.27	1.05
Post-LeTID486 Testing Data-Rear Side	51.806	45.215	10.629	9.168	414.514	75.28	1.36
Post-LeTID486 Testing Data-BNPI	52.300	44.459	14.799	14.090	626.419	80.94	0.59

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-15				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	52.162	44.241	13.516	12.843	568.176	80.59	—
Pre-HALT Testing Data-Rear Side	51.684	44.823	11.073	9.262	415.154	72.54	—
Pre-HALT Testing Data-BNPI	52.287	44.455	14.696	13.996	622.197	80.97	—
Post-LeTID162 Testing Data-Front Side	52.206	44.408	13.531	12.842	570.284	80.73	0.37
Post-LeTID162 Testing Data-Rear Side	51.732	45.034	10.374	9.195	414.097	77.16	-0.25
Post-LeTID162 Testing Data-BNPI	52.287	44.431	14.683	13.986	621.410	80.94	-0.13
Post-LeTID324 Testing Data-Front Side	52.351	44.712	13.520	12.857	574.871	81.22	1.18
Post-LeTID324 Testing Data-Rear Side	51.878	45.289	10.725	9.254	419.105	75.32	0.95
Post-LeTID324 Testing Data-BNPI	52.302	44.462	14.799	14.100	626.916	80.99	0.76
Post-LeTID486 Testing Data-Front Side	52.175	44.470	13.530	12.835	570.765	80.86	0.46
Post-LeTID486 Testing Data-Rear Side	51.696	44.937	10.709	9.255	415.883	75.12	0.18
Post-LeTID486 Testing Data-BNPI	52.291	44.378	14.704	14.005	621.538	80.84	-0.11

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

Test Date [YYYY-MM-DD]..... :				2023-10-08			—
Test method				☒ Simulator ☐ Natural sunlight			—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0230919-20-14	49.313	42.815	2.707	2.616	111.995	83.90	-0.05
0230919-20-15	49.514	42.832	2.717	2.606	111.619	82.97	-0.13

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	
0230919-20-14	Yes	Yes	Yes	Pass
0230919-20-15	Yes	Yes	Yes	Pass

8. Hail Stress Sequence Test

8.1. Hail Test

Sample #	0230919-20-16						—
Ice ball size [mm]	1	2	3	4	5	6	—
	44.9	44.8	45.5	45.2	45.0	44.9	
	7	8	9	10	11		
	44.8	45.3	44.7	44.9	45.1		
Ice ball weight [g]	1	2	3	4	5	6	—
	44.03	44.06	44.43	44.14	44.17	44.0	
	7	8	9	10	11		
	44.19	43.83	43.8	43.93	44.26		
Ice ball velocity [m/s]	1	2	3	4	5	6	—
	30.3	30.2	31.2	30.7	30.5	31.12	
	7	8	9	10	11		
	30.4	31.2	30.8	30.5	30.6		
Number of impact locations	11						—

Sample #	0230919-20-17						—
Ice ball size [mm]	1	2	3	4	5	6	—
	44.7	45.2	44.7	45.0	44.9	45.6	
	7	8	9	10	11		
	45.2	45.5	45.1	44.9	45.1		
Ice ball weight [g]	1	2	3	4	5	6	—
	43.91	44.03	44.17	43.52	43.95	44.3	
	7	8	9	10	11		
	44.29	44.28	44.26	43.82	43.83		
Ice ball velocity [m/s]	1	2	3	4	5	6	—
	31.1	30.9	30.9	30.8	30.5	30.6	
	7	8	9	10	11		
	31.1	30.5	30.8	30.6	30.3		
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-MNG144(HCBF)-570W	0230919-20-16	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-17	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·m².

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-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass
Post-Hail Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass
Post-DML Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass
Post-TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass
Post- HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	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·m².

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-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass
Post-Hail Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass
Post-DML Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass
Post-TC50 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	10	15.5	Pass

Post- HF10 Testing Data	PS-MNG144(HCBF)-570W	0230919-20-16	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-17	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-16				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	51.993	44.406	13.412	12.818	569.191	81.62	—
Pre-HALT Testing Data-Rear Side	51.505	44.994	10.773	9.275	417.312	75.21	—
Pre-HALT Testing Data-BNPI	52.435	44.580	14.721	13.899	619.624	80.27	—
Post-Hail Testing Data-Front Side	51.993	44.406	13.412	12.818	569.191	81.62	0.00%
Post-Hail Testing Data-Rear Side	51.505	44.994	10.773	9.275	417.312	75.21	0.00%
Post-Hail Testing Data-BNPI	52.441	44.599	14.744	13.911	620.424	80.24	0.13%
Post-DML Testing Data-Front Side	51.974	44.363	13.446	12.814	568.474	81.34	-0.13%
Post-DML Testing Data-Rear Side	51.492	44.776	11.305	9.176	410.867	70.58	-1.54%
Post-DML Testing Data-BNPI	52.445	44.594	14.733	13.898	619.754	80.21	0.02%
Post-TC50 Testing Data-Front Side	51.799	44.194	13.486	12.844	567.631	81.26	-0.27%
Post-TC50 Testing Data-Rear Side	51.358	44.994	10.536	9.263	416.766	77.02	-0.13%
Post-TC50 Testing Data-BNPI	52.452	44.600	14.732	13.886	619.301	80.14	-0.05%
Post-HF10 Testing Data-Front Side	51.800	44.212	13.411	12.750	563.703	81.15	-0.96%
Post-HF10 Testing Data-Rear Side	51.441	44.985	10.501	9.201	413.907	76.63	-0.82%

Post-HF10 Testing Data-BNPI	52.471	44.593	14.740	13.793	615.072	79.53	-0.73%
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Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-17				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	52.053	44.372	13.367	12.861	570.668	82.02	—
Pre-HALT Testing Data-Rear Side	51.469	45.011	10.820	9.299	418.557	75.16	—
Pre-HALT Testing Data-BNPI	52.418	44.578	14.705	13.926	620.793	80.54	—
Post-Hail Testing Data-Front Side	51.903	44.424	13.415	12.802	569.191	81.75	-0.26%
Post-Hail Testing Data-Rear Side	51.599	44.932	10.811	9.292	417.312	74.81	-0.30%
Post-Hail Testing Data-BNPI	52.526	44.645	14.712	13.897	620.432	80.29	-0.06%
Post-DML Testing Data-Front Side	51.799	44.194	13.486	12.844	567.631	81.26	-0.53%
Post-DML Testing Data-Rear Side	51.358	44.994	10.536	9.263	416.766	77.02	-0.43%
Post-DML Testing Data-BNPI	52.020	44.179	14.809	14.072	621.703	80.70	0.15%
Post-TC50 Testing Data-Front Side	51.974	44.363	13.446	12.814	568.474	81.35	-0.38%
Post-TC50 Testing Data-Rear Side	51.492	44.776	11.305	9.176	410.867	70.58	-1.84%
Post-TC50 Testing Data-BNPI	52.131	44.118	14.766	14.038	619.321	80.46	-0.24%
Post-HF10 Testing Data-Front Side	51.967	44.377	13.398	12.726	564.742	81.12	-1.04%
Post-HF10 Testing Data-Rear Side	51.515	44.832	11.264	9.112	408.510	70.41	-2.40%
Post-HF10 Testing Data-BNPI	52.194	44.132	14.708	13.936	615.024	80.12	-0.93%

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

Test Date [YYYY-MM-DD]..... :			2023-10-08				—
Test method			☒ Simulator ☐ Natural sunlight				—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0230919-20-16	49.266	42.406	2.684	2.571	109.025	82.46	-1.67%
0230919-20-17	49.239	42.265	2.677	2.586	109.313	82.94	-0.70%

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	
0230919-20-16	Yes	Yes	Yes	Pass
0230919-20-17	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
0230919-20-18	low-light behavior measurement, Bifaciality Factor measurement, IAM, Temperature coefficient
0230919-20-19	low-light behavior measurement, Bifaciality Factor measurement

were measured at test conditions: 25°C, and multiple irradiances: 100W/m², 200W/m², 400W/m², 600W/m², 800W/m², 1000W/m², 1100W/m², 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 0230919-20-18:

Gref (W/m ²)	Tref (°C)	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmp (W)
1100	25	52.415	44.512	14.845	14.111	628.114
1000	25	52.270	44.264	13.506	12.859	569.192
800	25	51.661	43.889	10.835	10.308	452.418
600	25	51.137	43.706	8.133	7.756	338.966
400	25	50.557	43.510	5.390	5.159	224.468
200	25	50.114	43.173	2.683	2.574	111.127
100	25	48.907	42.058	1.352	1.293	54.381

Sample 0230919-20-19:

Gref (W/m ²)	Tref (°C)	Voc (V)	Vmp (V)	Isc (A)	Imp (A)	Pmp (W)
1100	25	38.890	32.976	14.821	14.150	466.613
1000	25	38.778	32.951	13.488	12.886	424.616
800	25	38.479	32.877	10.796	10.327	339.522
600	25	38.092	32.725	8.100	7.751	253.659
400	25	37.529	32.373	5.380	5.158	166.981
200	25	36.550	31.569	2.677	2.571	81.177
100	25	35.553	30.641	1.327	1.269	38.872

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	0230919-20-18	0230919-20-19
Rshunt of Measure Model (Ohm)	2700	2700
Rserie (Ohm) of Measured sample	0.172	0.112
Error Measured - Model	0.00%	0.00%
RMS Measured - Model	0.95%	0.07%
Isc/G linear RMS	0.00%	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-MNG144(HCBF)-570W	PS-MNG108(HCBF)-425W
Rshunt (Ohm)	2600	2700
Rserie (Ohm)	0.190	0.135

9.2. Pmpp Temperature Coefficient

Intertek measured Pmpp Temperature coefficient on one sample of PS-MNG144(HCBF)-570W module as specified in IEC61215-2: 2021, since PS-MNG144(HCBF)-570W have same solar cell.

Test conditions:

Temperatures: 25°C, 30°C, 35°C, 40°C, 45°C, 50°C, 55°C

Irradiances: 1000W/m²

Pmpp temperature coefficient = -0.3022%/°C

9.3. IAM determination

IAM data was measured as per IEC 61853-2: 2016.

Model of PS-MNG144(HCBF)-570W and have same type of frontsheet, encapsulate and backsheet, test was performed on representative model 0230919-20-20, and test data was fitted according to analytical function:

$$\pi(\theta) = \frac{1 - \exp\left(\frac{-\cos(\theta)}{A}\right)}{1 - \exp\left(\frac{-1}{A}\right)}$$

Measurement of incidence angle effects					
Test Method.....:			Indoor Method		
Sample #			0230919-20-18		
Angle of incidence (°)	Three Readings	Isc (A)	Sample temperature (°C)	Test irradiance (W/m2)	IAM,τ (θ)
0	1	6.922	25	1000	1.000
	2	6.925	25	1000	
	3	6.925	25	1000	
10	1	6.801	25	1000	0.997
	2	6.797	25	1000	
	3	6.796	25	1000	
20	1	6.423	25	1000	0.987
	2	6.422	25	1000	
	3	6.421	25	1000	
30	1	5.923	25	1000	0.988
	2	5.925	25	1000	
	3	5.930	25	1000	
40	1	5.203	25	1000	0.981
	2	5.202	25	1000	
	3	5.201	25	1000	
45	1	4.826	25	1000	0.985
	2	4.821	25	1000	
	3	4.822	25	1000	
50	1	4.370	25	1000	0.982
	2	4.372	25	1000	
	3	4.371	25	1000	
55	1	3.824	25	1000	0.963
	2	3.827	25	1000	
	3	3.821	25	1000	
60	1	3.363	25	1000	0.972
	2	3.364	25	1000	
	3	3.365	25	1000	
65	1	2.771	25	1000	0.948
	2	2.773	25	1000	
	3	2.778	25	1000	
70	1	2.177	25	1000	0.919
	2	2.179	25	1000	
	3	2.172	25	1000	
75	1	1.497	25	1000	0.834
	2	1.495	25	1000	
	3	1.493	25	1000	
80	1	0.860	25	1000	0.717
	2	0.864	25	1000	

	3	0.862	25	1000	
85	1	0.424	25	1000	0.701
	2	0.425	25	1000	
	3	0.420	25	1000	
-10	1	6.866	25	1000	1.006
	2	6.863	25	1000	
	3	6.860	25	1000	
-20	1	6.495	25	1000	0.998
	2	6.495	25	1000	
	3	6.489	25	1000	
-30	1	6.008	25	1000	1.002
	2	6.011	25	1000	
	3	6.005	25	1000	
-40	1	5.232	25	1000	0.986
	2	5.230	25	1000	
	3	5.231	25	1000	
-45	1	4.890	25	1000	0.999
	2	4.892	25	1000	
	3	4.891	25	1000	
-50	1	4.375	25	1000	0.983
	2	4.371	25	1000	
	3	4.376	25	1000	
-55	1	3.855	25	1000	0.970
	2	3.856	25	1000	
	3	3.851	25	1000	
-60	1	3.347	25	1000	0.967
	2	3.347	25	1000	
	3	3.353	25	1000	
-65	1	2.771	25	1000	0.947
	2	2.772	25	1000	
	3	2.770	25	1000	
-70	1	2.168	25	1000	0.915
	2	2.164	25	1000	
	3	2.169	25	1000	
-75	1	1.498	25	1000	0.837
	2	1.497	25	1000	
	3	1.505	25	1000	
-80	1	0.854	25	1000	0.711
	2	0.858	25	1000	
	3	0.853	25	1000	
-85	1	0.430	25	1000	0.713
	2	0.431	25	1000	
	3	0.429	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

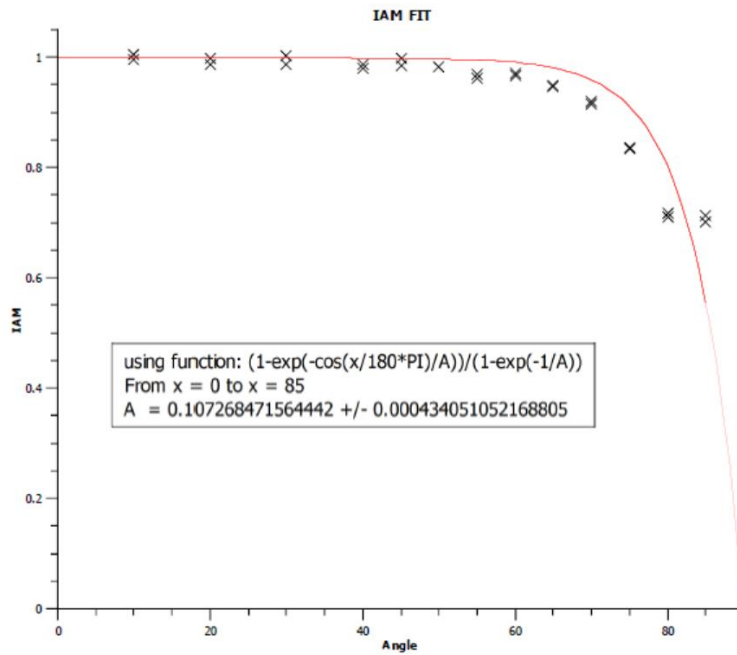
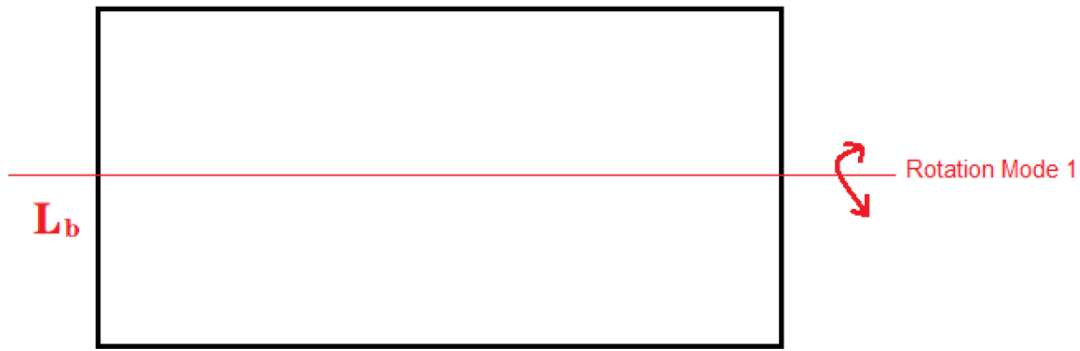


Table 4 IAM Data

Angle [°]	0	40	50	60	65	70	75	80	85
IAM	1.000	0.999	0.998	0.991	0.981	0.959	0.911	0.802	0.557

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
0230919-20-18-Front	52.270	44.264	13.506	12.859	569.192	73.1%
0230919-20-18-Rear	51.603	45.054	10.512	9.238	416.209	
0230919-20-19-Front	38.778	32.951	13.488	12.886	424.616	75.2%
0230919-20-19-Rear	38.440	33.441	10.895	9.546	319.226	

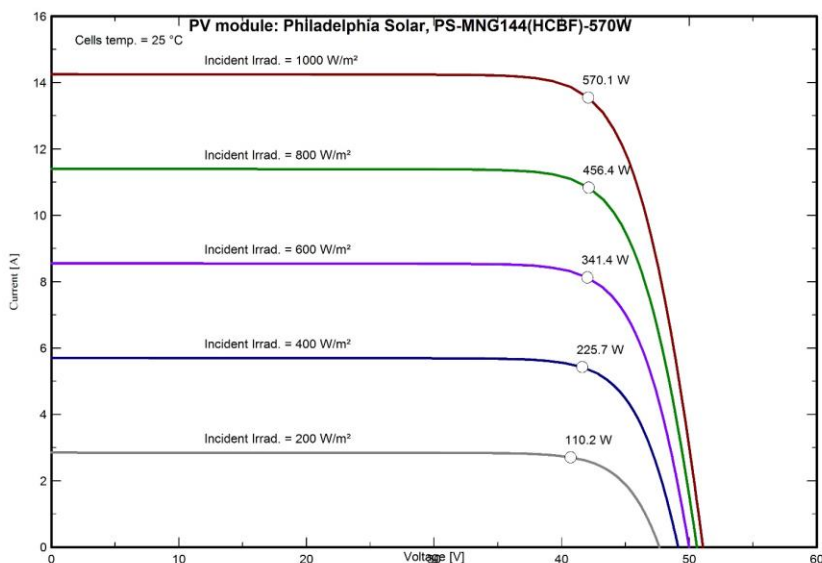


Shanghai Intertek Testing Services Co Ltd., (China)

PVsyst V7.4.2

PV module - PS-MNG144(HCBF)-570W

Manufacturer	Philadelphia Solar	Commercial data	
Model	PS-MNG144(HCBF)-570W	Data source :	Intertek Testing Services
Phom STC power (manufacturer)	570 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 2.278 m ²	Rough module area (A _{module})	2.58 m ²
Number of cells	2 x 72	Sensitive area (cells) (A _{cells})	2.38 m ²
Specifications for the model (manufacturer or measurement data)			
Reference temperature (T _{Ref})	25 °C	Reference irradiance (G _{Ref})	1000 W/m ²
Open circuit voltage (V _{oc})	51.1 V	Short-circuit current (I _{sc})	14.25 A
Max. power point voltage (V _{mpp})	42.3 V	Max. power point current (I _{mpp})	13.48 A
=> maximum power (P _{mpp})	570.1 W	I _{sc} temperature coefficient (μI _{sc})	6.0 mA/°C
One-diode model parameters			
Shunt resistance (R _{shunt})	2700 Ω	Diode saturation current (I _{oRef})	0.471 nA
Serie resistance (R _{serie})	0.19 Ω	V _{oc} temp. coefficient (μV _{oc})	-122 mV/°C
Specified P _{max} temper. coeff. (μP _{MaxR})	-0.30 %/°C	Diode quality factor (Gamma)	1.14
		Diode factor temper. coeff. (μGamma)	0.000 1/°C
Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch			
Reverse characteristics (dark) (B _{Rev})	3.20 mA/V ²	(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 (V _{mpp})	42.1 V	Max. power point current (I _{mpp})	13.54 A
Maximum power (P _{mpp})	570.1 Wp	Power temper. coefficient (μP _{mpp})	-0.30 %/°C
Efficiency(/ Module area) (Eff _{mod})	22.1 %	Fill factor (FF)	0.783
Efficiency(/ Cells area) (Eff _{cells})	23.9 %		

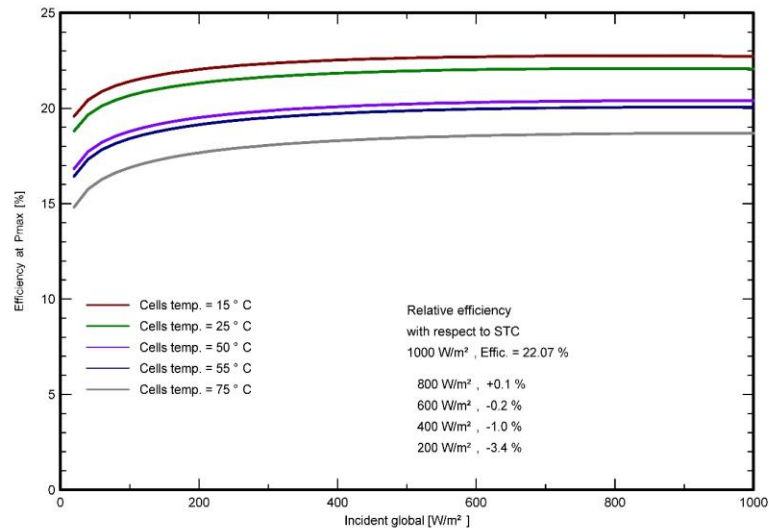




PVsyst V7.4.2

Shanghai Intertek Testing Services Co Ltd., (China)

PV module: Philadelphia Solar, PS-MNG144(HCBF)-570W



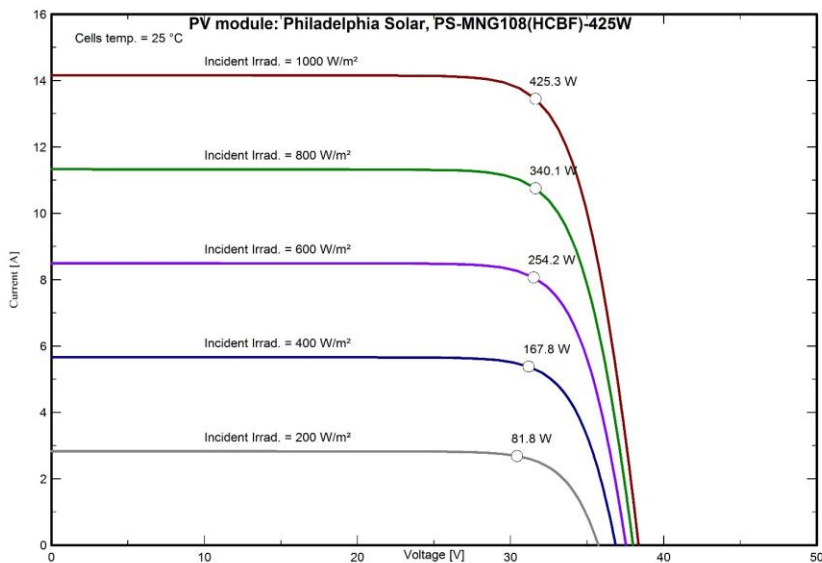


PVsyst V7.4.2

Shanghai Intertek Testing Services Co Ltd., (China)

PV module - PS-MNG108(HCBF)-425W

Manufacturer	Philadelphia Solar	Commercial data	
Model	PS-MNG108(HCBF)-425W	Data source :	Intertek Testing Services
Pnom STC power (manufacturer)	425 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 1.722 m ²	Rough module area (Amodule)	1.95 m ²
Number of cells	2 x 54	Sensitive area (cells) (Acells)	1.79 m ²
Specifications for the model (manufacturer or measurement data)			
Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m ²
Open circuit voltage (Voc)	38.4 V	Short-circuit current (Isc)	14.16 A
Max. power point voltage (Vmpp)	31.7 V	Max. power point current (Impp)	13.42 A
=> maximum power (Pmpp)	425.3 W	Isc temperature coefficient (mulsc)	6.0 mA/°C
One-diode model parameters			
Shunt resistance (Rshunt)	2700 Ω	Diode saturation current (IoRef)	0.945 nA
Series resistance (Rserie)	0.14 Ω	Voc temp. coefficient (MuVoc)	-92 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.30 %/°C	Diode quality factor (Gamma)	1.18
		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/V ²	(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)	31.6 V	Max. power point current (Impp)	13.44 A
Maximum power (Pmpp)	425.3 Wp	Power temper. coefficient (muPmpp)	-0.30 %/°C
Efficiency(/ Module area) (Eff_mod)	21.8 %	Fill factor (FF)	0.783
Efficiency(/ Cells area) (Eff_cells)	23.8 %		

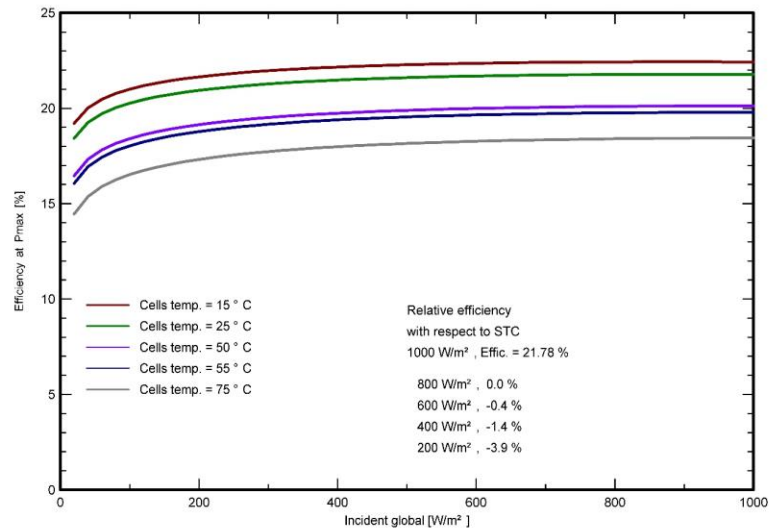




PVsyst V7.4.2

Shanghai Intertek Testing Services Co Ltd., (China)

PV module: Philadelphia Solar, PS-MNG108(HCBF)-425W



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-MNG144(HCBF)-570W	0230919-20-20	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-21	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·m².

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-MNG144(HCBF)-570W	0230919-20-20	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-21	10	15.5	Pass
Post-First Round-UVID Testing Data	PS-MNG144(HCBF)-570W	0230919-20-20	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-21	10	15.5	Pass
Post-Second Round-UVID Testing Data	PS-MNG144(HCBF)-570W	0230919-20-20	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-21	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·m².

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-MNG144(HCBF)-570W	0230919-20-20	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-21	10	15.5	Pass
Post-First Round-UVID Testing Data	PS-MNG144(HCBF)-570W	0230919-20-20	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-21	10	15.5	Pass
Post-Second	PS-MNG144(HCBF)-570W	0230919-20-20	10	15.5	Pass

Round-UVID Testing Data	PS-MNG144(HCBF)-570W	0230919-20-21	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-20				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	9.316	416.844	75.54	—
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	558.145	80.69	-2.66%
Post- First Round UVID Testing Data-Rear Side	51.137	45.416	10.222	9.243	419.780	71.62	0.70%
Post- First Round UVID Testing Data-BNPI	51.173	43.691	14.645	13.929	608.572	81.20	-2.62%
Post- Second Round UVID Testing Data-Front Side	50.666	43.551	13.402	12.785	556.800	82.00	-2.89%
Post- Second Round UVID Testing Data-Rear Side	50.126	45.415	10.216	9.219	418.666	81.76	0.44%
Post- Second Round UVID Testing Data-BNPI	50.837	43.693	14.566	13.899	607.289	82.01	-2.82%

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-21				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	9.298	415.983	75.46	—
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	555.384	80.55	-2.86%
Post- First Round UVID Testing Data-Rear Side	51.110	44.541	10.152	9.243	411.692	72.35	-1.03%
Post- First Round UVID Testing Data-BNPI	51.700	43.742	14.571	13.893	607.708	80.67	-2.65%
Post- Second Round UVID Testing Data-Front Side	50.743	43.481	13.337	12.759	554.774	81.98	-2.97%
Post- Second Round UVID Testing Data-Rear Side	50.099	44.528	9.755	9.182	408.856	83.66	-1.71%
Post- Second Round UVID Testing Data-BNPI	50.838	43.678	14.439	13.885	606.469	82.62	-2.85%

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

Test Date [YYYY-MM-DD]..... :				2023-10-08			—
Test method				☒ Simulator ☐ Natural sunlight			—
Sample #	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]	Pmp degradation from Pre-HALT Testing Data [%]
0230919-20-20	48.888	41.457	2.702	2.609	108.169	81.90	-2.01%
0230919-20-21	48.774	42.111	2.701	2.586	108.884	82.66	-2.04%

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	
0230919-20-20	Yes	Yes	Yes	Pass
0230919-20-21	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-MNG144(HCBF)-570W	0230919-20-22	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-23	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-24	No major visible defect	Pass
PS-MNG144(HCBF)-570W	0230919-20-25	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·m².

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-MNG144(HCBF)-570W	0230919-20-22	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-23	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-24	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-25	10	15.5	Pass
Post-6 months Field Exposure Testing Data	PS-MNG144(HCBF)-570W	0230919-20-22	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-23	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-24	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-25	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·m².

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-MNG144(HCBF)-570W	0230919-20-22	10	15.5	Pass

Testing Data	PS-MNG144(HCBF)-570W	0230919-20-23	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-24	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-25	10	15.5	Pass
Post-6 months Field Exposure Testing Data	PS-MNG144(HCBF)-570W	0230919-20-22	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-23	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-24	10	15.5	Pass
	PS-MNG144(HCBF)-570W	0230919-20-25	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-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-22				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	51.876	13.473	43.903	12.808	562.310	80.45	—
Pre-HALT Testing Data-Rear Side	51.689	10.483	45.575	9.055	412.688	76.16	—
Pre-HALT Testing Data-BNPI	52.082	14.812	43.927	14.075	618.263	80.14	—
Post-6 months Field Exposure Testing Data-Front Side	51.950	13.482	43.921	12.839	563.902	80.51	-0.28%
Post-6 months Field Exposure Testing Data-Rear Side	51.757	10.629	45.203	9.181	415.003	75.44	-0.56%
Post-6 months Field Exposure Testing Data-BNPI	52.130	14.813	44.116	14.088	621.493	80.48	-0.52%

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-23				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	52.082	13.465	44.042	12.808	564.090	80.44	—
Pre-HALT Testing Data-Rear Side	51.673	10.633	45.569	9.087	414.063	75.36	—
Pre-HALT Testing Data-BNPI	52.102	14.808	43.990	14.064	618.686	80.19	—

Post-6 months Field Exposure Testing Data-Front Side	51.958	13.483	43.923	12.854	564.581	80.59	-0.09%
Post-6 months Field Exposure Testing Data-Rear Side	51.754	10.738	45.284	9.173	415.369	74.74	-0.31%
Post-6 months Field Exposure Testing Data-BNPI	52.145	14.812	44.129	14.090	621.787	80.51	-0.50%

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-24				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	52.087	13.461	44.052	12.801	563.912	80.43	—
Pre-HALT Testing Data-Rear Side	51.684	10.639	45.578	9.080	413.855	75.27	—
Pre-HALT Testing Data-BNPI	52.112	14.806	44.016	14.054	618.588	80.17	—
Post-6 months Field Exposure Testing Data-Front Side	51.990	13.484	43.985	12.836	564.612	80.54	-0.12%
Post-6 months Field Exposure Testing Data-Rear Side	51.747	10.708	45.280	9.171	415.278	74.95	-0.34%
Post-6 months Field Exposure Testing Data-BNPI	52.149	14.810	44.153	14.088	622.045	80.54	-0.56%

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-25				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	52.092	13.460	44.056	12.802	563.990	80.44	—
Pre-HALT Testing Data-Rear Side	51.695	10.564	45.640	9.055	413.287	75.68	—
Pre-HALT Testing Data-BNPI	52.118	14.802	44.047	14.046	618.710	80.20	—
Post-6 months Field Exposure Testing Data-Front Side	52.000	13.472	44.002	12.832	564.656	80.60	-0.12%
Post-6 months Field Exposure Testing Data-Rear Side	51.745	10.723	45.309	9.166	415.287	74.84	-0.48%
Post-6 months Field Exposure Testing Data-BNPI	52.157	14.811	44.162	14.085	621.998	80.52	-0.53%

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

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-22				Irradiance: 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	49.099	2.674	42.340	2.565	108.605	82.74	—
Post-6 months Field Exposure Testing Data-Front Side	49.077	2.680	42.371	2.570	108.876	82.78	-0.25%

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-23				Irradiance: 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	49.105	2.674	42.354	2.566	108.676	82.75	—
Post-6 months Field Exposure Testing Data-Front Side	49.074	2.681	42.396	2.570	108.966	82.82	-0.27%

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-24				Irradiance: 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	49.109	2.677	42.318	2.567	108.651	82.66	—
Post-6 months Field Exposure Testing Data-Front Side	49.081	2.681	42.348	2.571	108.868	82.73	-0.20%

Maximum Power Determination Data at STC							
Model: PS-MNG144(HCBF)-570W				Module temperature: 25 [°C]			
Sample No.: 0230919-20-25				Irradiance: 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	49.113	2.674	42.305	2.567	108.590	82.68	—
Post-6 months Field Exposure Testing Data-Front Side	49.086	2.682	42.396	2.571	108.991	82.79	-0.37%

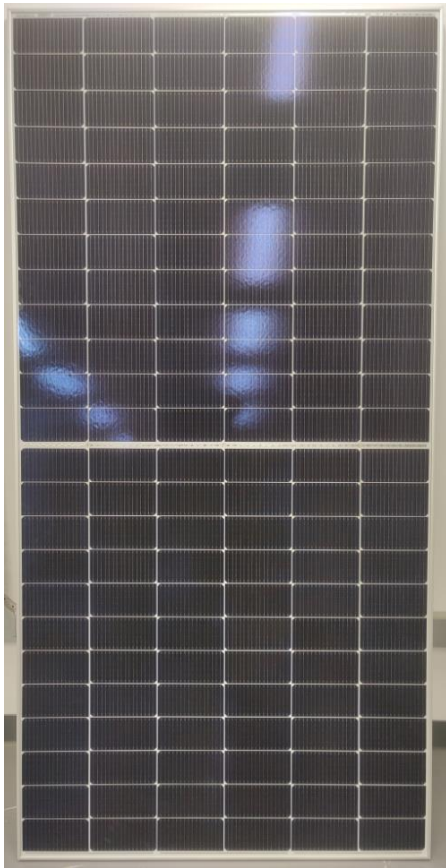
11.6. Bypass diode functionality test

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	
0230919-20-22	Yes	Yes	Yes	Pass
0230919-20-23	Yes	Yes	Yes	Pass
0230919-20-24	Yes	Yes	Yes	Pass
0230919-20-25	Yes	Yes	Yes	Pass

12. APPENDIX A – Photos

Module_PS-MNG144(HCBF)-570W



Module_PS-MNG108(HCBF)-425W



13. APPENDIX B – Product Description Sheet

A1.1	MODULE TYPE/S
	PS-M144(HCBF)-xxxW PS-M108(HCBF)-xxxW

A1.2	SOLAR CELL
	Cell type reference 1: SolarSpace 182 Monocrystalline Bifaical TOPCON Solarspace Technology Co.,Ltd. N type mono crystalline bifacial solar cell 182mm*91mm, 16 busbars 130um±30um
	Cell dimensions L x W (mm).....: 182*91
	Cell thickness (µm).....: 130µm±30µm

A1.3	IDENTIFICATION OF MATERIALS
	Front cover.....: tempered glass with AR coating Xinyi Solar (M)Sdn. Bhd. 2.0mm thickness
	Rear cover: tempered Pattern glass Xinyi Solar (M)Sdn. Bhd. 2.0mm thickness
	Encapsulate (upper side).....: EP304 HANGZHOU FIRST APPLIED MATERIAL CO., LTD Ethylene Vinyl Acetate (E/VAC), 0.5 mm thickness
	Encapsulate (lower side): F406PS HANGZHOU FIRST APPLIED MATERIAL CO., LTD Ethylene Vinyl Acetate (E/VAC), 0.5 mm thickness
	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 0.35m thick, 6mm wide by 0.35m thick

	Cell Connector	Sn 60%/Pb 40 % Taicang Juren International Trade Co., LTD Φ 0.26mm
A1.4	IDENTIFICATION OF COMPONENTS	
	Junction box	PV-GZX306 NINGBO GZX PV TECHNOLOGY CO., LTD.
	Cable	H1Z2Z2-K NINGBO GZX PV TECHNOLOGY CO., LTD.
	Connector	PV-KBT4/6II-UR PV-KST4/6II-UR Stäubli Electrical Connectors AG
	Bypass diode	GF5045E NINGBO GZX PV 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:

$P_m \leq \pm 2.4\%$

$I_{sc} \leq \pm 2.2\%$

$V_{oc} \leq \pm 1.04\%$

The accuracy of reproduction of the measurement with solar simulator is less than 1%.