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Test Report
No. TRPVP01195/24P/02

Commission Testing
Measurement of the luminance of the reflected light
for PV Modules

Applicant: **Tongwei Co., Ltd.**
No. 588, Middle Section Tianfu Avenue, High-Tech Zone,
Chengdu, China (Sichuan) Pilot Free Trade Zone

File No.: PVP01195/24P-02

Designed: Apr. 15, 2024 by: Tony Ye

Reviewed: Apr. 15. 2024 by: Kwan Zhu

Applicant ..... :	**Tongwei Co., Ltd.** No. 588, Middle Section Tianfu Avenue, High-Tech Zone, Chengdu, China (Sichuan) Pilot Free Trade Zone
Manufacturer ..... :	**Tongwei Solar (Hefei) Co., Ltd.** No.888, Changning Road, High-tech District, Hefei City, Anhui Province, 230088, P.R. China
Order No. ..... :	QT-PVP01195/24P
Date of Application ..... :	02/01/2024
Product ..... :	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
Model type(s) ..... :	**Double Glass PV Modules with Half-cut 7" TOPCon Mono-crystalline Silicon Solar Cells:** 132 cells: TWMNH-66HDxxx (xxx = 580-620, in increment of 5) 120 cells: TWMNH-60HDxxx (xxx = 530-560, in increment of 5) 108 cells: TWMNH-54HDxxx (xxx = 475-505, in increment of 5) 108 cells: TWMNH-54HCxxx (xxx = 475-505, in increment of 5) 96 cells: TWMNH-48HDxxx (xxx = 420-450, in increment of 5) 96 cells: TWMNH-48HCxxx (xxx = 420-450, in increment of 5) xxx indicates rated output power generated from front side under STC.
Type of examination ..... :	Commission testing only
Testing Period ..... :	03/21/2023 - 03/22/2023
Testing Laboratory ..... :	**Shanghai Institute of Quality Inspection and Technical Research** No. 900, Jiangyue Road, Minhang District, Shanghai 201114, China

Test results listed in this test report refer exclusively to the mentioned test sample.

The submitted test samples as described in the reports hereunder are tested based on the requirements:

CS-ADR-DSN, Issue 2, 29 January 2015 “Certification Specifications and Guidance Material for Aerodromes Design”

List of contents

Summary of testing

According to the enquiry of the applicant and specific protocol, a commission testing was performed according to CS-ADR-DSN, testing items are listed in page 6 in this report.

The purpose of the test is to determine the highest luminance of the reflected sunlight from a PV module when it is illuminated by a sun simulated light source.

Reflected luminance values have to be compared to the limit values of 10000 cd/m² or 20000cd/m² according on the location of photovoltaic project in relation to the airfield. The related information can be find on CS-ADR-DSN, Issue 2, 29 January 2015 “Certification Specifications and Guidance Material for Aerodromes Design” from European Aviation Safety Agency.

The small modules with dimension of 300mm x 300mm as the representative sample were delivered to testing lab as test samples and conducted with all the related tests.

The representative samples include all the key materials and subassemblies of the module, except for some components do not affect the results of the test like frame/J-BOX/adhesive.

According to the declaration of applicant, the following module types can be considered met the test sample.

Double Glass PV Modules with Half-cut 7" TOPCon Mono-crystalline Silicon Solar Cells:

132 cells: TWMNH-66HDxxx (xxx = 580-620, in increment of 5)

120 cells: TWMNH-60HDxxx (xxx = 530-560, in increment of 5)

108 cells: TWMNH-54HDxxx (xxx = 475-505, in increment of 5)

108 cells: TWMNH-54HCxxx (xxx = 475-505, in increment of 5)

96 cells: TWMNH-48HDxxx (xxx = 420-450, in increment of 5)

96 cells: TWMNH-48HCxxx (xxx = 420-450, in increment of 5)

xxx indicates rated output power generated from front side under STC.

The maximum of reflected luminance can be measured at a certain mounting angle, and it tends to become smaller when the angle changes. After the changing tendency of values is determined, no further test will be operated.

The luminance values of the tested sample are higher than 20000 cd/m². Data need to be re-evaluated depending on the geographic features of the PV project.

Testing procedure

Testing sample: TWMNH-xxHDxxx, TWMNH-xxHCxxx

☐	Random sampling from production
☒	Prototype submitted by client

Supplementary information:

According to the declaration of applicant, the sample represent the following module types:

Double Glass PV Modules with Half-cut 7" TOPCon Mono-crystalline Silicon Solar Cells:

132 cells: TWMNH-66HDxxx (xxx = 580-620, in increment of 5)

120 cells: TWMNH-60HDxxx (xxx = 530-560, in increment of 5)

108 cells: TWMNH-54HDxxx (xxx = 475-505, in increment of 5)

108 cells: TWMNH-54HCxxx (xxx = 475-505, in increment of 5)

96 cells: TWMNH-48HDxxx (xxx = 420-450, in increment of 5)

96 cells: TWMNH-48HCxxx (xxx = 420-450, in increment of 5)

xxx indicates rated output power generated from front side under STC.

Module group assignment

Sample #	Serial number	Dimension (l x w) [mm]	Remark
1	N/A	300 x 300	reflected light test

Test program

The sample is placed on a goniometer (figure 1):

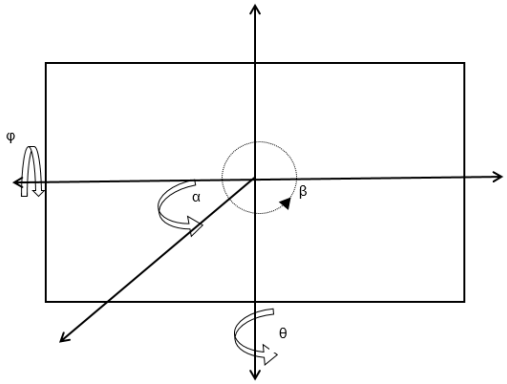


Figure 1: Goniometer. Angles identification

- α angle is defined the light source direction relative to the normal to the module surface
- θ angle is the site position.
- φ angle is the azimuth position.
- β is the module rotation angle relative to its normal.

All sides of the sample are covered with black tape, and only cell, interconnection and spacing of cells are retained.

The reflected luminances are measured under the following condition:

- The light source is a collimated light beam with uniform illumination.
- Set up projection lights at each point as shown in Figure 2. And the reflected luminance is determined considering the illuminance value of direct sunlight, which is >100000 lux.
- The direction β=0 in the figure 1 was tested, and the reflected luminance values of other directions did not exceed that direction.
- At each point of light source shown in Figure 2, the reflected luminance values of the sample surface at each angle were measured and recorded at 5° step in the interval around the maximum visual luminance according to θ and φ shown in Figure 1.
- Near the maximum reflected luminance values of each point, the reflected luminance values were measured and recorded at 1° (or 2°) step according to θ and φ shown in Figure 1.

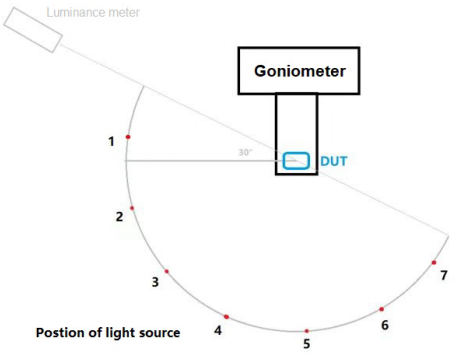


Figure 2: Schematic diagram of test process

Test results

Point 1 of light source shown in Figure 2, α=20°

θ \ φ	-20	-15	-10	-5	0	5	10	15	20
-5	799	849	925	1155	2000	998	884	827	782
0	827	885	984	1251	2330	1101	930	861	807
5	847	922	1068	1606	9600	1340	1005	893	829
10	857	928	1068	1636	6440	1347	1007	899	837
15	859	919	1022	1270	2680	1187	983	900	841
20	850	906	980	1178	2460	1116	965	892	837
25	837	887	956	1137	2550	1096	940	875	823
30	819	867	926	1093	2500	1086	920	858	810

θ \ φ	-5	-4	-3	-2	-1	0	1	2	3	4	5
3	1411	1616	2010	2830	3760	3140	2230	1769	1492	1318	1211
4	1498	1795	2400	3680	5140	4360	2820	2030	1628	1403	1256
5	1597	2050	3340	6910	11730	9480	4590	2510	1801	1494	1319
6	1742	2440	5310	18000	44800	31100	9110	3310	2020	1611	1395
7	1870	2820	7450	35900	112300	72500	14750	4020	2240	1724	1455
8	1910	2820	6930	28300	81700	54600	12850	3910	2250	1716	1439
9	1765	2390	4610	12170	23600	17710	6910	3050	2020	1603	1384
10	1622	2030	3030	5280	7820	6760	3830	2380	1804	1511	1335

Point 2 of light source shown in Figure 2, α=45°

θ \ φ	-20	-15	-10	-5	0	5	10	15	20
5	638	685	748	956	1737	818	718	658	619
10	685	738	814	1034	1981	916	775	711	658
15	722	791	899	1235	2980	1066	842	755	697
20	758	835	983	1745	62200	1335	919	794	728
25	767	835	944	1261	2870	1124	896	805	742
30	774	832	913	1122	2380	1058	892	812	754
35	776	832	907	1103	2520	1056	887	815	759
40	764	815	889	1061	2520	1048	872	806	753

θ \ φ	-5	-4	-3	-2	-1	0	1	2	3	4	5
15	1239	1419	1778	2510	3370	2900	2020	1584	1327	1169	1064
16	1310	1559	2050	3110	4410	3840	2510	1820	1451	1244	1121
17	1482	1758	2710	5190	8740	7480	3890	2250	1624	1341	1176
18	1526	2860	3990	11910	29800	22600	7660	2980	1858	1462	1256
19	1666	2410	5710	25600	85400	61500	13510	3770	2090	1582	1328
20	1748	2530	5950	25600	84900	62100	13730	3860	2140	1608	1333
21	1641	2250	4440	13170	30300	23600	8110	3160	1960	1531	1292
22	1511	1918	3010	5870	9610	8370	4360	2460	1769	1433	1241
23	1416	1702	2260	3370	4750	4420	2910	2050	1598	1352	1206
24	1331	1554	1980	2550	3440	3290	2370	1804	1479	1286	1163
25	1267	1448	1714	2200	2940	2870	2120	1688	1483	1239	1129

Point 3 of light source shown in Figure 2, α=70°

θ \ φ	-20	-15	-10	-5	0	5	10	15	20
20	547	593	662	876	1638	738	625	574	530
25	602	659	756	1023	2050	881	706	634	584
30	650	724	874	1493	16050	1159	804	693	631
35	688	762	907	1472	5770	1182	850	730	660
40	700	764	873	1155	2410	1042	838	749	687
45	708	768	852	1079	2250	1080	838	759	700
50	698	761	845	1075	2410	1003	828	753	693
55	674	737	814	1023	2330	993	808	735	672
60	630	694	779	993	2340	983	774	691	626

θ \ φ	-5	-4	-3	-2	-1	0	1	2	3	4	5
28	2351	1506	2020	3030	3960	3460	2320	1691	1353	1152	1020
29	1357	1752	2710	4840	7110	3120	3460	2080	1519	1249	1090
30	1500	2130	4250	10770	20200	16090	6610	2810	1742	1363	1160
31	1670	2640	6800	26100	65900	46400	12620	3780	2030	1501	1248
32	1804	2970	8460	37300	101900	69900	16290	4320	2210	1605	1298
33	1784	2790	6880	23400	52600	38000	11490	3750	2100	1544	1271
34	1614	2280	4360	9990	16600	13300	6040	2870	1870	1461	1229
35	1477	1912	2870	4710	6590	5780	3510	2240	1667	1364	1182
36	1374	1683	2180	3080	3940	3680	2610	1900	1516	1295	1146

Point 4 of light source shown in Figure 2, α=95°

θ \ φ	-20	-15	-10	-5	0	5	10	15	20
30	393	433	500	719	1223	551	457	409	377
35	467	525	619	899	1637	711	561	492	448
40	535	615	773	1321	3360	1000	684	572	512
45	596	696	957	2690	87400	1474	817	652	571
50	619	711	882	1414	2970	1152	808	681	601
55	624	706	842	1163	2210	1017	792	682	608
60	602	680	804	1107	2110	1008	772	668	591
65	548	631	740	1026	1990	968	726	623	544

θ \ φ	-5	-3	-1	1	3	5
40	1315	2320	3840	2390	1385	999
42	1840	7130	22700	8250	2020	1221
44	2630	24300	166900	32200	2920	1462
46	2330	12030	43700	13530	2510	1416
48	1726	3360	5940	3650	1833	1259

Point 5 of light source shown in Figure 2, α=120°

θ \ φ	-20	-15	-10	-5	0	5	10	15	20
45	308	353	436	731	954	498	376	315	280
50	415	508	688	1258	1890	903	574	448	380
55	540	699	1151	8770	91100	1952	893	607	484
60	620	868	1463	4840	16770	2230	1122	735	564
65	656	957	1588	2750	3740	2200	1297	824	602
70	656	1010	1723	2840	3660	2400	1468	883	594
75	529	841	1428	2290	2840	2030	1244	736	475

θ \ φ	-5	-3	-1	1	3	5
52	1820	3090	3940	2830	1724	1195
54	4440	9590	29700	24800	3290	1658
56	15620	185500	>200000	112200	7810	2260
58	14280	120400	>200000	76400	7220	2450
60	4870	14410	21100	10500	3790	2230

Point 6 of light source shown in Figure 2, α=145°

θ \ φ	-20	-15	-10	-5	0	5	10	15	20
60	492	775	1306	1970	1998	1352	789	484	374
65	1540	3180	6660	17250	20000	7510	3490	1671	929
70	3320	7780	19800	>200000	>200000	27900	9100	3950	1870
75	4130	9960	21200	34400	36300	24100	12140	5230	2290

Remark:

(1) The field of view for luminance meter includes the area covered by black tape on sample when θ is between 65° and 75°.

(2) Since the angle of path for reflected light towards the luminance meter relative to the surface of sample is very small when θ is larger than 75°, the field of view for luminance meter will exceed the sample area if larger range of θ were tested. Therefore, a limited range of θ was tested for this point of light source.

Point 7 of light source shown in Figure 2, α=170°

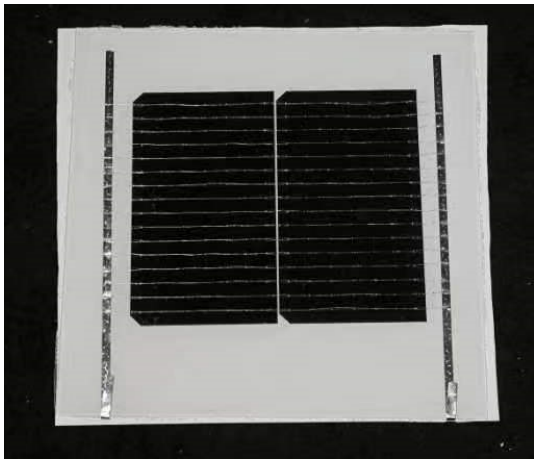
θ \ φ	-25	-20	-15	-10	-5	0	5	10	15	20
70	108	106	111	111	95	69	44	28	20	16
75	8810	3390	652	394	343	265	179	109	92	464

Remark: Since the angle of path for reflected light towards the luminance meter relative to the surface of sample is very small when θ is larger than 75°, the field of view for luminance meter will exceed the sample area if larger range of θ were tested. Therefore, a limited range of θ was tested for this point of light source.

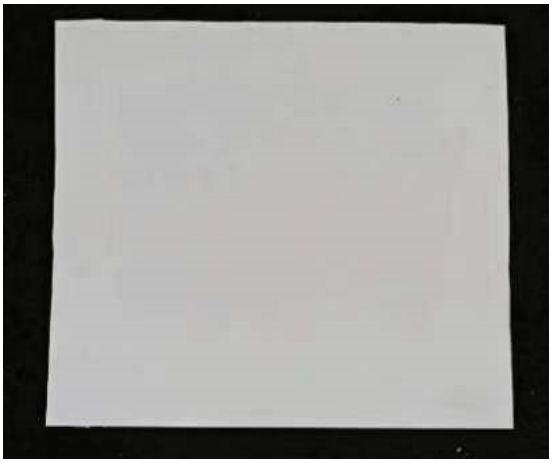
Annex 1: List of measurement equipment

No	Equipment	Identification	Next calibration date
1	Horizontal distribution photometer	ZM-A-A1-0215	03/04/2025
2	Luminance meter	ZM-A-A1-0160	10/27/2024
3	Illuminance meter	ZM-A-A1-0139	08/30/2024

Annex 2: Sample Photos



Front overview



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