MBJ Services GmbH - Neuer Höltigbaum 15 - 22143 Hamburg

Test Report

Mobile PV-Testcenter

Report No. 2001.2020.02.06

Hamburg, February 2020

Test report no.:	**2001.2020.02.06**
Client:	**SecondSol** **Märzenquelle 6** **98617 Meiningen**
Mobile PV-Testcenter:	**2001_MBJ**
Test date:	**05.02.2020**
Testing location:	**SecondSol** **Märzenquelle 6** **98617 Meiningen**
Test procedure/specification:	**1. Non-uniformity adjustment and calibration of irradiance in the module area (IEC 60904-9)** **2. IV-curve measurement adjustment and calibration** **3. Reference cell adjustment and calibration using reference pv-panels** **4. Electroluminescence image acquisition test and optimization** **5. Thermography image acquisition test and verification** **6. Temperature measurement verification and correction**
Test operator:	**B.Sc. Simon Averbeck**
06.02.2020	
Reviewed by:	**Dipl.-Ing. Erik Lohse**
06.02.2020	

1. Results non uniformity measurement

The non-uniformity measurement was done by using a 4 inch reference cell at 66 different positions in the test area combined with the proprietary MBJ Software “Homogeneity Tool”.
The temperature drift during the measurement was recorded and corrected. The result of the relative measurement is shown below as a graphical summary, the detailed test data is attached at the end of this document. (see “LED Homogeneity Log”)

Full Power Matrix:

X / Y	1	2	3	4	5	6
1	-0,13%	0,59%	0,24%	0,75%	0,21%	0,52%
2	-0,38%	0,49%	-0,34%	0,49%	1,14%	0,74%
3	-0,21%	-0,55%	-0,35%	-0,18%	0,98%	0,36%
4	-0,48%	0,74%	0,82%	-0,68%	-0,40%	-0,16%
5	0,73%	-0,03%	-0,26%	0,11%	-0,83%	-0,99%
6	0,11%	-0,67%	0,29%	0,26%	0,61%	-1,13%
7	0,31%	-0,01%	0,37%	-0,91%	0,68%	0,98%
8	-0,66%	0,16%	0,00%	0,28%	-1,11%	-0,10%
9	-1,01%	0,53%	0,30%	-0,32%	-0,16%	0,48%
10	0,79%	-0,48%	-1,74%	-0,35%	-0,41%	-0,15%
11	0,00%	-0,57%	-0,19%	-0,06%	0,60%	0,32%
	< -3 %	< -2 %	< -1 %	0%	> +1 %	>+ 2 %	> +3 %

Percentages based on average: 674,2915616

Non-uniformity of irradiance in the test plane (IEC): **+/- 1,45 %**

Class: **A**

2. IV-curve measurement adjustment and calibration

The MBJ IV-curve measurement device was calibrated using a calibrated reference volt/ampere meter. The data was read out synchronously from the MBJ device and the voltmeter via infrared serial communication.

Measurement range Voltage –Low- (0-100V)
MBJ specification: +/- 0.2% (FSR)

Result: **±0.032 %**

Measurement range Voltage –High- (0-200V)
MBJ specification: +/- 0.2% (FSR)

Result: **±0.165 %**

Measurement range Current (0-16A)
MBJ specification: +/- 0.2% (FSR)

Result: **±0.007 %**

Measurement range Current –Low- (0-6A)
MBJ specification: +/- 0.2% (FSR)

Result: **±0.034 %**

Adjustment was done according to the measurement results.

All measurement and calibration data is attached at the end of this document.
(see “IVCurve Calibration Protocol”)

Results for 2:

The measurement accuracy of the build in MBJ IV-curve measurement unit is showing results as designed and at the specified performance.

3. Reference cell adjustment and calibration using reference pv-panels

The MBJ solar simulator has been calibrated to TÜV Rheinland verified reference panels. This is done by adjusting the irradiance being measured by the internal reference cells in a way, so that the Pmpp measured by TÜV Rheinland for the reference panels is reproduced by the MBJ Testcenter.

This will also result in a spectral sensitivity correction towards the spectral sensitivity of the reference panels for the built in reference sensors.

The MBJ Testcenter is using correction procedure 2 of IEC 60891 for correcting the IV-curves according to irradiance and module temperature.

Polycrystalline reference panel being used:
MBJ_Poly_Referenzmodul_9:

Monocrystalline reference panel being used:
MBJ_Mono_Referenzmodul_6:

After adjusting the reference cells to reproduce the Pmpp of the reference panels above, the measured values have been:

Results for 3:

Polycrystalline

MBJ Pmpp (Initial measurement)	**= 265,5 W**
TÜV Pmpp (August 2019)	**= 267,7 W**
MBJ Pmpp (After calibration*)	**= 268,0 W (deviation: + 0,11 %)**

Monocrystalline

MBJ Pmpp (Initial measurement)	**= 258,7 W**
TÜV Pmpp (August 2019)	**= 258,8 W**
MBJ Pmpp (After calibration*)	**= 258,9 W (deviation: + 0,04 %)**

The deviation should not exceed ± 1 %.

Overall result MBJ solar simulator (1-3):

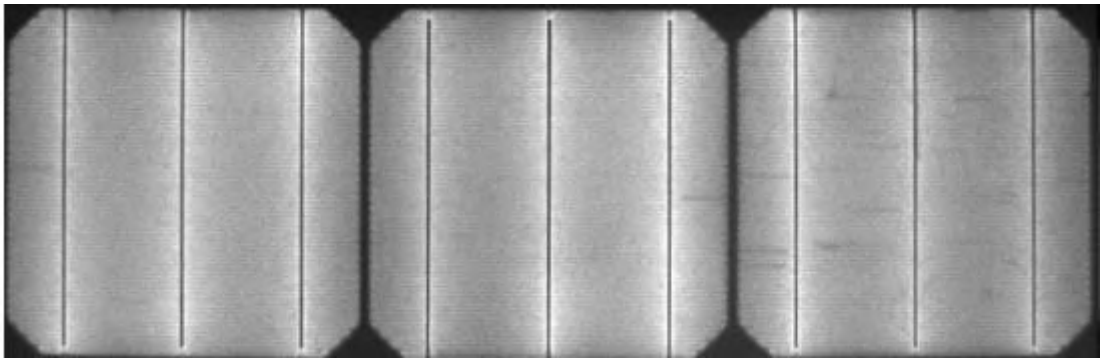
The performance of the build in MBJ solar simulator is showing results as designed and at the specified performance.

*Includes IV-curve measurement calibration and optimization of the LED flasher panels.

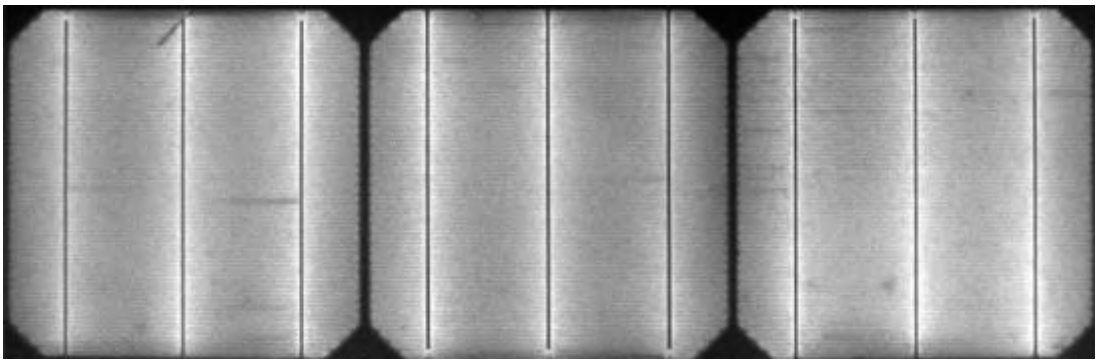
4. Electroluminescence image acquisition test and optimization

To test the electroluminescence image acquisition and to reconfirm the sharpness of the lenses, the monocrystalline reference panel was used.

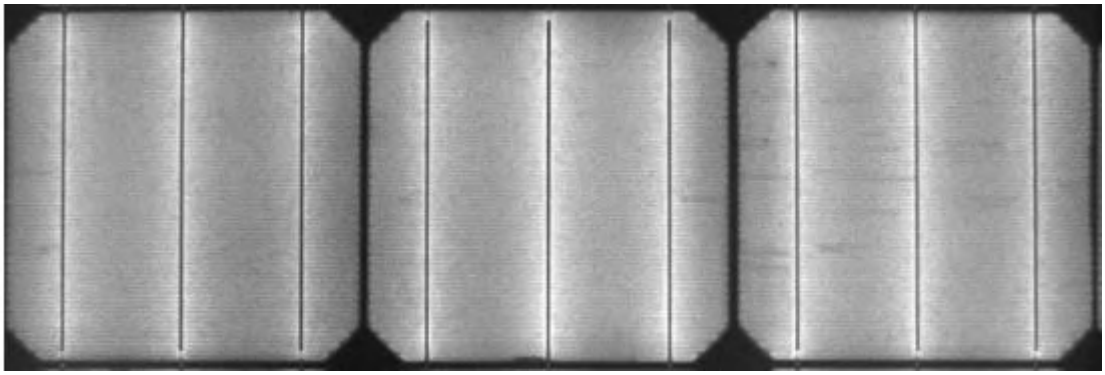
Cam 1: cell index 1/1 to 3/1



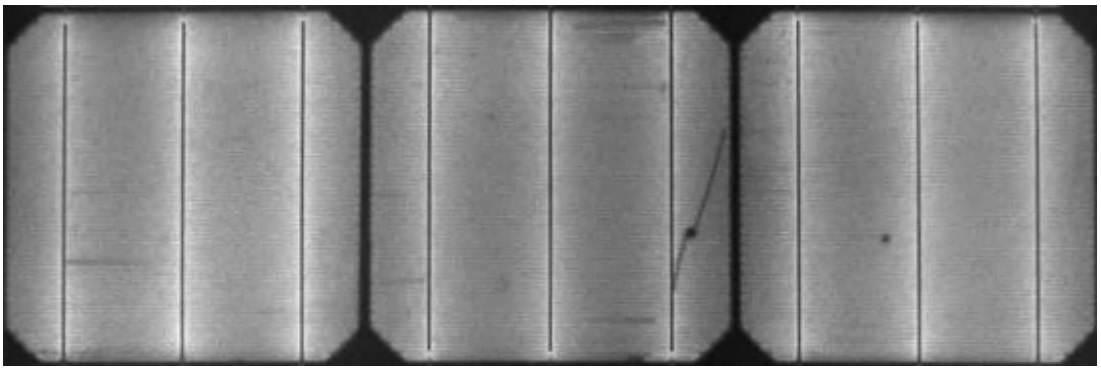
Cam 2: cell index 4/1 to 6/1



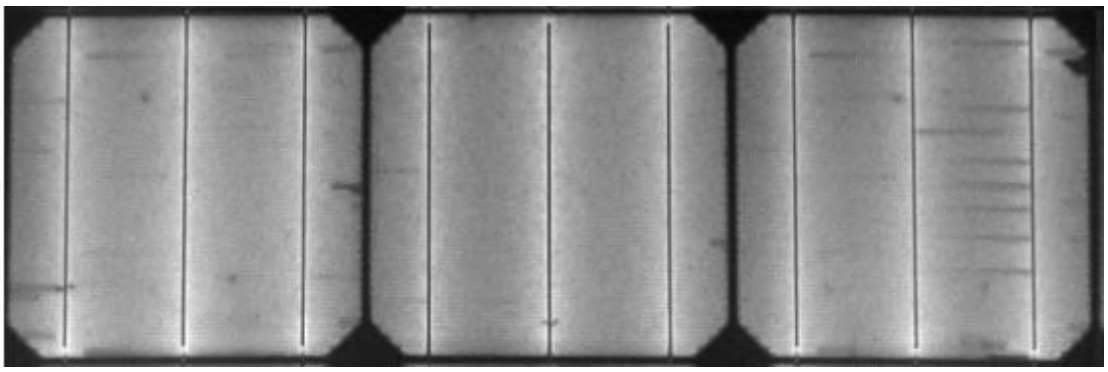
Cam 3: cell index 1/4 to 3/4



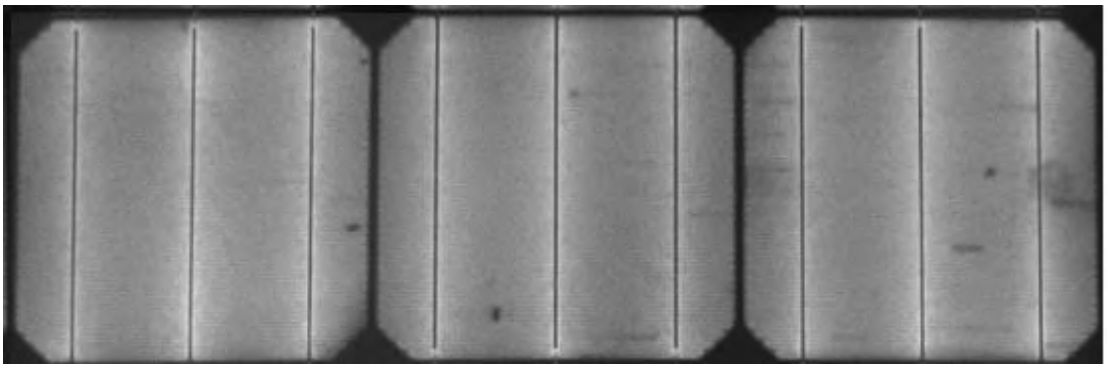
Cam 4: cell index 4/4 to 6/4



Cam 5: cell index 1/7 to 3/7



Cam 6: cell index 4/7 to 6/7



Used current: 13.95 A
Integration time: 3000 ms

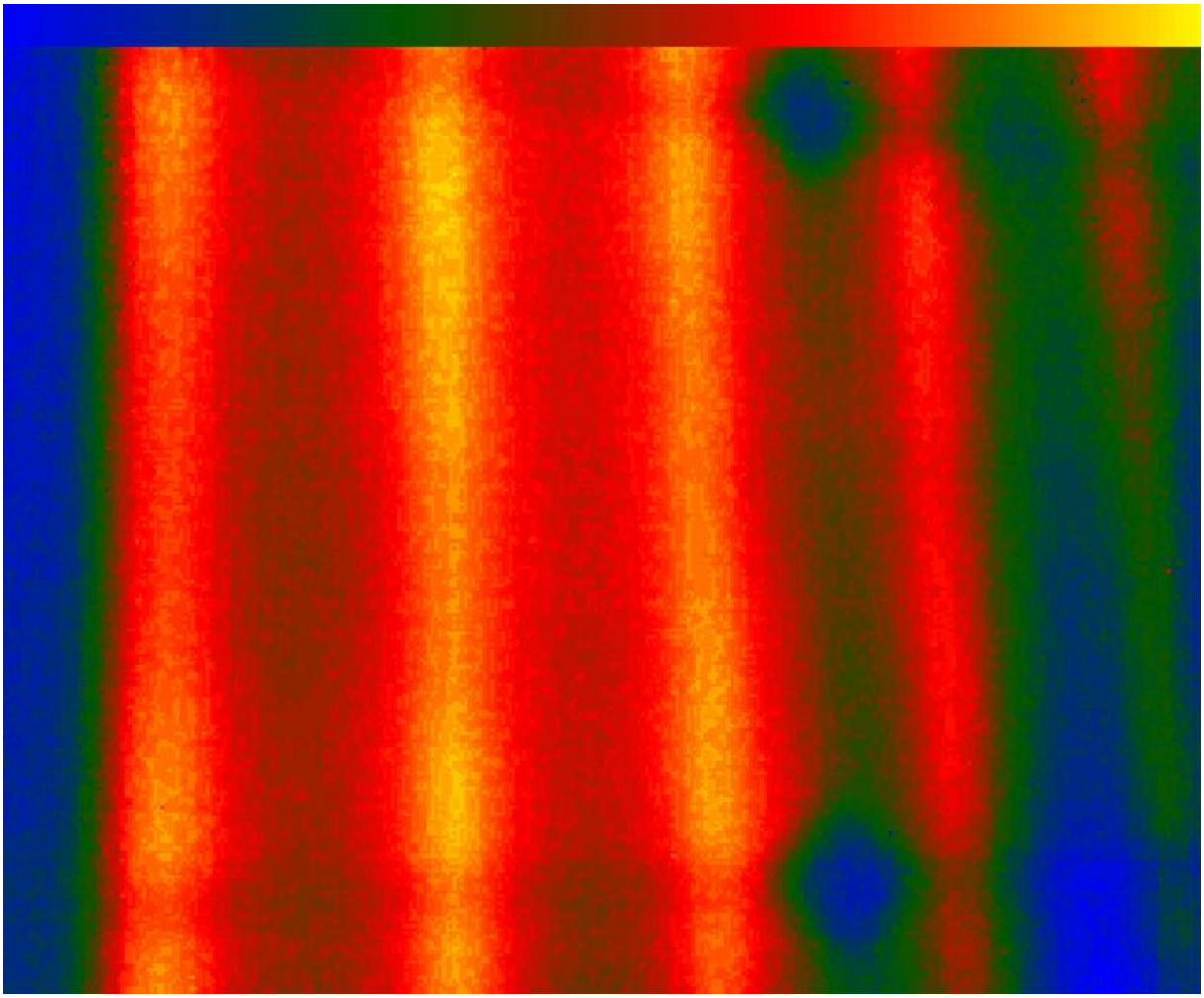
Result:

The electroluminescence image acquisition of this system is working properly as designed and at the specified performance.

5. Thermography image acquisition test and verification

The thermographic image acquisition was tested using the monocrystalline reference panel. This system is just providing a non-calibrated thermographic image, so there is no need for calibration.

Test image (MBJ Mono Referenzmodul 6):



Result:

The thermographic image acquisition of this system is working properly as designed and at the specified performance.

6. Temperature measurement verification

To verify the temperature measurement, the MBJ Testcenter with a solar panel inside was placed for at least 2 hours to ensure a uniform temperature distribution. Than the temperature, at the points where the sensors of the MBJ Testcenter are located is measured with a reference thermometer. The readings of the temperature sensors of the MBJ Testcenter were compared with that of the reference thermometer. The result of the measurement verification is shown in the table on the next page. The resulting deviation is shown in the table as well, leading to a correction offset factor which is used finally in the system and results in corrected temperatures.

Temperature sensors:

- **1x Infrared thermometer for the module temperature**
  man.: B&B Thermotechnik
  Accuracy ± 1% of reading or ± 1°C (whichever is greater)
- **2x PT1000 with PT1000 Transducer for the reference cell**
  => PT1000: Tolerance A (0,15 K+ 0,002 x ltl), Alpha = 3,850 x 10 °C
  => Transducer: man.: Hygrosens, Accuracy ±0,15% FS (-30 bis +70°C measuring range)
- **2x PT1000 with PT1000 Transducer for the temperature measurement inside and outside the device**
  => PT1000: Tolerance B/F0.30
  => Transducer: man.: LEG, linearity error < 0,1%, (-50°C to +500°C measuring range)

Reference thermometer:

- **Greisinger Digitalthermometer GMH 3210 / temperature sensor GOF 400VE**
  - Certificate No.: 3053386
  - Last calibration: 02.2019
  - Next calibration: 02.2020

First measurement/ @ STC temperature (~ 25 °C) - offset determination

	Mobile Tester	GMH3210	Dev. 3210	Correction Offset	corrected Mobile Lab
Temperature inside the device [°C]	25,30	25,20	0,10	0,00	0,10
Temperature outside the device [°C]	7,00	7,10	-0,10	0,00	-0,10
Module Temperature [°C]	25,00	24,50	0,50	0,00	0,50
Temperature of mono reference cell [°C]	25,20	25,30	-0,10	0,00	-0,10
Temperature of poly reference cell [°C]	25,2	25,40	-0,20	0,00	-0,20

The deviation should not exceed ±1°C(including correction offset).

Greatest deviation: 0,50 °C

Result:

The temperature measurement of this system is working properly as designed and at the specified performance.

Appendix – Test Data / specification of the system

a. **Homogeneity measurement data**
b. **IV-CurveBox calibration data**
c. **Reference panel test results (TÜV Rheinland)**
d. **Reference panel test reports (MBJ after calibration)**
e. **Technical specification MBJ Mobile PV-Testcenter**

LED Homogeneity Log

Mobile Tester: **2001_MBJ**
IV Curve MC Serial: 130210/01

Date: **2020-02-05**

Target Sensor: 2847 / 111,485
Sequence: M1

IV Curve RefA: Offset: -0,000577 Factor: 51,19941373
IV Curve RefB: Offset: -0,000612 Factor: 51,2163798

Full Power Matrix:

X / Y	1	2	3	4	5	6
1	-0,13%	0,59%	0,24%	0,75%	0,21%	0,52%
2	-0,38%	0,49%	-0,34%	0,49%	1,14%	0,74%
3	-0,21%	-0,55%	-0,35%	-0,18%	0,98%	0,36%
4	-0,48%	0,74%	0,82%	-0,68%	-0,40%	-0,16%
5	0,73%	-0,03%	-0,26%	0,11%	-0,83%	-0,99%
6	0,11%	-0,67%	0,29%	0,26%	0,61%	-1,13%
7	0,31%	-0,01%	0,37%	-0,91%	0,68%	0,98%
8	-0,66%	0,16%	0,00%	0,28%	-1,11%	-0,10%
9	-1,01%	0,53%	0,30%	-0,32%	-0,16%	0,48%
10	0,79%	-0,48%	-1,74%	-0,35%	-0,41%	-0,15%
11	0,00%	-0,57%	-0,19%	-0,06%	0,60%	0,32%
	< -3 %	< -2 %	< -1 %	0%	> +1 %	>+ 2 %	> +3 %

Percentages based on average: 674,2915616
Non-uniformity of irradiance in the test plane (IEC): **+/- 1,45 %**

Class: **A**

MAX. Irradiance: 682 W
MIN. Irradiance: 662,53 W
Delta IRR. : 19,471 W

MAX. Temperature: 13,92 °C
MIN. Temperature: 11,79 °C
Delta T. : 2,13 °C

Comment:

IV-Curve Calibration

Mobile Tester: **2001_MBJ**
IV Curve MC Serial: MBJ-2016-IV-023 **Date:** **05.02.2020**

Calibration Reference: **Voltcraft 960** Calib. Date: 11.02.2019
Reference serial: 11100778142 to: FLUKE 5520A - D - K -15070-01-01

Type	Control	Reference	FSR	Rel. Deviation	Abs. Deviation	FSR Deviation
VOLTAGELOW	1,85832	1,8716	86,10	-0,7096	-0,0133	-0,0154
VOLTAGELOW	26,0133	26,016	86,10	-0,0105	-0,0027	-0,0032
VOLTAGELOW	47,9477	47,92	86,10	0,0578	0,0277	0,0322
VOLTAGELOW	73,9663	73,95	86,10	0,0220	0,0163	0,0189
VOLTAGELOW	79,9138	79,9	86,10	0,0172	0,0138	0,0160
VOLTAGEHIGH	112,397	111,98	252,93	0,3727	0,4174	0,1650
VOLTAGEHIGH	229,276	229,38	252,93	-0,0453	-0,1040	-0,0411
VOLTAGEHIGH	148,138	148,15	252,93	-0,0084	-0,0124	-0,0049
CURRENT	1,28544	1,289	15,88	-0,2760	-0,0036	-0,0224
CURRENT	2,89315	2,894	15,88	-0,0295	-0,0009	-0,0054
CURRENT	6,19208	6,191	15,88	0,0174	0,0011	0,0068
CURRENT	8,89189	8,891	15,88	0,0101	0,0009	0,0056
CURRENTLOW	2,29068	2,292	5,93	-0,0576	-0,0013	-0,0222
CURRENTLOW	3,19924	3,2	5,93	-0,0237	-0,0008	-0,0128
CURRENTLOW	4,79898	4,798	5,93	0,0204	0,0010	0,0165
CURRENTLOW	5,69603	5,694	5,93	0,0357	0,0020	0,0343

IV-Verification Results:

MBJ specification: +/- 0,2 % (FSR)

Measurement range	VOLTAGELOW	(0 - 100V)	**Result:**	**+/- 0,03 %**
Measurement range	VOLTAGEHIGH	(0 - 200V)	**Result:**	**+/- 0,16 %**
Measurement range	CURRENT	(0 - 14A)	**Result:**	**+/- 0,01 %**
Measurement range	CURRENTLOW	(0 - 6A)	**Result:**	**+/- 0,03 %**

Comment:

Prüfprotokoll

Modul ID:	Mono6_After
Hersteller:	Yingli
Modultyp / Beschreibung:	YL265C-30b
Testcenter Seriennummer:	2001_MBJ
Auftrag ID:	20200205_LargeService_Meiningen
Adresse:	SecondSol GmH / Märzquelle 6
Ort:	DE 98617 Meiningen

Leistungsmessung

Pmpp @ STC IEC60891:	258,9W
Leistungsabweichung:	-2,3% zu 265,0W (0,0%->+3,0%)
Tmod / Tref:	23,7C / 26,6C
Flash Dauer:	109,0ms
Flasher Parameter:	C16480N
Bediener / Zeitpunkt:	S. Averbeck 05.02.2020 12:56

Elektrisch

Connection Check:	Erfolgreich: 9,3A /43,3V
Diodentest:	Mindestens eine Diode scheint kurzgeschlossen zu sein: 0,0A /-12,5V

Elektrolumineszenz

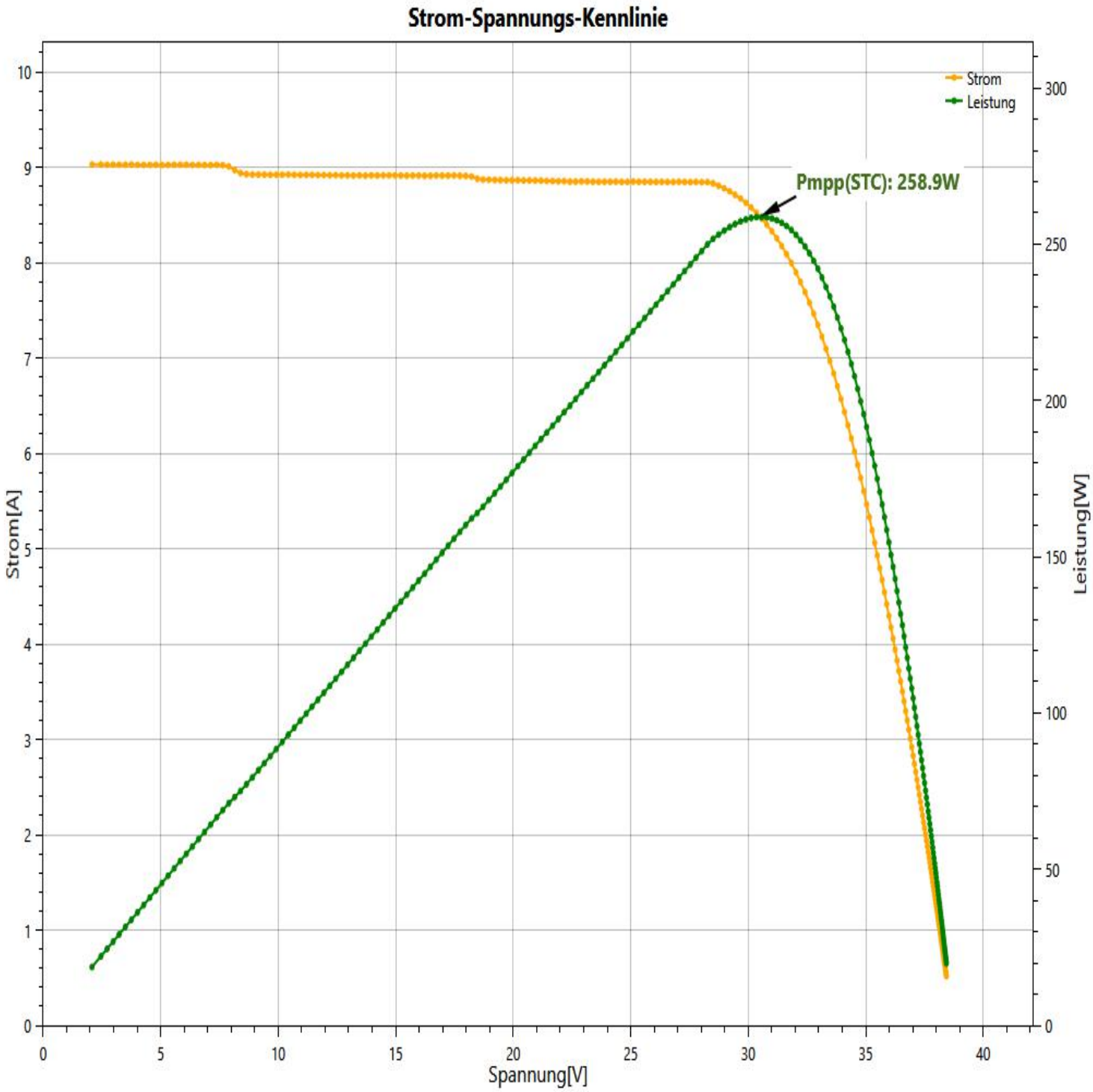
EL Zellbewertungen:	0 sehr kritisch: >=20% Zellfläche betr. 0 kritisch: <20% Zellfläche betr. 0 unkritisch: keine Zellfläche betr. 0 andere EL Auffälligkeiten
Zellen ohne Bewertung:	60
EL Einstellungen:	3,0s / 45,5V / 14,0A / Zellbasiert / Softwareunterstützt
Bediener / Zeitpunkt:	S. Averbeck 05.02.2020 13:02

Thermografie

Thermografie Bilder:	1 dT max.: 2,8°C
Bediener / Zeitpunkt:	S. Averbeck 05.02.2020 12:51

Modul ID: Mono6_After

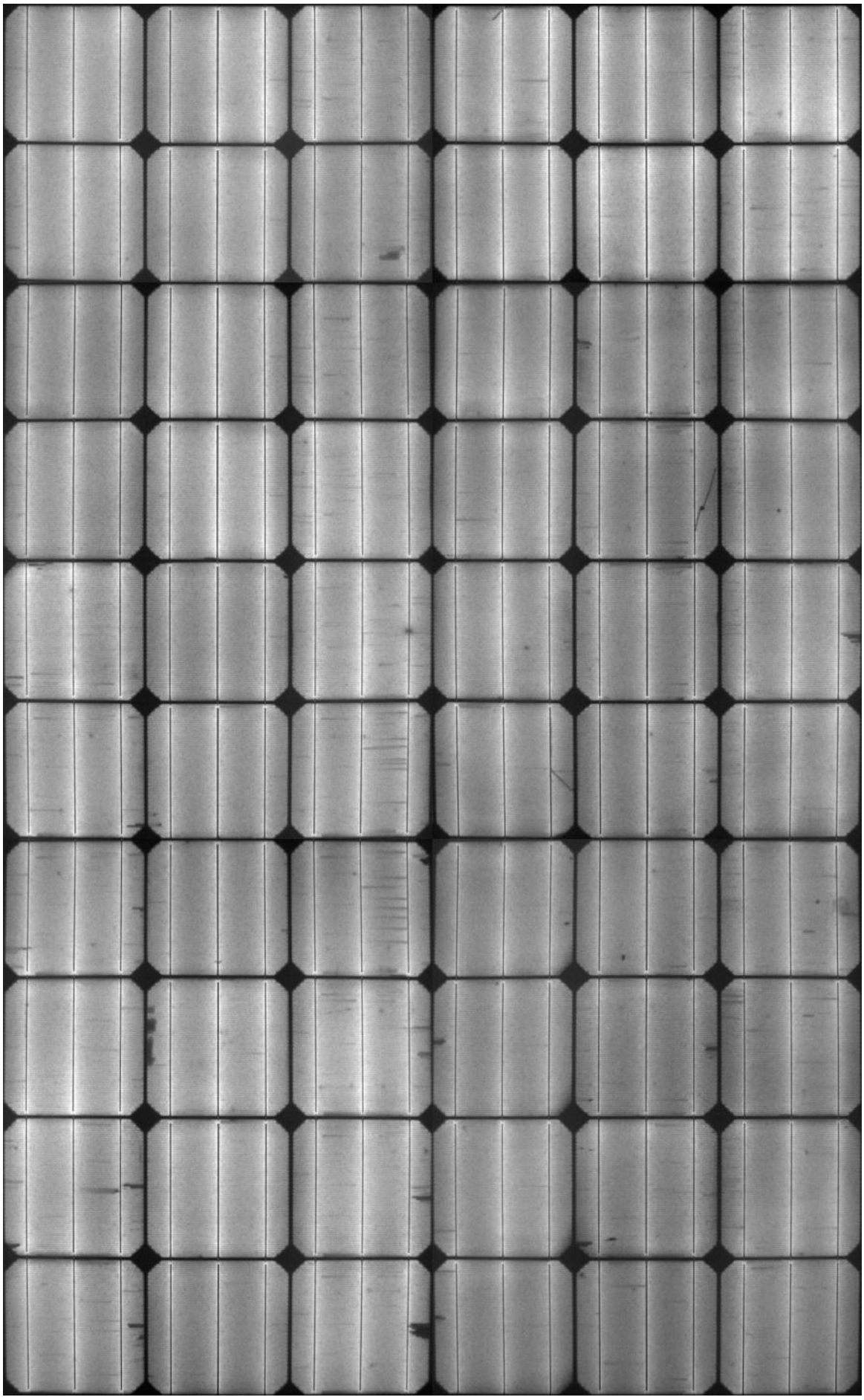
Typ ID: Yingli / YL265C-30b



	Pmpp[W]	Impp[A]	Umpp[V]	Isc[A]	Uoc[V]	Irr[W/m2]	FF[%]
IEC60891 STC	258,9	8,48	30,52	9,03	38,72	1000,0	74,0
Gemessen	218,0	7,01	31,11	7,73	38,47	823,7	73,3

Tmod[°C]:23,7	Tref[°C]:26,6	Tdev[°C]:25,2	Tout[°C]:11,0	T[ms]:109,0
Typ:Mono	alpha[%]:0,040	beta[%]:-0,450		
IEC aICF:0,060	IEC Rs[Ohm]:0,60	kappa[mOhm/K]:3,00		
Software:722p				

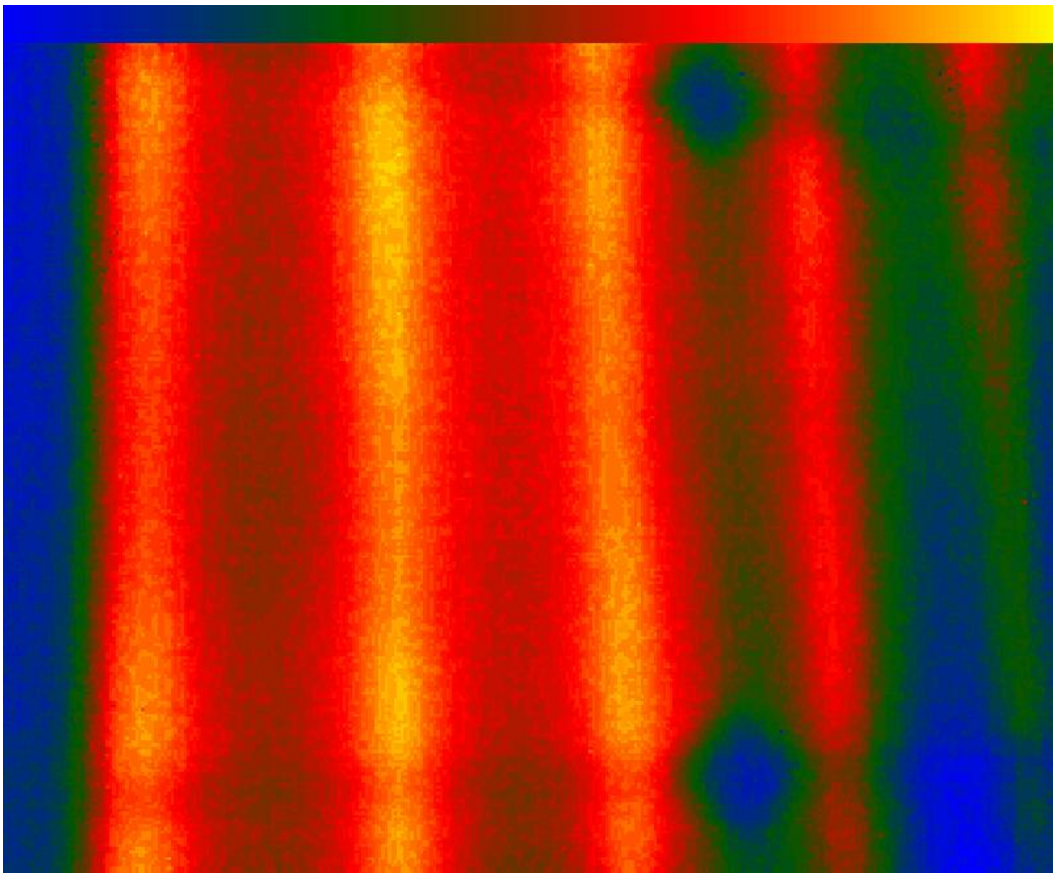
Elektrolumineszenz für Mono6_After



Strom[A]: 13,951
Belichtungszeit [ms]: 3000

Spannung[V]: 45,514
S. Averbeck 05.02.2020 13:02

Thermografie für Mono6_After



Farbe Kalt:33,4°C Warm:36,1°C
I[A]:14,0 U[V]:45,7 t[s]:21 dT[°C]:2,8

Prüfprotokoll

Modul ID:	Poly9_After
Hersteller:	Talesun
Modultyp / Beschreibung:	TP660P-270
Testcenter Seriennummer:	2001_MBJ
Auftrag ID:	20200205_LargeService_Meiningen
Adresse:	SecondSol GmH / Märzquelle 6
Ort:	DE 98617 Meiningen

Leistungsmessung

Pmpp @ STC IEC60891:	268,0W
Leistungsabweichung:	-0,7% zu 270,0W (0,0%->+3,0%)
Tmod / Tref:	24,2C / 25,4C
Flash Dauer:	100,0ms
Flasher Parameter:	C16480N
Bediener / Zeitpunkt:	S. Averbeck 05.02.2020 13:28

Elektrisch

Connection Check:	Erfolgreich: 9,0A /41,8V

Elektrolumineszenz

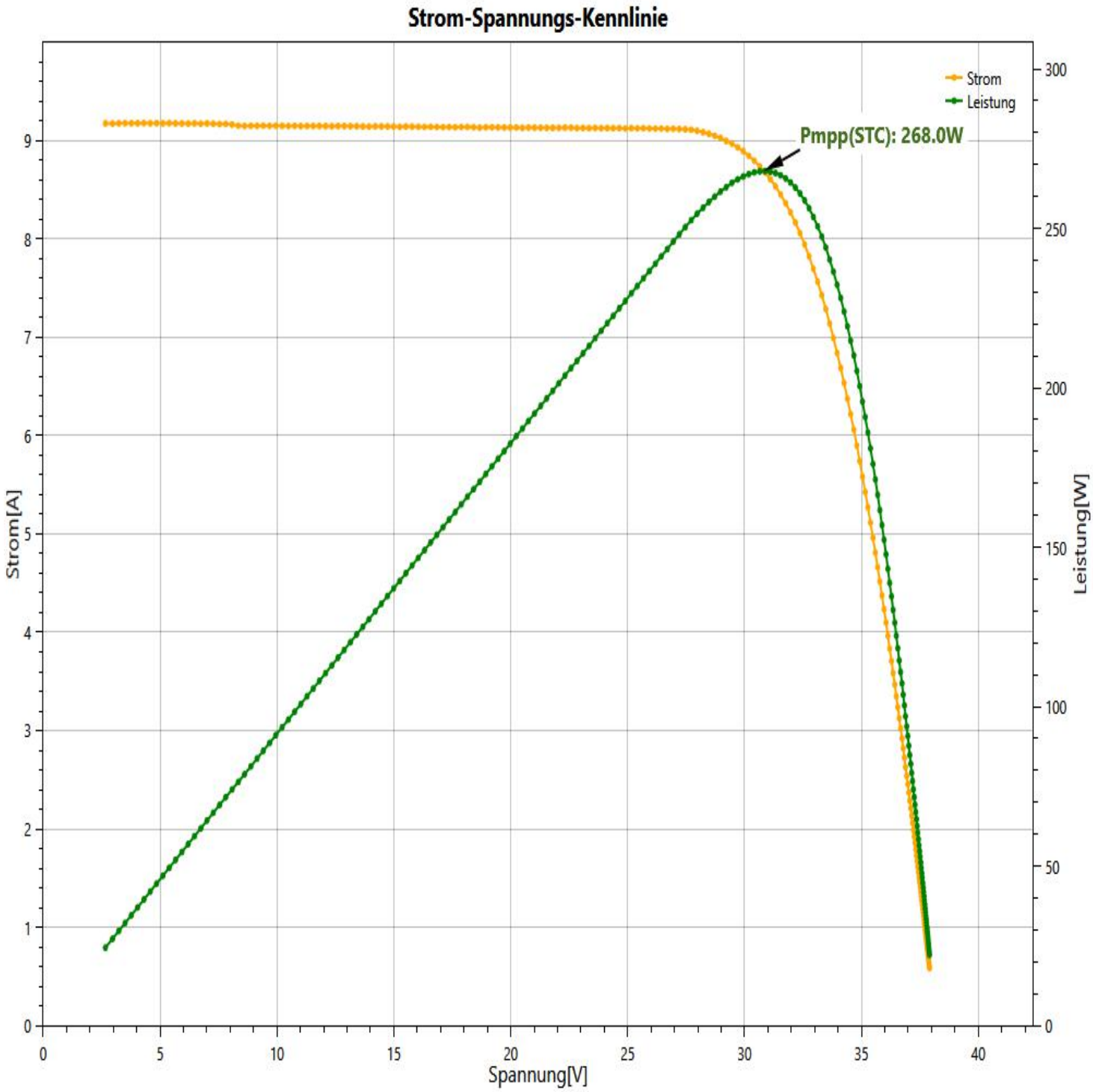
EL Zellbewertungen:	0 sehr kritisch: >=20% Zellfläche betr. 0 kritisch: <20% Zellfläche betr. 0 unkritisch: keine Zellfläche betr. 0 andere EL Auffälligkeiten
Zellen ohne Bewertung:	60
EL Einstellungen:	5,0s / 43,9V / 13,6A / Zellbasiert / Statisch
Bediener / Zeitpunkt:	S. Averbeck 05.02.2020 13:11

Thermografie

Thermografie Bilder:	1 dT max.: 2,3°C
Bediener / Zeitpunkt:	S. Averbeck 05.02.2020 13:09

Modul ID: Poly9_After

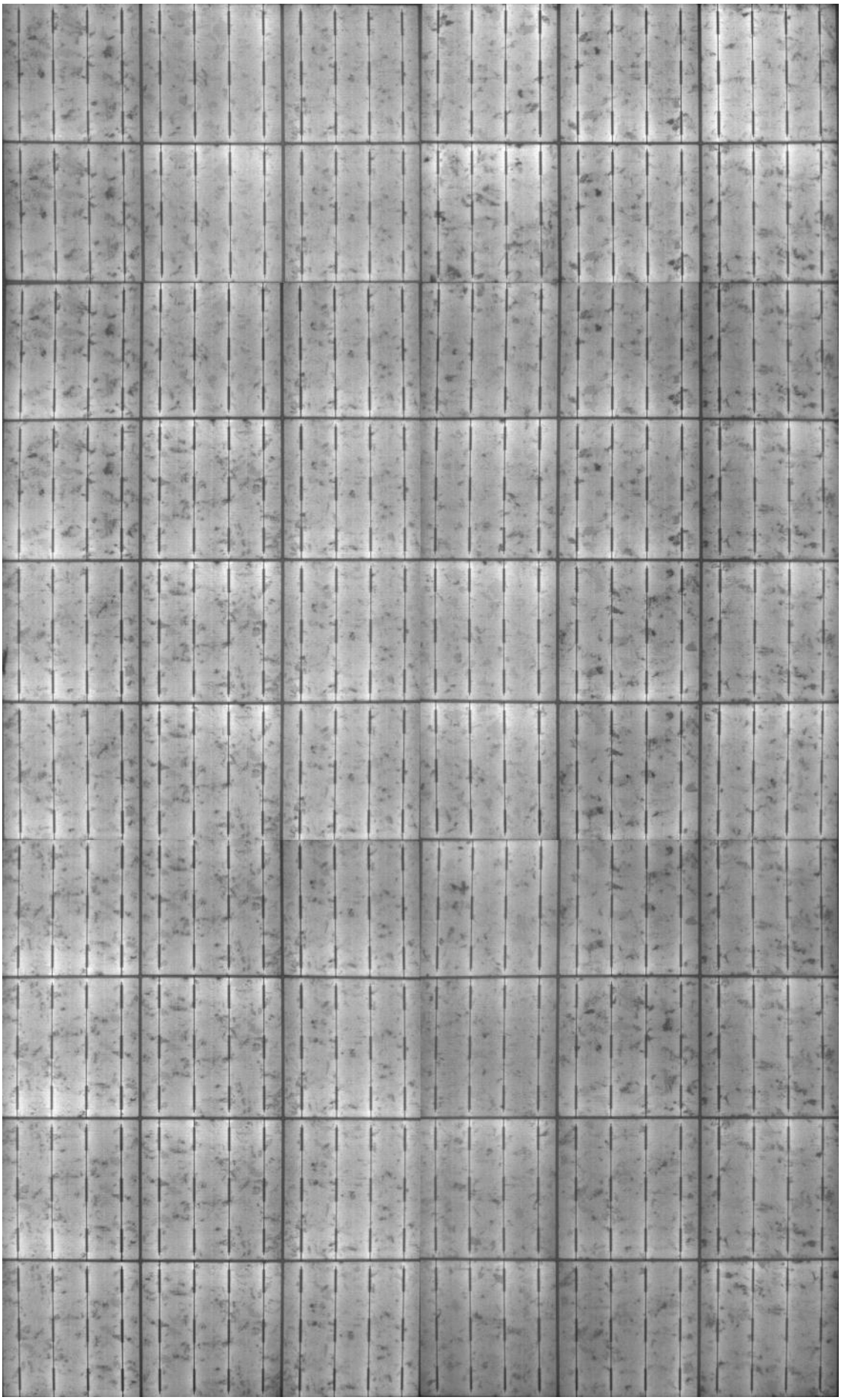
Typ ID: Talesun / TP660P-270



	Pmpp[W]	Impp[A]	Umpp[V]	Isc[A]	Uoc[V]	Irr[W/m2]	FF[%]
IEC60891 STC	268,0	8,69	30,83	9,18	38,18	1000,0	76,5
Gemessen	228,4	7,35	31,07	8,02	37,87	843,0	75,2

Tmod[°C]:24,2	Tref[°C]:25,4	Tdev[°C]:22,0	Tout[°C]:11,9	T[ms]:100,0
Typ:Poly	alpha[%]:0,050	beta[%]:-0,350		
IEC aICF:0,060	IEC Rs[Ohm]:0,44			
Software:722p				

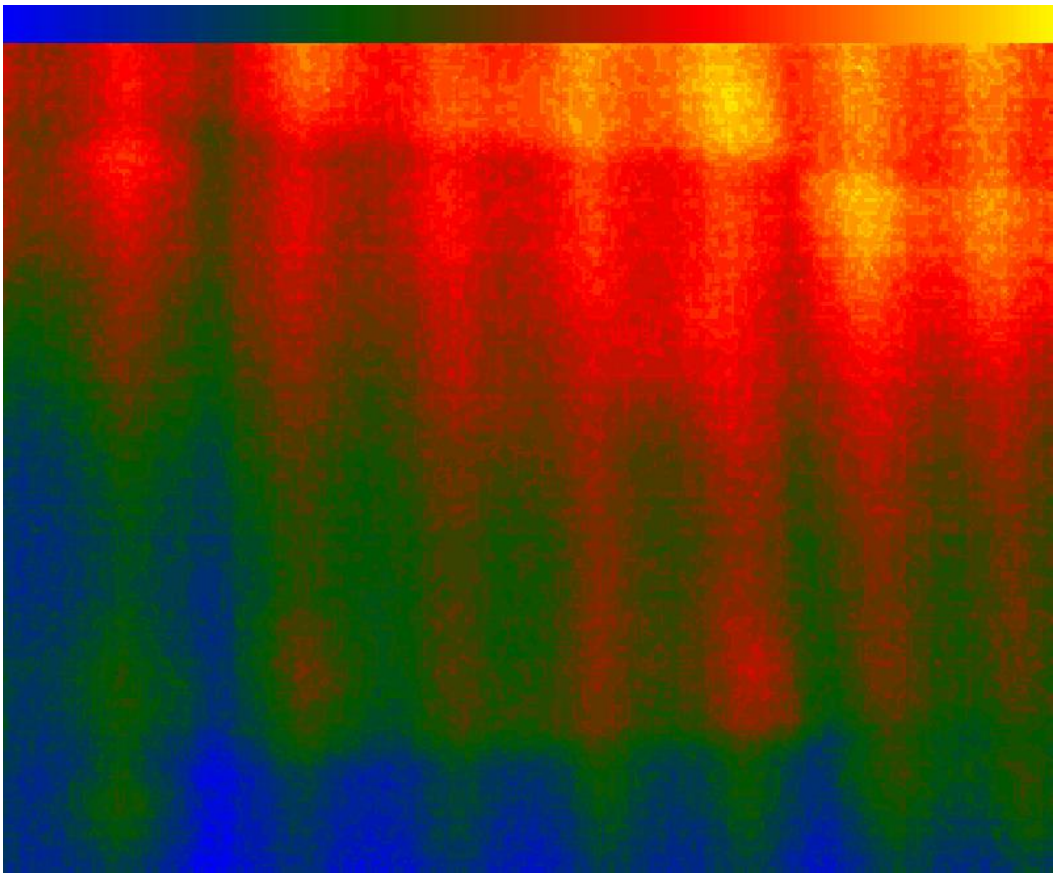
Elektrolumineszenz für Poly9_After



Strom[A]: 13,557
Belichtungszeit [ms]: 5000

Spannung[V]: 43,873
S. Averbeck 05.02.2020 13:11

Thermografie für Poly9_After

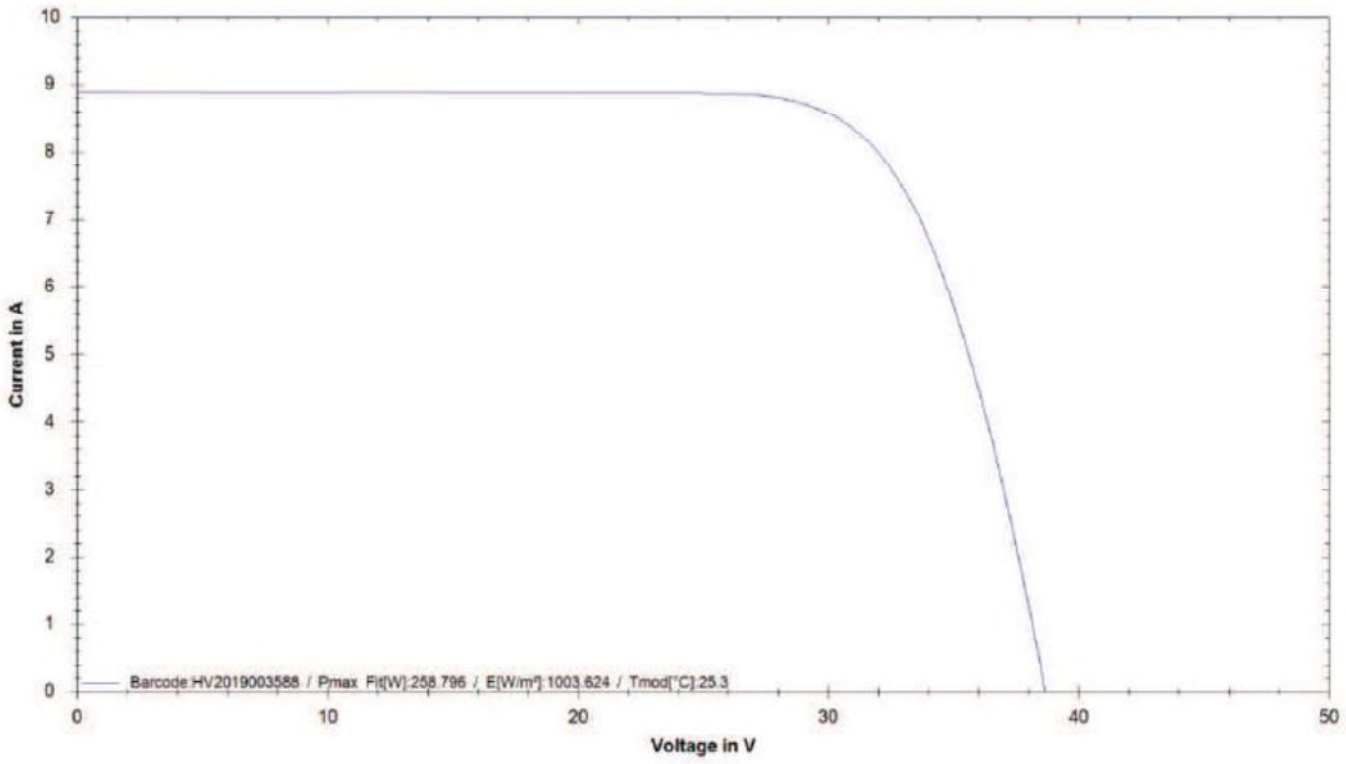


Farbe Kalt:32,1°C Warm:34,4°C
I[A]:13,6 U[V]:44,0 t[s]:19 dT[°C]:2,3

MBJ Referencemodule Mono 6

Module type	YL265C-30b	
Cell type	6" mono crystalline	
Sample #		Serial number
HV2019003588		140805000300691
Supplementary information: none		

Sample #	P_{max} [W]	V_{mpp} [V]	I_{mpp} [A]	V_{oc} [V]	I_{sc} [A]	FF [%]
HV2019003588	258.8	30.91	8.37	38.69	8.89	75.3

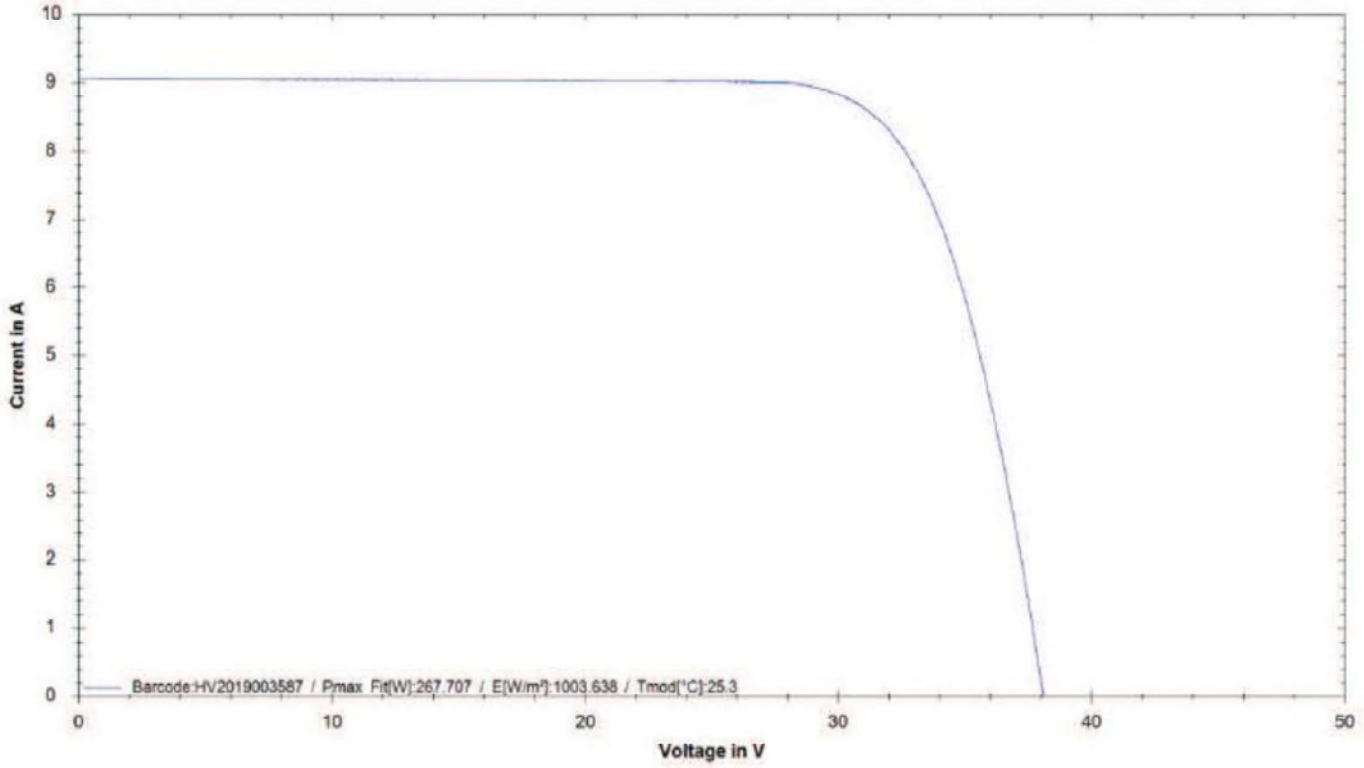


TÜV barcode HV2019003588

MBJ Referencemodule Poly 9

Module type	TP660P-270	
Cell type	6" poly crystalline	
Sample #		Serial number
HV2019003587		PW66090028810118
Supplementary information: none		

Sample #	P_{max} [W]	V_{mpp} [V]	I_{mpp} [A]	V_{oc} [V]	I_{sc} [A]	FF [%]
HV2019003587	267.7	31.18	8.59	38.12	9.05	77.6



TÜV barcode HV2019003587

Kalibrier-Zertifikat Calibration certificate

3053386

Gegenstand Object	Digitalthermometer	Oberflächenfühler
Hersteller Manufacturer	GREISINGER ELECTRONIC GMBH	GREISINGER ELECTRONIC GMBH
Typ Type description	GMH 3210	GOF 400VE
Serien Nr. Serial no.	---	---
Inventar Nr. Inventory no.	MBJ-N-001	---
Prüfmittel Nr. Test equipment no.	---	---
Equipment Nr. Equipment no.	11820410	11820413
Standort Location	---	---

Auftraggeber Customer	MBJ Services GmbH DE-22143 Hamburg
Auftrags Nr. Order no.	9313293 / 0520 0071
Datum der Kalibrierung Date of calibration	27.02.2019
Datum der empfohlenen Rekalibrierung Date of the recommended re-calibration	27.02.2020

Hiermit bestätigen wir, dass das durchführende Kalibrierlabor ein Managementsystem nach ISO 9001:2015, sowie ISO/IEC 17025:2005 eingeführt hat. Die Urkunden finden Sie auf www.testotis.de. Die für die Kalibrierung verwendeten Messeinrichtungen werden regelmäßig kalibriert und sind rückführbar auf die nationalen Normale der Physikalisch Technischen Bundesanstalt (PTB) Deutschlands oder auf andere nationale Normale. Wo keine nationalen Normale existieren, entspricht das Messverfahren den derzeit gültigen technischen Regeln und Normen. Die für diesen Vorgang angefertigte Dokumentation kann eingesehen werden. Alle erforderlichen Messdaten sind in diesem Kalibrier-Zertifikat aufgelistet.

Hereby we confirm that the performing calibration laboratory is working with a management system according to ISO 9001:2015 and ISO/IEC 17025:2005. Accreditation certificates can be found under www.testotis.de. The measuring installations used for calibration are regularly calibrated and traceable to the national standards of the German Federal Physical Technical Institute (PTB) or other national standards. Should no national standards exist, the measuring procedure corresponds with the technical regulations and norms valid at the time of the measurement. The documents established for this procedure are available for viewing. All the necessary measured data can be found on this calibration certificate.

Konformitätsaussage Conformity statement

[X] Messwert(e) innerhalb der zulässigen Abweichung[1]. Measured value(s) within the allowable deviation[1].

[ ] Messwert(e) außerhalb der zulässigen Abweichung[1]. Measured value(s) outside of the allowable deviation[1].

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[1]) Die Messunsicherheit wurde nach GUM mit dem Erweiterungsfaktor k=2 berechnet und enthält die Unsicherheit des Verfahrens sowie die Unsicherheit des Prüflings. Die Konformitätsaussage erfolgte nach DIN EN ISO 14253-1 gemäß der Kalibrieranweisung 4_AA_00120_DE.

[1]) The measurement uncertainty was calculated according to the regulations of GUM with the coverage factor k=2 and contains the uncertainty of the measuring procedure and the uncertainty of the measuring system. The statement of conformity was made according to DIN EN ISO 14253-1 according to calibration instruction 4_AA_00120_DE.

Stempel Seal

TESTO INDUSTRIAL SERVICES testo KIRCHZARTEN

Fachverantwortlicher Supervisor

P. Löffler

Philipp Löffler

Bearbeiter Technician

B Bednarz

Birgitt Bednarz

Kalibrier-Zertifikat Calibration certificate

3053386

Messeinrichtungen Measuring equipment

Index	Referenz Reference	Rückführung Traceability	Rekal. Next cal.	Zertifikat-Nr. Certificate-no.	Eq.-Nr. Eq.-no.
a	testo 454 mit Fühler testo 454 with probe	15070-01-01 2018-03	2019-03	T94597	10227947
b	testo 454 mit Fühler testo 454 with probe	15070-01-01 2018-03	2019-03	T94599	10320230
c	testo 454 mit Fühler testo 454 with probe	15070-01-01 2018-03	2019-03	T94598	10227948

Referenzzertifikate sind auf www.primasonline.com abrufbar Reference certificates are available at www.primasonline.com

Umgebungsbedingungen Ambient conditions

Temperatur Temperature 24,1 °C Feuchte Humidity 31,8 % rF % RH

Messverfahren Measuring procedure

Vergleichsmessung auf blanker Oberfläche gemäß Kalibrieranweisung 4_AA_00078_DE.
Comparison measurement on a polish surface according to calibration instruction 4_AA_00078_DE.

Messergebnisse Measuring results

Kanal Channel ---

Anzeige des Kalibriergegenstandes bei Raumtemperatur: 24,1 °C ± 1 K
Display of the tested instrument at ambient temperature:

Bezugswert Reference value °C	Messwert Kalibrier-gegenstand Measured value probe °C	Abweichung Deviation °C	Korrigierter Istwert mit OFZ Corrected value with surface correction factor = 0,981 °C	Zulässige Abweichung[2] Allowed deviation[2] °C	Messunsicherheit (k=2) Measurement uncertainty (k=2) °C	Bewertung Confirmation
60,4[a]	60,8	0,4	60,1	± 5,7	1,01	pass
120,3[b]	122,1	1,8	120,2	± 10,5	1,21	pass
180,3[c]	184,8	4,5	181,7	± 15,3	1,81	pass

[2] gemäß Abschätzung Testo Industrial Services GmbH in accordance with the estimation of Testo Industrial Services GmbH

Der korrigierte Istwert des Kalibriergegenstandes, unter Berücksichtigung des Oberflächenzuschlags (OFZ) wird nach folgender Formel berechnet: Korrigierter Istwert = (angezeigter Messwert Kalibriergegenstand - Kalibriergegenstand bei Raumtemperatur) * Oberflächenzuschlag + Kalibriergegenstand bei Raumtemperatur

The corrected display of the value probe has to be calculated by the following formula (the surface correction factor taken under consideration): Corrected display = (indicated measured value probe – value probe at ambient temperature) * surface correction factor + value probe at ambient temperature

Besondere Bemerkungen Special remarks

Kalibrierzertifikat / Calibration Certificate

Instrument: **VOLTCRAFT VC960**
customer

Serien Nr: **1110778142**
serial no.

Inventar Nr: 9601110778142
inventory no.

Auftraggeber: MBJ Services GmbH
customer

Kalibriert am: **22.02.2019** 07:39:32 Uhr
calibration on

Empf. Nachkalibrierung: **21.02.2020**
recommended calibration

Temperatur: 22,00°C +/-1.5°C
temperature

Luftfeuchte: 50 % +/-10%
humidity

Bearbeiter: Barinshtein
person responsible

Prozedur Art: VC960
procedure mode

Revision: 2
revision

Die für die Kalibrierung verwendeten Normale werden regelmäßig kalibriert und sind auf dem Kalibrierschein dokumentiert. Die verwendeten Normale sind rückführbar auf nationale Normale der Bundesrepuplik Deutschland oder auf andere nationale Normale.
The standards used for the calibration are constant calibrated and documented on the calibration certificate. The used standards are traceable back to the national standards of Germany or any other nation.

Dieser Kalibrierschein darf nur vollständig und unverändert weitergegeben werden. Kalibrierscheine ohne Unterschrift sind nicht gültig.
It is only allowed to pass on the complete and unchanged calibration certificate. Calibration certificate without a signature are invalid.

Die Kalibrierung erfolgte unter Beachtung eines nach DIN EN ISO 9001 zertifizierten Qualitätsmanagements. Der Kalibrierumfang ist auf den nachfolgenden Seiten ersichtlich.
The calibraton occured under the consideration of an accredited quality managment according to DIN EN ISO 9001. You can find the complexity of the calibration on the following pages.

Messwerte liegen innerhalb der angegebenen Toleranzen: Y
measured values are within the given tolerances:

Notiz:
note

Bearbeiter
person responsible

Laborleiter
laboratory head

CONRAD ELECTRONIC SE
Klaus-Conrad-Str. 1
92240 Hirschau

Fax: 09622/305575
www.conrad.com

Kalibrierschein

CONRAD ELECTRONIC SE

Prüfling: VOLTCRAFT VC960
Auftraggeber: MBJ Services GmbH
Serien Nr: 1110778142
Inventar Nr. 9601110778142

Ergebnis: **PASS**
Datum: 22.02.2019 07:39:32 Uhr
Prüfer: Barinshtein
Klima: Temp. 22,0°C +/- 1.5°C
Luftf. 50 % +/- 10%

Notiz:

Daten Kalibrator

Inventar Nr.	Hersteller	Modell	Beschreibung	Kalibriert am	Fällig am
5522A1	FLUKE	5522A	D-K-15070-01-01	8-Feb-2019	7-Feb-2020

Daten Prüfling

TEST#	STD System Bereich	Sollwert	Prüfling Istwert	Fehler		(% von Tol)
	Gleichspannungsprüfung					
1	400	0V	0V	0.00		0
	SYSTEM TOL:1uV		TEST TOL:100uV			
2	400	40mV	39.99mV	-250	ppm	9
	SYSTEM TOL:1.8uV		TEST TOL:110uV			
3	400	360mV	360.03mV	83.3	ppm	16
	SYSTEM TOL:5.96uV		TEST TOL:190uV			
4	400	-360mV	-360.03mV	83.3	ppm	16
	SYSTEM TOL:5.96uV		TEST TOL:190uV			
5	4	3.6V	3.6006V	166	ppm	15
	SYSTEM TOL:63.2uV		TEST TOL:3.88mV			
6	40	36V	36.003V	83.3	ppm	8
	SYSTEM TOL:798uV		TEST TOL:38.8mV			
7	400	360V	360.05V	138	ppm	11
	SYSTEM TOL:7.98mV		TEST TOL:460mV			

TEST#	STD Bereich	System Sollwert	Prüfling Istwert	Fehler	(% von Tol)
8	1000	900V	900.1V	111 ppm	5
	SYSTEM TOL:17.7mV		TEST TOL:1.9V		
	Wechselspannungstest				
9	4	400mV 50Hz	397.9mV	-0.525 %	35
	SYSTEM TOL:120uV		TEST TOL:6mV		
10	4	3.6V 50Hz	3.5946V	-0.150 %	25
	SYSTEM TOL:1.14mV		TEST TOL:22mV		
11	4	3.6V 1kHz	3.6041V	0.114 %	19
	SYSTEM TOL:1.14mV		TEST TOL:22mV		
12	4	3.6V 10kHz	3.57V	-0.833 %	39
	SYSTEM TOL:1.14mV		TEST TOL:76mV		
13	4	3.6V 100kHz	3.6601V	1.66 %	54
	SYSTEM TOL:4.84mV		TEST TOL:112mV		
14	40	36V 50Hz	35.941V	-0.164 %	27
	SYSTEM TOL:8.84mV		TEST TOL:220mV		
15	40	36V 1kHz	36.06V	0.167 %	27
	SYSTEM TOL:8.84mV		TEST TOL:220mV		
16	40	36V 10kHz	36.125V	0.347 %	16
	SYSTEM TOL:13.2mV		TEST TOL:760mV		
17	40	36V 20kHz	35.654V	-0.961 %	14
	SYSTEM TOL:15mV		TEST TOL:2.56V		
18	40	36V 100kHz	36.815V	2.26 %	28
	SYSTEM TOL:122mV		TEST TOL:2.92V		
19	400	360V 50Hz	359.42V	-0.161 %	26
	SYSTEM TOL:118mV		TEST TOL:2.2V		
20	400	360V 1kHz	360.44V	0.122 %	20
	SYSTEM TOL:118mV		TEST TOL:2.2V		
21	400	360V 10kHz	354.17V	-1.61 %	26
	SYSTEM TOL:118mV		TEST TOL:22V		
22	750	675V 50Hz	676.3V	0.193 %	7
	SYSTEM TOL:212.5mV		TEST TOL:17.5V		
23	750	675V 1kHz	677.2V	0.326 %	13
	SYSTEM TOL:212.5mV		TEST TOL:17.5V		
24	750	675V 5kHz	672.7V	-0.341 %	5
	SYSTEM TOL:178.75mV		TEST TOL:44.5V		
25	750	675V 10kHz	649.3V	-3.80 %	30
	SYSTEM TOL:212.5mV		TEST TOL:85V		

TEST#	STD System Bereich	Sollwert	---------- Prüfling ---------- Istwert	Fehler		(% von Tol)
		Widerstandstest				
26	400	0Ohms	0Ohms	0.00		0
	SYSTEM TOL:1mOhms		TEST TOL:20hms			
27	400	360Ohms	360Ohms	0.00	ppm	0
	SYSTEM TOL:12.08mOhms		TEST TOL:4.88Ohms			
28	4	3.6kOhms	3.601kOhms	277	ppm	4
	SYSTEM TOL:120.8mOhms		TEST TOL:28Ohms			
29	40	36kOhms	36.02kOhms	555	ppm	7
	SYSTEM TOL:1.208Ohms		TEST TOL:280Ohms			
30	400	360kOhms	360.4kOhms	0.111	%	14
	SYSTEM TOL:13.52Ohms		TEST TOL:2.8kOhms			
31	4	3.6MOhms	3.595MOhms	-0.139	%	10
	SYSTEM TOL:518Ohms		TEST TOL:51kOhms			
32	40	36MOhms	35.94MOhms	-0.167	%	7
	SYSTEM TOL:21kOhms		TEST TOL:920kOhms			
		Wechselstromtest				
33	400	360uA 50Hz	359.86uA	-388	ppm	4
	SYSTEM TOL:510nA		TEST TOL:3.8uA			
34	400	360uA 1kHz	360.28uA	777	ppm	7
	SYSTEM TOL:510nA		TEST TOL:3.8uA			
35	400	360uA 10kHz	359.9uA	-277	ppm	1
	SYSTEM TOL:2.1uA		TEST TOL:7.6uA	TUR: 3.6		
36	4000	3.6mA 50Hz	3.5977mA	-638	ppm	6
	SYSTEM TOL:3.44uA		TEST TOL:38uA			
37	4000	3.6mA 1kHz	3.6018mA	500	ppm	5
	SYSTEM TOL:3.44uA		TEST TOL:38uA			
38	4000	3.6mA 10kHz	3.6164mA	0.456	%	22
	SYSTEM TOL:10.2uA		TEST TOL:76uA			
39	40	36mA 50Hz	35.935mA	-0.181	%	17
	SYSTEM TOL:34.4uA		TEST TOL:380uA			
40	40	36mA 1kHz	35.98mA	-555	ppm	5
	SYSTEM TOL:34.4uA		TEST TOL:380uA			
41	40	36mA 10kHz	35.965mA	-972	ppm	5
	SYSTEM TOL:172uA		TEST TOL:760uA			
42	400	360mA 50Hz	359.63mA	-0.103	%	10
	SYSTEM TOL:280uA		TEST TOL:3.8mA			

TEST#	STD System Bereich	Sollwert	---------- Prüfling --------- Istwert	Fehler		(% von Tol)
43	400	360mA 1kHz	360.17mA	472	ppm	4
	SYSTEM TOL:280uA		TEST TOL:3.8mA			
44	400	360mA 5kHz	361.16mA	0.322	%	15
	SYSTEM TOL:3.16mA		TEST TOL:7.6mA	TUR: 2.4		
45	10	9A 50Hz	8.999A	-111	ppm	0
	SYSTEM TOL:7.4mA		TEST TOL:200mA			
46	10	9A 1kHz	9.021A	0.233	%	11
	SYSTEM TOL:11mA		TEST TOL:200mA			
	Gleichstromtest					
47	400	0A	0A	0.00		0
	SYSTEM TOL:20nA		TEST TOL:200nA			
48	400	360uA	360.17uA	472	ppm	15
	SYSTEM TOL:86nA		TEST TOL:1.1uA			
49	4000	3.6mA	3.6011mA	305	ppm	3
	SYSTEM TOL:610nA		TEST TOL:38uA			
50	40	36mA	36.014mA	388	ppm	4
	SYSTEM TOL:6.1uA		TEST TOL:380uA			
51	400	360mA	360.48mA	0.133	%	13
	SYSTEM TOL:112uA		TEST TOL:3.8mA			
52	400	-360mA	-360.47mA	0.131	%	12
	SYSTEM TOL:112uA		TEST TOL:3.8mA			
53	10	9A	9.01A	0.111	%	5
	SYSTEM TOL:5mA		TEST TOL:210mA			

End of Test Data

Mobile PV-Testcenter

Technical Specification

Date: 2012.05.03

MBJ Services GmbH
Merkurring 82
D-22143 Hamburg

Tel +49 (0)40 606 870 32
Fax +49 (0)40 606 870 132
www.mbj-services.com

General Description

The Mobile PV-Testcenter is designed for use in the field at installation sites for an in-depth quality analysis of solar modules. The mobile inspection system is providing Electroluminescence inspection, IV-curve measuring using an innovative LED flasher, and Infrared Imaging. Accuracy of testing and measurement is designed and optimized for the requirements which are needed to qualify PV modules on site.

General Technical Data

Module sizes (W x L)	Min.: 590mm x 890mm Max.: 1060mm x 1700mm
Module types	Framed modules, mono-crystalline or multi-crystalline and thin film
Frame thickness	6mm to 55mm
Cell formats	5 and 6 inch
Contacting of modules	Manual
User interface	24“ TFT Display with Lenovo keyboard and trackpoint
Configuration	Module type based configuration of all system parameters through SW

Technical Data Electroluminescence

Cameras	6 MBJ NIR-CCD cameras, each 1.3 Megapixel, adaptive and active cooled CCD
Resolution	580 µm/Pixel
Image acquisition time	< 30s
Power supply unit	Power supply up to 220V, 20A for module power supply. Voltage and current controlled by software
Operation mode	Full automatic image acquisition, manual cell/module judgment through operator

Technical Data LED Flasher and I/V Curve Measurement

Illuminated area (W x L)	1200mm x 1900mm
Non uniformity	< +/- 2% (Class A IEC60904 Ed2)
Short term instability (STI)	< +/- 0.5% (Class A IEC60904 Ed2)
Long term instability (LTI)	< +/- 2% (Class A IEC60904 Ed2)
Spectrum	Warm white (400-800nm)
Total irradiance	850-1100 W/m² (depending on the silicon type and ambient temperature)
Repeatability of Pmax (Flash to Flash)	<0.5% (absolute)
Current measurement	0-10A
Current accuracy	+/- 0.2% (FSR)

Voltage measurement	0-200V
Voltage accuracy	+/- 0.2% (FSR)
Sampling	16Bit / 50kHz fully synchronously / configurable IV data recording time
Flash pulse duration	Long pulse, 180ms at full irradiance
Contacting	4 wire
Load element	Adjustable capacitive load
Reference cells	mono-crystalline and multi-crystalline, calibrated at Frauenhofer IWES with +/- 4% accuracy, calibration reference IWE001001IWE0510-V01 ISE CalLab, Shunt voltage is measured with +/- 0.1% (above 2% of measurement range) Recalibrated to reference panels calibrated by TÜV Rheinland.
Accuracy of Pmax	+/- 5% based on in system reference cell usage (assuming to have valid alpha and beta temperature coefficients available and measurement is done between 10°C to 40 °C module temperature) The accuracy of measurement can be increased to up to +/- 1% against calibrated panel of similar type (same technical/spectral parameters) used as reference prior to measurement at the same temperature than the module in test. (accuracy of reference has to be added to calculate overall accuracy) Correction of irradiance and temperature to STC conditions is done according to IEC 60891 Procedure 2
Operation mode	Full automatic measurement, no operator interaction needed

Technical Data Infrared Imaging

Camera	FLIR based MBJ IR camera, attached to the trailer
Resolution	324 x 256 Pixel
Sensor	FLIR-Indigo Microbolometer
Display	Live view on 24” TFT monitor, various color schemes selectable
Operation mode	Manual operation, temperature difference measurement

Software

Operating system	Microsoft Windows 7® 64 Bit
User interface	Windows compliant graphical user interface. Easy to operate. Displays images, stores image data on hard disk drive, and controls the system. User interface facilitates grading the module und test. Several user levels available.
Data Interfaces	File transfer via USB storage device / optional Ethernet
System control	Control of the cameras and the digital I/O signals via one Gigabit Ethernet network

Operation Performance

Tact time	Less than 2-3 Minutes for a combined measurement
Operators	One operator for the system, one person to load/unload (optional)
Daily throughput	With just the operator, including loading and unloading, 100 modules in 8h
	With two persons up to 150 modules in 8h working time

Dimensions of the trailer

Height	3000 mm
Width	2080 mm
Length	4500 mm (trailer body 3150mm plus 1350mm drawbar)
Max driving speed	100 km/h
Weight	approx. 1400 kg, 1600kg total maximum weight

Ambient conditions

Ambient temperature	0°C to 30°C (without additional air condition)
Relative humidity	20% to 90% not condensing

Power requirements

Voltage	230V, 50Hz
Current	16A fused

Documentation and training

User manual	English
Training	On request

Standards

Machinery Directive	2006/42/EG
Low Voltage Directive	2006/95/EG
EMC-Directive	2004/108/EG
ROHS	2003/108/EG