INSPECTOR	Hasan Özşahin	TÜV NORD TURKEY ORDER NO	2116146719
PLACE & DATE	19.11.2024 & İstanbul	REPORT NO	RP-TUVNORD-25/0126-R00
CUSTOMER	BİNTECH Robot Teknolojileri A.Ş.	MANUFACTURER	BİNTECH Robot Teknolojileri A.Ş.
CUSTOMER ORDER NO	2116146719	MANUFACTURER ORDER NO	2116146719
INSPECTION DATES	23.09.2024/01.10.2024 /11.11.2024/19.11.202 04	MANUFACTURER CONTACT	Batuhan Mert Laçinkaya
CUSTOMER CONTACT:	Batuhan Mert Laçinkaya	STAMP	☐ Yes ☐ No
REPORT TYPE	☐ Initial	☐ In-tern	☒ Final
ANNEXES	☒ Yes	☐ No	
SENT TO	☐ Customer	☐ Manufacturer	☐ Archive

- **INSPECTION SUBJECT**

This inspection covers the "Third Party Inspection" technical supervision services and reporting of the impact on solar panels after cleaning, using the OTR/ROBSYS cleaning robot manufactured by BİNTECH Robot Teknolojileri A.Ş.

DOCUMENT REFERENCES & REVISION	Revision Date
EN 61215-2: 2021	2021

- **PROJECT DEVELOPMENT**

The purpose of this test is to examine whether the solar panel cleaning robot causes any damage to the cleaned solar panels during periodic cleaning operations. During the test, the robot will perform the cleaning operation under specified conditions, and its impact on the panels will be assessed using visual and technical devices.

This inspection was conducted in three stages:

Stage 1 - Initial Inspections:

- **Date:** 23.09.2024 - 1.10.2024
- **Location:** TÜBİTAK Test Laboratory
- **Purpose:** Determination of the condition of the panels before cleaning.
- **Examinations:**
  - Visual inspection (micro-crack control)
  - Electroluminescence imaging
  - Maximum power measurement

Stage 2 - Cleaning Process:

- **Date:** 03.10.2024 - 19.11.2024
- **Location:** Outdoor test area
- **Setup:** The solar panels were installed according to the manufacturer's (Schmid Pekintaş) installation instructions (Appendix-7 Installation Guide).
- **Purpose:** OTR/ROBSYS cleaning robot to perform 2000 cycles of cleaning.
- **Setup Details:**
    - The table on which the panels were mounted was set at a 0° angle and at a height of 0 cm from the ground.
    - The robot cleaned an area measuring 7 meters in length and 1.134 meters in width.
    - During the robot's movement, abnormalities such as vibration, excessive friction, or pressure changes were monitored.
    - The test setup consists of three panels; however, the tests were conducted on two panels. The three-panel test setup was used to maintain the procedure and avoid any changes in the solar panel cleaning process, but only two panels were evaluated.

Stage 3 - Final Inspections:

- **Date:** 11.11.2024 - 21.11.2024
- **Location:** TÜBİTAK Test Laboratory
- **Purpose:** Determination of the condition of the panels after cleaning.
- **Examinations:**
    - Visual inspection (micro-crack control)
    - Electroluminescence imaging
    - Maximum power measurement

Cleaning Device:

- **Model:** OTR/ROBSYS
- **Serial No.:** OTR-0001
- **Production Date:** 24.05.2024

Solar Panel:

- **Manufacturer:** Schmid Pekintaş, 550 Watt Mono PERC Monofacial
- **Panels Used:**
- Serial No.: SPE-08-2409052808

TÜV NORD Turkey Teknik Kontrol ve Belgelendirme A.Ş.
Şehit Mehmet Fatih Ongül Sokak, No:5 Kat:4 Odak Plaza, Kozyatağı, 34742 İstanbul-TÜRKİYE
Telefon +90 216 361 2995 • Fax +90 216 380 67 87 • E-mail: tuv-nord@tuv-turkey.com

- Serial No.: SPE-08-2409051010

- **RESULTS & OPINIONS**

Stage 1: Initial Inspection

- Panels' visual and technical inspections were conducted at TÜBİTAK laboratories.
- Micro-crack analysis and power measurements were recorded.

Serial No	Inspection Date	Visual Check	Maximum Power	Microcrack
SPE-08-2409052808	23.09.2024-01.10.2024	EK-1	550,4 W (EK-1)	YOK (EK-1)
SPE-08-2409051010	23.09.2024-01.10.2024	EK-3	552 W (EK-3)	YOK (EK-3)

Stage 2: Cleaning Process

- The robot performed 2000 cleaning cycles on two panels.
- The cleaning operation lasted 8 hours, with the panels positioned at a 0° angle.
- Environmental conditions were recorded (temperature ranged from 8°C to 14°C, and humidity varied between 0% and 8%). No abnormalities were observed in the robot's performance.
- The cleaning process was conducted without water.
- It started with 500 cycles. The battery was replaced after 1240 cycles. The remaining 260 cycles were completed after the battery replacement, making a total of 2000 washing cycles.
- After cleaning, the panels were sent to TÜBİTAK test laboratory for analysis.
- The robot performed 2,000 cleaning cycles on three panels. EL tests were conducted on two panels. The reason for using three panels was due to the established test setup.

Stage 3: Final Inspection

Panellerin Son Kontrolü: (EK-4, EK-5, EK-6)
Microcracks have formed on only one solar panel. The serial number of the panel with microcracks is SPE-08-2408281724. A new crack formation has been observed on the microcracked panel, but no progression of the existing crack has been detected.

The OTR/ROBSYS cleaning robot has not caused any significant physical damage to the solar panels and has not led to the progression of microcracks over 2,000 cleaning cycles.

Serial No	Inspection Date	Visual Check	Maximum Power	Microcrack
SPE-08-2409052808	11.11.2024-21.11.2024	EK-4	548,4 W (EK-4)	YOK (EK-4)
SPE-08-2409051010	11.11.2024-21.11.2024	EK-6	549,6 W (EK-6)	YOK (EK-6)

TÜV NORD Turkey Teknik Kontrol ve Belgelendirme A.Ş.
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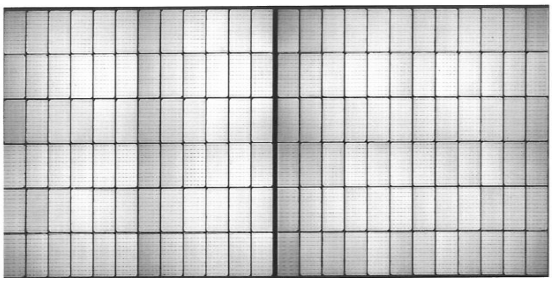
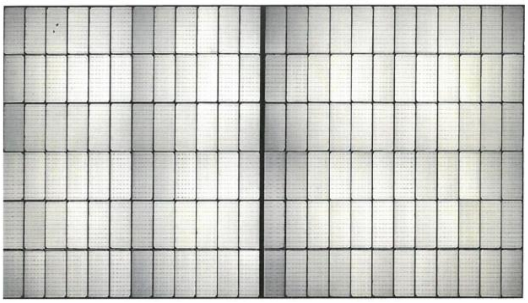
Telefon +90 216 361 2995 • Fax +90 216 380 67 87 • E-mail: tuv-nord@tuv-turkey.com

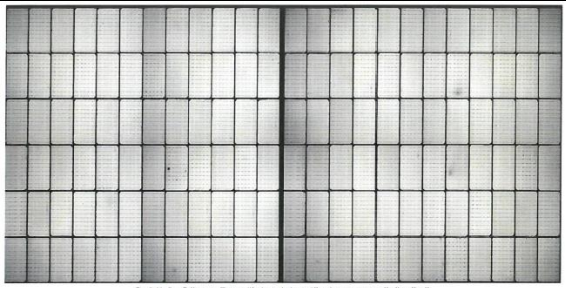
EVALUATION

No microcracks have been detected in the solar panels.

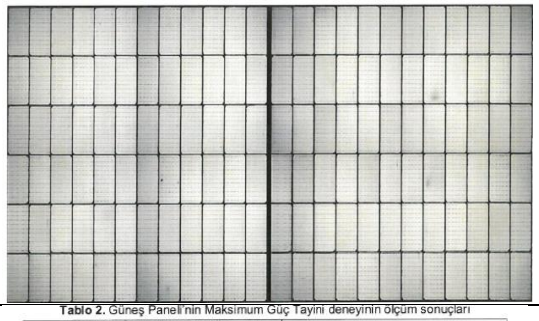
The OTR/ROBSYS cleaning robot has not caused any significant physical damage to the solar panels or contributed to the progression of microcracks over 2,000 cleaning cycles.

<table>
<tr><th>PVSERIAL NO</th><th>Initial Test Result</th><th>Final Test Result</th></tr>
<tr><td>SPE-08-2409052808</td><td> 

Tablo 2. Güneş Paneli'nin Maksimum Güç Tayini deneyinin ölçüm sonuçları
<table>
<tr><td rowspan="2">Deney Koşulları</td><td>Panel Sıcaklığı (°C)</td><td colspan="2">24,6</td></tr>
<tr><td>Işınım Düzeyi (W·m^{-2})</td><td colspan="2">1000,2</td></tr>
<tr><th colspan="2">Ölçülen Parametreler</th><th>Ölçülen Değer</th><th>Belirsizlik</th></tr>
<tr><td colspan="2">Maksimum Güç, P_{max} (W)</td><td>550,4</td><td>7,7</td></tr>
<tr><td colspan="2">Açık Devre Gerilimi, V_{oc} (V)</td><td>50,26</td><td>0,35</td></tr>
<tr><td colspan="2">Kısa Devre Akımı, I_{sc} (A)</td><td>13,67</td><td>0,12</td></tr>
<tr><td colspan="2">Maksimum Güçteki Gerilim, V_{pmax} (V)</td><td>42,11</td><td>0,46</td></tr>
<tr><td colspan="2">Maksimum Güçteki Akım, I_{pmax} (A)</td><td>13,07</td><td>0,17</td></tr>
<tr><td colspan="2">Dolum Faktörü, FF (%)</td><td>80,11</td><td>0,96</td></tr>
</table></td><td> 

Tablo 2. Güneş Paneli'nin Maksimum Güç Tayini deneyinin ölçüm sonuçları
<table>
<tr><td rowspan="2">Deney Koşulları</td><td>Panel Sıcaklığı (°C)</td><td colspan="2">24,7</td></tr>
<tr><td>Işınım Düzeyi (W·m^{-2})</td><td colspan="2">1000,4</td></tr>
<tr><th colspan="2">Ölçülen Parametreler</th><th>Ölçülen Değer</th><th>Belirsizlik</th></tr>
<tr><td colspan="2">Maksimum Güç, P_{max} (W)</td><td>548,4</td><td>7,7</td></tr>
<tr><td colspan="2">Açık Devre Gerilimi, V_{oc} (V)</td><td>50,28</td><td>0,35</td></tr>
<tr><td colspan="2">Kısa Devre Akımı, I_{sc} (A)</td><td>13,60</td><td>0,12</td></tr>
<tr><td colspan="2">Maksimum Güçteki Gerilim, V_{pmax} (V)</td><td>42,15</td><td>0,46</td></tr>
<tr><td colspan="2">Maksimum Güçteki Akım, I_{pmax} (A)</td><td>13,01</td><td>0,17</td></tr>
<tr><td colspan="2">Dolum Faktörü, FF (%)</td><td>80,22</td><td>0,96</td></tr>
</table></td></tr>
<tr><td>SPE-08-2409051010</td><td> 

Şekil 2. Güneş Paneli'nin elektrolüminesans görüntüsü

Tablo 2. Güneş Paneli'nin Maksimum Güç Tayini deneyinin ölçüm sonuçları
<table>
<tr><td rowspan="2">Deney Koşulları</td><td>Panel Sıcaklığı (°C)</td><td colspan="2">24,7</td></tr>
<tr><td>Işınım Düzeyi (W·m^{-2})</td><td colspan="2">1000,2</td></tr>
<tr><th colspan="2">Ölçülen Parametreler</th><th>Ölçülen Değer</th><th>Belirsizlik</th></tr>
<tr><td colspan="2">Maksimum Güç, P_{max} (W)</td><td>552,0</td><td>7,7</td></tr>
<tr><td colspan="2">Açık Devre Gerilimi, V_{oc} (V)</td><td>50,25</td><td>0,35</td></tr>
<tr><td colspan="2">Kısa Devre Akımı, I_{sc} (A)</td><td>13,72</td><td>0,12</td></tr>
<tr><td colspan="2">Maksimum Güçteki Gerilim, V_{pmax} (V)</td><td>42,07</td><td>0,46</td></tr>
<tr><td colspan="2">Maksimum Güçteki Akım, I_{pmax} (A)</td><td>13,12</td><td>0,17</td></tr>
<tr><td colspan="2">Dolum Faktörü, FF (%)</td><td>80,04</td><td>0,96</td></tr>
</table></td><td> 

Tablo 2. Güneş Paneli'nin Maksimum Güç Tayini deneyinin ölçüm sonuçları
<table>
<tr><td rowspan="2">Deney Koşulları</td><td>Panel Sıcaklığı (°C)</td><td colspan="2">24,7</td></tr>
<tr><td>Işınım Düzeyi (W·m^{-2})</td><td colspan="2">1000,5</td></tr>
<tr><th colspan="2">Ölçülen Parametreler</th><th>Ölçülen Değer</th><th>Belirsizlik</th></tr>
<tr><td colspan="2">Maksimum Güç, P_{max} (W)</td><td>549,6</td><td>7,7</td></tr>
<tr><td colspan="2">Açık Devre Gerilimi, V_{oc} (V)</td><td>50,25</td><td>0,35</td></tr>
<tr><td colspan="2">Kısa Devre Akımı, I_{sc} (A)</td><td>13,65</td><td>0,12</td></tr>
<tr><td colspan="2">Maksimum Güçteki Gerilim, V_{pmax} (V)</td><td>42,09</td><td>0,46</td></tr>
<tr><td colspan="2">Maksimum Güçteki Akım, I_{pmax} (A)</td><td>13,06</td><td>0,17</td></tr>
<tr><td colspan="2">Dolum Faktörü, FF (%)</td><td>80,15</td><td>0,96</td></tr>
</table></td></tr>
</table>

- **ATTACHMENTS**
  - **Appendix-1:** Initial test results for panel SPE-08-2409052808
  - **Appendix-2:** Initial test results for panel SPE-08-2409051010

- **Appendix-3:** Final test results for panel SPE-08-2409052808
- **Appendix-4:** Final test results for panel SPE-08-2409051010
- **Appendix-5:** Photovoltaic Solar Panel Installation Guide

- **DENETİMDEN FOTOĞRAFLAR**

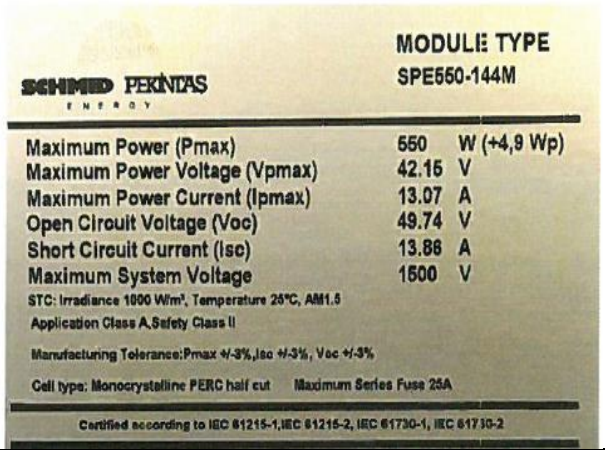


Photo 1 - Annex 1: Label Information of the Solar Panel with Serial Number SPE-08-2409052808

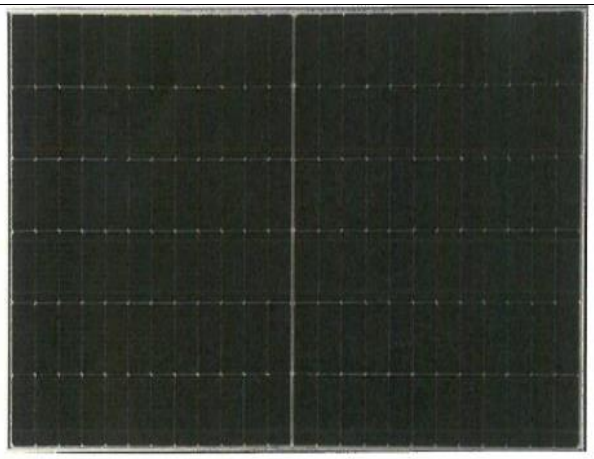


Photo 2 - Annex 1: Image of the Solar Panel with Serial Number SPE-08-2409052808

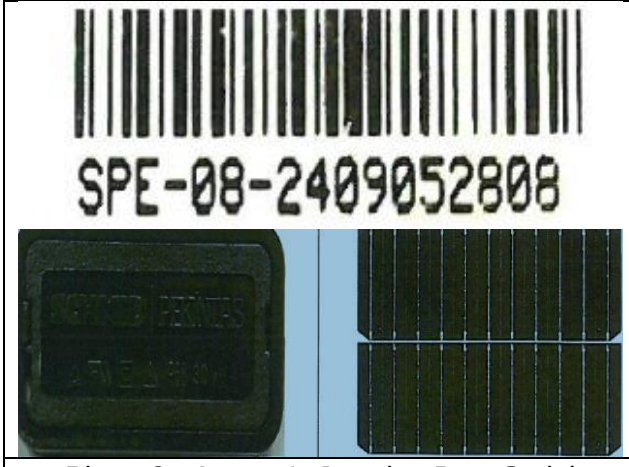


Photo 3 - Annex 1: Junction Box, Serial Number, Busbar, and Fingerprint Lines of the Solar Panel with Serial Number SPE-08-2409052808

Tablo 1. Güneş Paneli'nin Görsel Muayene/ Elektrolüminesans deneyi ile gözlemlenen bulgular

Temel Görsel Kusurlar	Panelin Ön Yüzeyi Kusur (Var/Yok)
Panelin dış yüzeyinde tespit edilen bükülme, çatlama, ezilme ve/veya kopma gibi bulgular	Yok
Panelin çalışmasını bozacak şekilde yanlış hizalanmış alt tabakalar, çerçeveler ve bağlantı kutuları	Yok
Panelin ön ve arka yüzeylerinde veya panelin aktif bileşenlerinde yanma, erime vb bulgular	Yok
Laminasyon veya diğer yapıştırma yöntemleri nedeniyle panelin toplan alanının % 1'ini aşan kabarcıklar	Yok
Panelin elektriksel devresindeki bulunan hücrelerin % 10'undan fazlasını etkileyebilen kırık ve/veya çatlak hücreler	Yok
Panelin aktif devresinin herhangi bir katmanında bulunan ve herhangi bir hücrenin % 10'undan fazlasını kaplayan, boşluklar ve/veya korozyonlar	Yok
Panelin aktif hücrelerde elektriksel bağlantılar arası mikro kırılmalar, mikro kopmalar, çatlamalar ve/veya ezilmeler gibi bulgular	Yok
Panel Görsel Muayene/Elektrolüminesans Deneyi Sonucu	Geçti*

* Değerlendirme Koşulu: IEC 61215-1:2021 ve IEC 61215-2:2021 standartlarına göre aktif hücrelerdeki kırık ve çatlakların sayısı, panelin elektriksel devresinin % 10'undan düşük olmalıdır.

Photo 4 - Annex 1: Visual Inspection of the Solar Panel with Serial Number SPE-08-2409052808

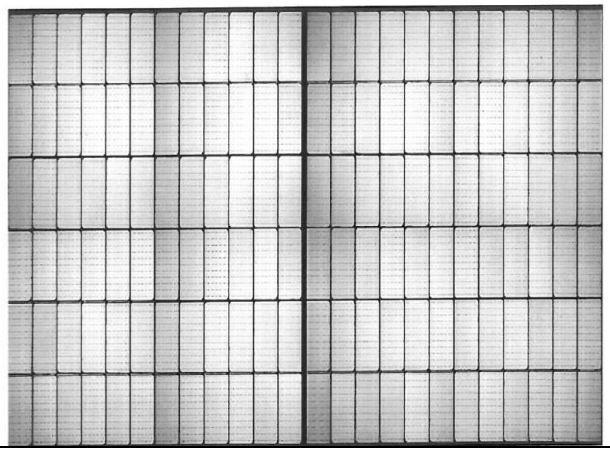


Photo 5 - Annex 1: Initial Test Results of the Solar Panel with Serial Number SPE-08-2409052808

Tablo 2. Güneş Paneli'nin Maksimum Güç Tayini deneyinin ölçüm sonuçları

Deney Koşulları	Panel Sıcaklığı	(°C)	24,6	
	Işınım Düzeyi	($W \cdot m^{-2}$)	1000,2	
Ölçülen Parametreler			Ölçülen Değer	Belirsizlik
Maksimum Güç, P_{max}		(W)	550,4	7,7
Açık Devre Gerilimi, V_{oc}		(V)	50,26	0,35
Kısa Devre Akımı, I_{sc}		(A)	13,67	0,12
Maksimum Güçteki Gerilim, V_{pmax}		(V)	42,11	0,46
Maksimum Güçteki Akım, I_{pmax}		(A)	13,07	0,17
Dolum Faktörü, FF		(%)	80,11	0,96

Photo 6 - Annex 1: Initial Test Results of the Solar Panel with Serial Number SPE-08-2409052808

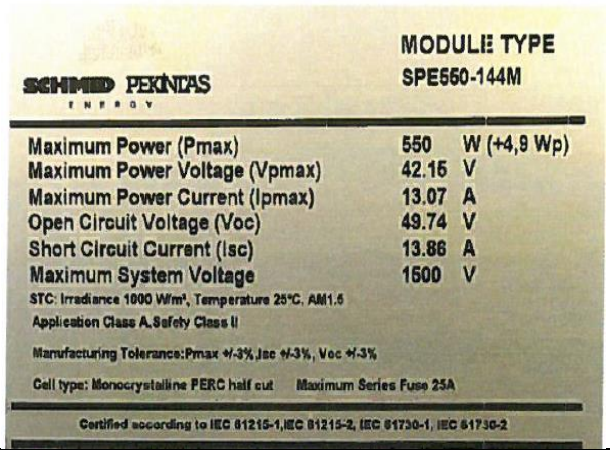


Photo 7 - Annex 3: Label Information of the Solar Panel with Serial Number SPE-08-2409051010

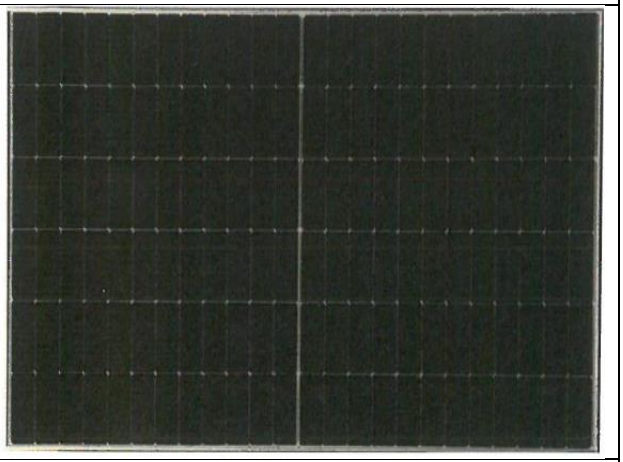


Photo 8 - Annex 3: Image of the Solar Panel with Serial Number SPE-08-2409051010

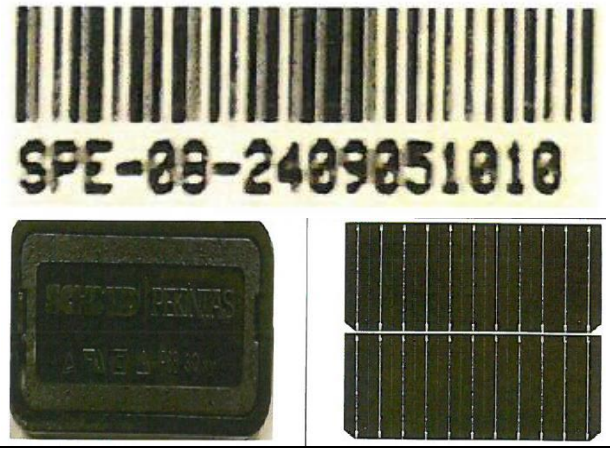


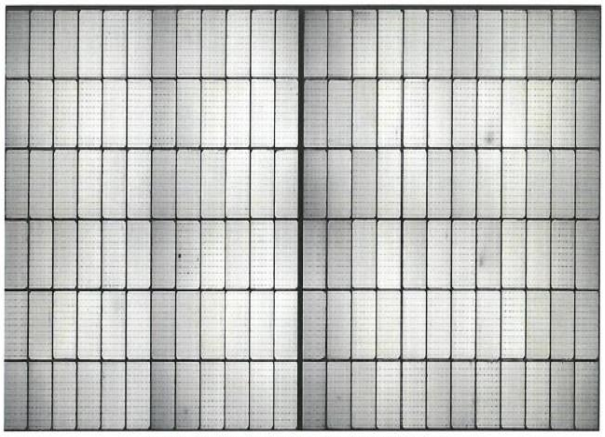
Photo 9 - Annex 3: Serial Number of the Solar Panel with Serial Number SPE-08-2409051010

Tablo 1. Güneş Paneli'nin Görsel Muayene/ Elektrolüminesans deneyi ile gözlemlenen bulgular

Temel Görsel Kusurlar	Panelin Ön Yüzeyi Kusur (Var/Yok)
Panelin dış yüzeyinde tespit edilen bükülme, çatlama, ezilme ve/veya kopma gibi bulgular	Yok
Panelin çalışmasını bozacak şekilde yanlış hizalanmış alt tabakalar, çerçeveler ve bağlantı kutuları	Yok
Panelin ön ve arka yüzeylerinde veya panelin aktif bileşenlerinde yanma, erime vb bulgular	Yok
Laminasyon veya diğer yapıştırma yöntemleri nedeniyle panelin toplan alanının % 1'ini aşan kabarcıklar	Yok
Panelin elektriksel devresindeki bulunan hücrelerin % 10'undan fazlasını etkileyebilen kırık ve/veya çatlak hücreler	Yok
Panelin aktif devresinin herhangi bir katmanında bulunan ve herhangi bir hücrenin % 10'undan fazlasını kaplayan, boşluklar ve/veya korozyonlar	Yok
Panelin aktif hücrelerde elektriksel bağlantılar arası mikro kırılmalar, mikro kopmalar, çatlamalar ve/veya ezilmeler gibi bulgular	Yok
Panel Görsel Muayene/Elektrolüminesans Deneyi Sonucu	Geçti*

* Değerlendirme Koşulu: IEC 61215-1:2021 ve IEC 61215-2:2021 standartlarına göre aktif hücrelerdeki kırık ve çatlakların sayısı, panelin elektriksel devresinin % 10'undan düşük olmalıdır.

Photo 10 - Annex 3: Initial Test Results of the Solar Panel with Serial Number SPE-08-2409051010



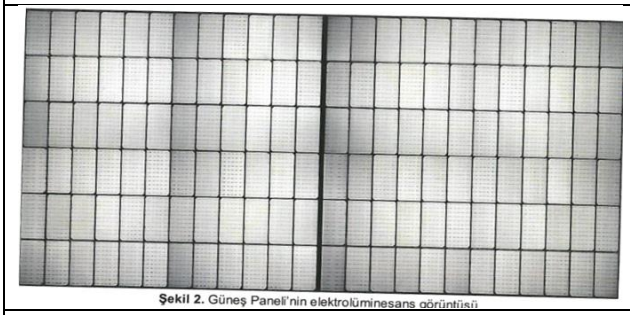
Şekil 2. Güneş Paneli'nin elektrolüminesans görüntüsü

Photo 11 - Annex 3: Initial Test Results of the Solar Panel with Serial Number SPE-08-2409051010

Tablo 2. Güneş Paneli'nin Maksimum Güç Tayini deneyinin ölçüm sonuçları

Deney Koşulları				
	Panel Sıcaklığı	(°C)	24,7	
	Işınım Düzeyi	($W \cdot m^{-2}$)	1000,2	
Ölçülen Parametreler			Ölçülen Değer	Belirsizlik
Maksimum Güç, P_{max}		(W)	552,0	7,7
Açık Devre Gerilimi, V_{oc}		(V)	50,25	0,35
Kısa Devre Akımı, I_{sc}		(A)	13,72	0,12
Maksimum Güçteki Gerilim, V_{pmax}		(V)	42,07	0,46
Maksimum Güçteki Akım, I_{pmax}		(A)	13,12	0,17
Dolum Faktörü, FF		(%)	80,04	0,96

Photo 12 - Annex 3: Initial Test Results of the Solar Panel with Serial Number SPE-08-2409051010



Şekil 2. Güneş Paneli'nin elektrolüminesans görüntüsü

Photo 13: Initial Test Results of the Solar Panel with Serial Number SPE-08-2409052808

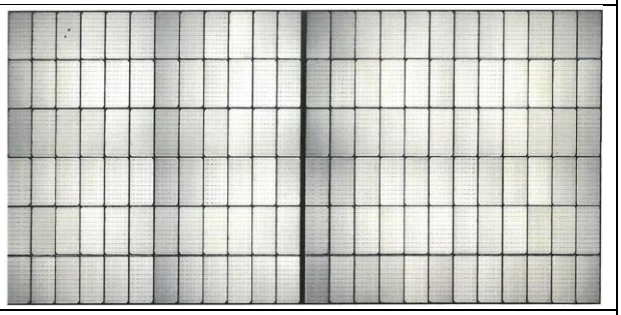


Photo 14: Final Test Results of the Solar Panel with Serial Number SPE-08-2409052808

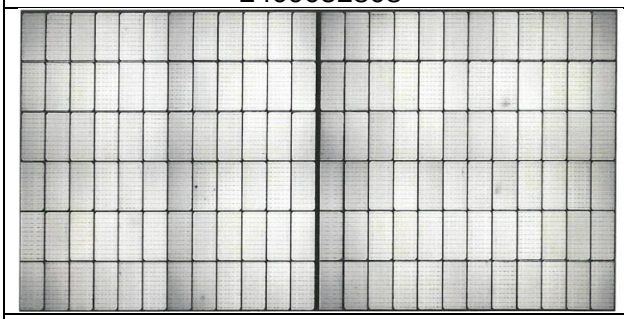


Photo 15: Initial Test Results of the Solar Panel with Serial Number SPE-08-2409051010

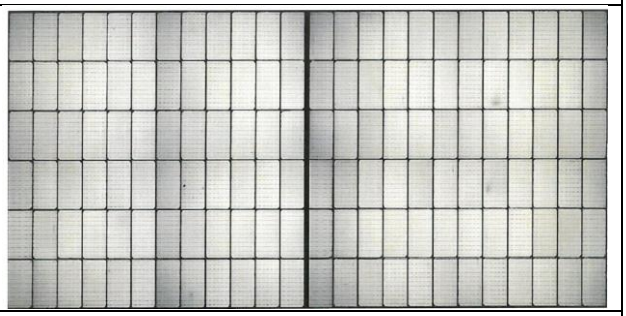


Photo 16: Final Test Results of the Solar Panel with Serial Number SPE-08-2409051010

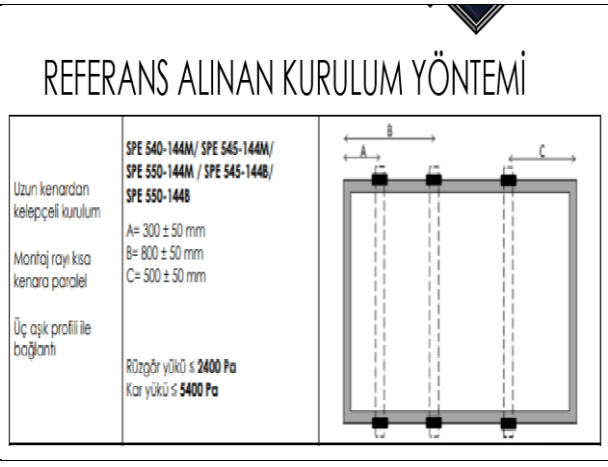
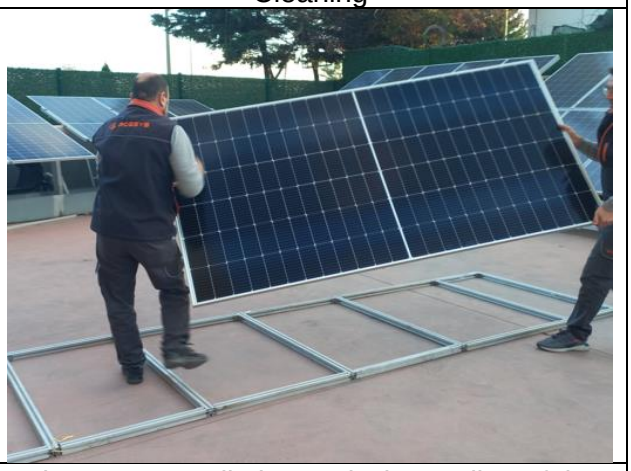


Photo 17: The Table Where the Panels Are Installed	Photo 18: Installation Dimensions
	
Photo 19: Robot Label	Photo 20: Image of the Panels Before Cleaning
	
Photo 21: Image of the Panels Before the Cleaning Stage	Photo 22: Installation and Dismantling of the Panels

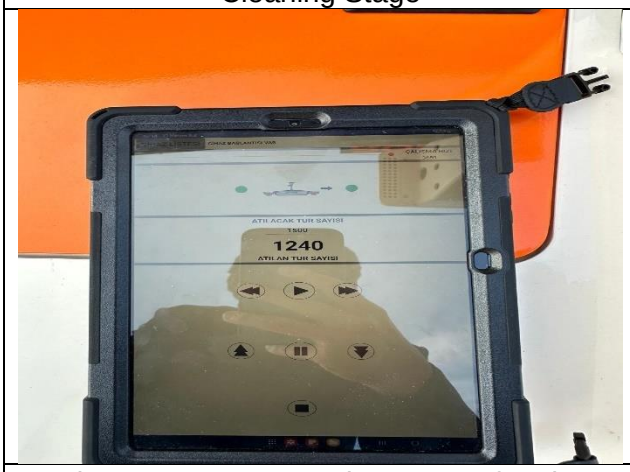



Photo 23: Battery Replacement After the 1240th Revolution	Photo 24: Battery Replacement During the Revolution

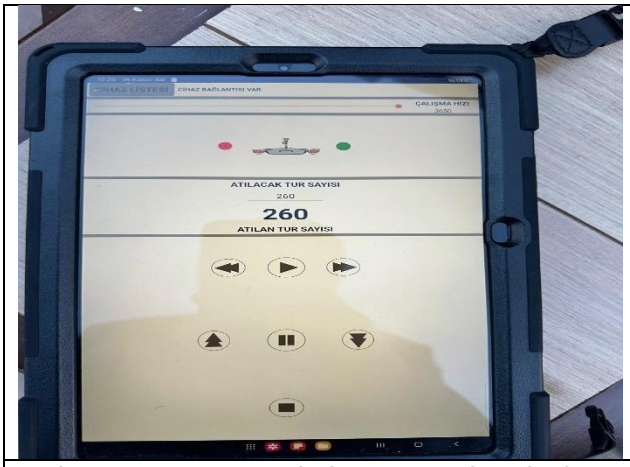


Photo 25: 260 Revolutions Completed After Battery Replacement	Photo 26: Packaging Stage of the Panels

INSPECTOR

Name : Hasan Özşahin

SIGNATURE

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